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NATIONAL BANK OF THE REPUBLIC OF MACEDONIA

2nd Research Conference "Policy Nexus and the Global Environment: A New Consensus Emerging from the Crisis?"

Skopje, 26 April, 2013

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Foreword

On April 26, 2013, the National Bank of the Republic of Macedonia organized an international conference entitled: "Policy Nexus and the Global Environment: A New Consensus Emerging from the Crisis". This conference was organized on the occasion of the anniversary of the monetary independence of the Republic of Macedonia. High quality papers were presented on the conference, received upon Call for papers sent to the central banks in the region, or on invitation. This booklet incorporates the papers presented at the conference, as well as the official speech of the Governor of the National Bank of the Republic of Macedonia.

Launching this booklet, we would like to express our gratitude to all presenters, the esteemed keynote speaker, the moderators of the conference sessions, as well as to all other participants, all of them adding value to the success of the conference.

National Bank of the Republic of Macedonia

Ladies and Gentlemen,

Dear guests,

Let me wish you welcome on our second Research Conference that we usually organize on the day of the monetary independence anniversary of the Republic of Macedonia. The subject of this year's conference we believe is highly topical, in line with the ongoing lively discussions among central bankers, research and academic institutions worldwide.

The global economy in the last couple of years undergone remarkable changes, both from institutional and policy design setup. We witnessed financial market turbulences, banks failures and sovereign debt crisis with strong contagion around the world economy that was almost unique by its size, and the global economy is still struggling to recover. After five years of global crisis we could say that we experienced a lot, and hopefully, we learnt a lot. One of the main lessons of the crisis was exactly related to the topic of the conference - the need of policy nexus as a kind of a consensus emerging from the crisis.

What is the policy nexus about?

At the initial stage of the financial crisis the importance of the macro prudential policies in the overall policy mix was highlighted and therefore, a lot of attention has been put on the monetary and macro prudential policy nexus, conveying the main message that the price stability and financial stability are interconnected. With the appearance of the sovereign debt and banking crisis in the last couple of years in the euro area, it was quite obvious that the poor public finances management could also impose threats to the financial system. The financial instability and weak public finances can potentially have adverse effects on the financial markets, imposing distortions in the monetary policy transmission mechanism, and resulting in serious macroeconomic imbalances. The required policy nexus is becoming a necessary precondition for designing and implementing a sound macroeconomic management.

Under situation that was more specific than usual, when the role of traditional instruments was limited, the monetary policy turned to unconventional policy measures. Although the monetary policy in the region has not been constrained by zero lower bound on interest rates, the central banks also turned towards unconventional monetary policy tools, having in mind the potential risks of repeated deterioration of the external imbalances and inflationary pressures or aiming at supporting other objectives (including credit growth). While listing the experiences of unconventional measures among the central banks, we can distinguish between: measures for increasing and changing the composition of the assets in the balance sheet of the central banks in different forms and with high heterogeneity across the countries, and measures for influencing agents' expectations by strong commitment by the central banks for keeping low interest rate for a longer time horizon.

In the public finances domain, the strengthening of fiscal discipline and the need of careful monitoring of fiscal sustainability can be taken as the core preventing arms against fiscal imbalances that highlight this crisis. The fiscal consolidation is already on the list of objectives within the EU and it will require serious efforts and internal adjustments for reaching this goal. In the midstream of the crisis, the need of fiscal adjustment imposed the confronting issue of the adverse impact over recovery and growth dynamics that was really one of the tight spot in the crisis management. The fiscal stimulus obviously supported the recovery in the countries where there was a room for it, but looking forward the need for fiscal consolidation should be taken seriously.

The financial stability, not only nationwide, but also in international framework, is quite often quoted as a common good and therefore we have to take care of it. Attention should be paid to the risk distribution among financial institutions, as well as to the aggregate risk level evolution. The regulatory response to the crisis was oriented towards strengthening the banks' soundness as well as designing treatment of systemically important banks which certainly require a special attention by the authorities. Systemic risk requires systemic and comprehensive solutions, including changes in the institutional setup. In the EU it was done by establishing crisis management mechanisms, strengthened governance aimed to monitor and prevent against any macroeconomic imbalances, as well as to move towards the banking

union. The EU member states and institutions face many challenges when making the new institutional setup operational and when making the necessary adjustments in a reasonable time framework. In addition, all other countries face the challenge of converting the lessons from the crisis into policy actions.

The changing role of central banks

During the crisis, the role of the central banks moved from traditional way of monetary policy implementation towards combining the monetary and financial stability objectives, both being complementary components of macroeconomic stability. The set of instruments became more complex because of the unconventional measures, designed to bridge the period of extraordinary circumstances affecting the effectiveness of standard instruments, and aiming to strengthen the financial stability or economic recovery. Due to the variety of those unconventional measures across the countries, it is still difficult to assess their impact, although the experiences of countries could confirm the quite largely accepted consensus that the "monetary stimulus" really supported the economy. However, we should be aware that at one point in the future their contribution will be overwhelmed and we will need to take appropriate action on time in order to impede any reverse effects.

In the policy design and decision making process under the current dynamic environment, the strengthening of analytical tools and the enhancement of knowledge on the policy nexus are extremely important. The interplay of monetary, fiscal and macro prudential policies is a quite new area, seeking for deeper research work to support the decision making process at the central banks and other policy makers, to provide appropriate advices and policy recommendation and therefore, to prevent from underlying risks. The aim of our conference is to contribute towards building knowledge and exchanging views on the policy nexus issue. Having in mind the quality of papers that are going to be presented today, I truly hope that we will make our contribution towards this aim.

I wish you a successful conference and fruitful discussion!

Thank you.

Dimitar Bogov, Governor of the National Bank of the Republic of Macedonia

Skopje, Holiday Inn Hotel, 26 April 2013

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UNCONVENTIONAL MONETARY POLICY IN THEORY AND IN PRACTICE[1]

by Martina Cecioni[2], Giuseppe Ferrero[2] and Alessandro Secchi[2]

Abstract

In this paper, after discussing the theoretical underpinnings of unconventional monetary policy measures, we review the existing empirical evidence on their effectiveness, focusing on those adopted by the European Central Bank and by the Federal Reserve. These measures operate in two ways: through the signalling channel and through the portfolio- balance channel. In the former, the central bank can use communication to steer interest rates and to restore confidence in the financial markets; the latter hinges on the hypothesis of imperfect substitutability of assets and liabilities in the balance sheet of the private sector and postulates that the central bank's asset purchases and liquidity provision lower financial yields and improve funding conditions. The review of the empirical literature suggests that the unconventional measures were effective and that their impact on the economy was sizeable. However, a very large degree of uncertainty surrounds the precise quantification of these effects.

JEL Codes: E52, E58.

Keywords: Central bank, unconventional monetary policy, financial crisis, signalling channel, portfolio balance channel.

September 2011

[1] Bank of Italy, Occasional Papers, No. 102, September 2011

[2] Bank of Italy, Economic Outlook and Monetary Policy Research Department

1. Introduction[3]

In normal times central banks implement monetary policy by steering official interest rates and explaining to the public how a particular monetary stance in a given economic environment should contribute to achieving the final goals. To this purpose, central banks may decide to share with the public their views about the future evolution of some key macroeconomic variables or even their policy intentions.

Monetary policy decisions and announcements are first transmitted to the interbank market (the market for central bank reserves). When market conditions are quiet, central banks' monopolistic power in the provision of reserves allows them to steer interest rates in the interbank market very accurately.

In such an environment the provision of liquidity to the banking system is a mechanical exercise and liquidity management operations are designed exclusively to implement the desired level of short-term interest rates. In particular, the provision of liquidity does not contain any information about the monetary policy stance beyond that included in the official interest rate.[4] Moreover, during normal times the central bank only cares about injecting the banking system with the appropriate amount of reserves while their distribution among depository institutions takes place endogenously through the interbank market.

The monetary impulse is then transmitted through different channels to all the other financial markets.[5] In particular, it also affects credit market conditions and long-term interest rates, which are key elements in the public's investment-consumption decisions. Through this transmission mechanism the central bank can therefore pursue its final objectives in terms of inflation and possibly growth.

During a financial crisis implementing monetary policy is a much more complex exercise as the transmission mechanism can be severely impaired by disruptions in the financial markets. First of all, the increase in the volatility of the demand for reserves and the limited redistribution of liquidity among depository institutions may adversely affect the central bank's ability to control short-term interest rates in the interbank market. Second, disruptions in other segments of the financial market may hamper the transmission of the monetary impulse across the full spectrum of financial assets. Finally, when the effect of the crisis on the real economy is large, the zero lower bound for interest rates may become a binding constraint for monetary policy decisions.[6] In these situations central banks may need to resort to unconventional measures to regain control on the economy.

There is not a universally accepted definition of a non-standard monetary policy measure: as Borio and Disyatat (2010) observe, the difference between a conventional and an unconventional tool might, in some cases, be very tenuous.[7] In this paper we adopt a very broad characterization and we include in the set of unconventional measures any policy intervention that aims to rectify a malfunctioning of the monetary transmission mechanism or to provide further stimulus to the economy when the official interest rates reach the zero bound. We therefore classify as non-standard tools all the measures implemented during the global financial crisis that addressed liquidity shortages both of depository institutions and of other important segments of the financial market, the direct purchase of private and public securities, and the adoption of particular forms of communication designed to restore a more normal functioning of the markets and influence expectations about future official interest rates.

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[3] E-mail: martina.cecioni@bancaditalia.it, giuseppe.ferrero@bancaditalia.it, alessandro.secchi@bancaditalia.it. We thank Paolo Del Giovane, Eugenio Gaiotti, Stefano Neri and Luca Sessa for useful comments and suggestions. All remaining errors are our own. The views expressed in this paper do not necessarily reflect those of the Bank of Italy.

[4] This independence between policy decisions and liquidity provision is called the "separation" or "decoupling" principle (Borio and Disyatat 2010).

[5] Bernanke and Gertler (1995), Mishkin (1996), Blinder, Ehrmann, Fratzscher, de Haan, Jansen (2008) and Boivin, Kiley and Mishkin (2010).

[6] "The zero lower bound on nominal interest rates limits the ability of central banks to reduce short-term interest rates. As a result, when nominal interest rates are near zero, central banks are unable to use further reductions in short-term interest rates to provide additional stimulus to the economy and check unwelcome disinflation", Chung et al. (2011).

[7] While the adoption of a new monetary policy tool is certainly an unconventional measure, it is less clear whether more frequent and more intense use of a standard tool can be classified as a conventional or as an unconventional measure, especially when it is used for non-standard purposes.

During the global financial crisis recourse to these measures was heterogeneous across countries. This reflected differences in the structure of the respective financial systems and in the severity of market disruptions, as well as the role of central banks' judgment. During unconventional times this last factor contributes more because of the lack of sound theory and empirical evidence on the effectiveness of non-standard measures (Trichet 2010). To fill this gap, and to equip policy makers with sounder evaluation instruments, the profession has recently devoted considerable effort to improving formal understanding of the mechanisms through which unconventional monetary measures influence the economy and to testing for their empirical relevance. This strand of literature has grown rapidly and is now sufficiently large to allow some conclusions to be drawn.

In this paper, we describe the various measures adopted in the US and in the euro area during the recent crisis, we provide a review of the main theoretical underpinnings that support the use of unconventional measures in the case of financial distress, and we survey the evidence on their effectiveness. While there is no doubt that these measures prevented a collapse of the financial system and a deeper contraction of the real economy as a result of the global crisis, a clearer understanding of the contribution of each, from both a theoretical and an empirical perspective, is a necessary step towards defining an "optimal unconventional tool-box".

In the review of the theoretical literature on the functioning of unconventional measures we identify two channels of transmission.

The first is the *signalling channel*, which enables the central bank to use communication to restore confidence in the markets and influence private expectations about future policy decisions. This channel may be particularly useful when official interest rates reach the zero lower bound and the central bank needs to provide further stimulus to the economy.

The purchase of public and private securities and the provision of credit to financial and non-financial institutions affect the economy through the portfolio-balance channel, which operates when assets and liabilities in the balance sheets of the private sector are imperfectly substitutable. The central bank can exploit this channel when it wants to alleviate tensions in particular segments of the financial markets, when it seeks to reduce yields more widely, and when it decides to counteract the impact of financial frictions on funding conditions.

In the review of the empirical evidence on the effectiveness of unconventional measures we focus on the euro area and on the US as the analysis of these two areas allows us to review a broad spectrum of unconventional measures ranging from the bank-oriented decisions adopted in the euro area to the more market-oriented actions implemented on the other side of the Atlantic.

The choice of a classification scheme for unconventional measures displays the same degree of arbitrariness as the division of monetary measures into conventional and unconventional. This is reflected in the abundance of taxonomies currently available in the literature.[8] In this paper we classify the available empirical studies according to whether they examine the impact of non-traditional tools (i) on financial variables or (ii) on macroeconomic variables, and according to the methodology followed in the empirical investigation.

[8] Stone, Fujita and Ishi (2011), for example, suggest a classification based on whether the final objective of the unconventional operation is one of financial or macroeconomic stability; Borio and Disyatat (2011) propose a taxonomy based on the particular financial market targeted by the unconventional operations and on their impact on the private sector's balance sheets; Bini Smaghi (2009) classifies unconventional measures into "endogenous credit easing" - measures designed to provide abundant liquidity to commercial banks - "credit easing" - measures to address liquidity shortages and counter spreads in other dysfunctional segments of the financial market - and "quantitative easing" - purchases of government bonds to reduce long-term risk-free rates; Bernanke (2009) adopts a similar taxonomy.

All in all, this review suggests that the unconventional measures adopted on both sides of the Atlantic were so far effective in influencing financial and macroeconomic variables. However, considerable uncertainty surrounds the quantification of these effects. Moreover, an important issue, only mentioned at the end of the paper, concerns the potential costs to central banks of reversing such measures and their possible impact on private banks' risk-taking behaviour (moral hazard). [9]

The paper is organized as follows. Section 2 provides a brief chronological description of the unconventional measures adopted in the US and in the euro area up to mid-2011. Section 3 analyses the theoretical support for their effectiveness. Section 4 surveys the empirical evidence and Section 5 concludes.

2. Description of central banks' interventions during the financial crisis

In this section we present the unconventional tools adopted by the Fed and the ECB during the global financial crisis, up to mid-2011.[10] We provide two types of complementary information. In the text we mostly focus on the rationale behind each specific measure, on the description of the particular market conditions that led to its adoption, and on how each of these measures was expected to restore a more normal functioning of the monetary transmission mechanism and/or to provide further stimulus to the economy. In addition, in Tables 1 and 2 we describe in detail the main characteristics of each unconventional tool adopted, respectively, by the Fed and the ECB (inception and duration of the programme, maximum and average impact on the central bank's balance sheet, eligible counterparties, collateral, etc.). We first describe the measures adopted at the beginning of the crisis (August 2007 - September 2008) and then the actions taken in the most acute phase, following the collapse of Lehman Brothers in September 2008.

Measures adopted by the Fed in the pre-Lehman phase (August 2007-September 2008)

The first phase of the crisis featured a significantly higher volatility of banks' liquidity demand, a heightened preference for long-term liquidity and severe impairments in the redistribution of funds in the interbank market. During this period the unconventional measures adopted by the Fed and the ECB aimed to prevent disorders in money markets hampering the monetary transmission mechanism, but both central banks sterilized the impact of their actions on the monetary base in order to keep overnight interest rates in line with their targets (Figure 1).

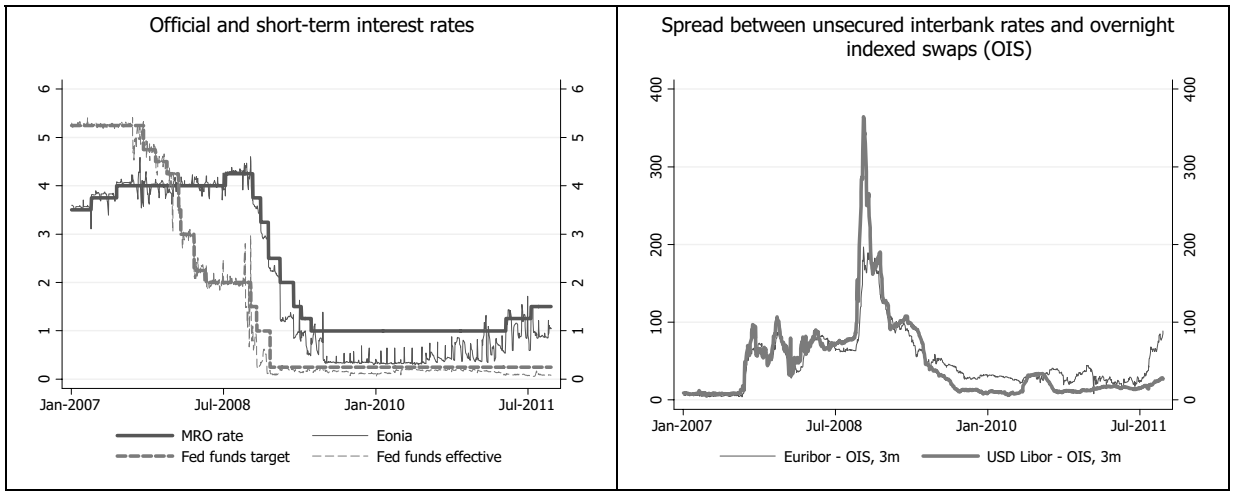
In the US, where reserves are normally channelled to the banking system through a small group of primary dealers, the Fed implemented a series of measures to extend the availability of emergency and long-term funding to both these intermediaries and depository institutions.[11]

[9] Some remarks on the challenges and risks of reversing unconventional monetary policy are discussed in Buiter (2010) and Borio and Disyatat (2010).

[10] We do not consider here other important economies. Stone, Fujita and Ishi (2011) provide an exhaustive description of the main unconventional monetary measures adopted both in advanced and in emerging countries.

[11] The Fed manages its balance sheet so as to maintain the permanent liquidity deficit of the banking system very low and satisfies it, so to keep the effective fed fund rate in line with its target, through short term repo operations implemented with a small group of primary dealers. In the US this operational framework was considered to be more efficient than one based on a direct relation between the central bank and each depository institution. In normal times primary dealers do not have access to emergency funding.

Figure 1: Official and short-term interest rates in the US and in the euro area



With the adoption of the *Term Discount Window Program* (TDWP; Table 1, column 1) the Fed progressively extended the maximum maturity of emergency loans available to depository institutions through the Discount Window and diminished the discount rate premium charged on this facility. The *Term Auction Facility* (TAF; Table 1, column 2) pursued a similar objective by providing collateralized long-term liquidity to depository institutions and supporting the redistribution of funds in the interbank market.[12] However, under the TAF the Fed auctioned term funds to banks to minimize the risk that depository institutions could be discouraged from requesting funds because of "stigma" issues. While use of the TDWP was generally limited, possibly owing to the associated perceived stigma, the TAF turned out to be an important channel of liquidity provision (Figure 2). Recourse to it reached a peak of around $500 billion after the collapse of Lehman Brothers.

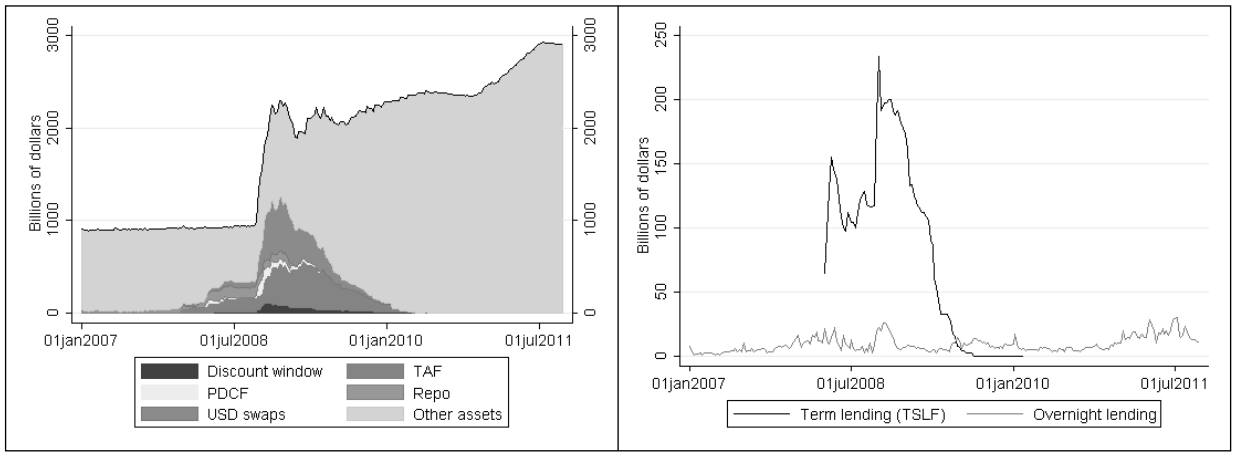
[12] The collateral that is eligible in the TAF programme is the same as in the Discount Window Facility.

Table 1: Unconventional measures adopted by the Federal Reserve (August 2007 - September 2011)

	1	2	3	4	5	6	7	8	9	10	11
	Term Discount Window Program (TDWP)	Term Auction Facility (TAF)	Reciprocal Currency Agreements (RCA)	Term Securities Lending Facility (TSLF)	Single-Tranche OMO programme	Primary Dealers Credit Facility (PDCF)	ABCP Money Market Fund Liquidity Facility (AMLF)	Commercial Paper Funding Facility (CPFF)	Term Asset-Backed Securities Loan Facility (TALF)	Purchase of Agency Debt and Agency MBS	Purchases of long-term Treasuries
Announcement date	Aug. 17, 2007	Dec. 12, 2007	Dec. 12, 2007	Mar. 11, 2008	Mar. 11, 2008	Mar. 16, 2008	Sept. 19, 2008	Oct. 7, 2008	Nov. 25, 2008	Nov. 25, 2008	Mar. 18, 2009
Start date	Aug. 17, 2007	Dec. 17, 2007	-	Mar. 27, 2008	Mar. 27, 2008	Mar. 17, 2008	Sept. 22, 2008	Oct. 27, 2008	Mar. 17, 2009	Jan. 5, 2009	Mar. 25, 2009
End date	Mar. 18, 2010 (2)	Mar. 8, 2010	-	Feb. 1, 2010	Dec. 30, 2008	Feb. 1, 2010	Feb. 1, 2010	Feb. 1, 2010	Jun. 30, 2010(4)	Mar. 31, 2010	Jun. 30, 2011(5)
Participants	Depository institutions	Depository institutions	Foreign central banks	Primary dealers	Primary dealers	Primary dealers	Depository institutions, bank holding companies (domestic and international)	Eligible CP issuers	All US persons that owns eligible collateral	-	-
What are theyborrowing?	Funds	Funds	US dollars	US Treasuries	Funds	Funds Fund	s Funds		Funds	-	-
Collateral	Full range of Discount Window Collateral	Full range of Discount Window Collateral	Central banks pledge foreign currency and lend against collateral in their jurisdictions	US Treasuries, agencies, agencies MBS and all investment grade debt securities	US Treasuries, agencies, agencies MBS, but typically agencies MBS	Full range of tri-party repo system collateral	First-tier ABCP	Newly-issued 3-month unsecured and asset-backed CP from eligible US issuers	Recently originated US dollar-denominated AAA, ABS, CMBS and legacy CMBS	-	-
Term of the loan	up to 90 days	28 or 84 days	up to 3-month	28 days	28 days	Overnight	ABCP maturity date (max 270- day)	3 months	3 or 5 years	Outright purchases	Outright purchases
Frequency	Standing facility	Every other week, or as necessary (auction)	-	Every four weeks (auction)	Every week (auction)	Standing facility	Standing facility	Standing facility	Twice a month, alternating ABS and CMBS	-	-
Average impact on Fed balance sheet (1)	$29 bn	$206 bn	$90 bn	$80 bn	approx $80 bn.	$19 bn	$21 bn	$147 bn	$36 bn	$107 bn (Agency debt), $575 bn (Agency MBS)	$471 bn (6)
Max impact on Fed balance sheet (1)	$112 bn	$493 bn	$583 bn	$234 bn	$80 bn	$148 bn	$146 bn	$350 bn	$48 bn	$169 bn (Agency debt), $1074 bn (Agency MBS)	$1182 bn (6)
Objective	Provide liquidity to depository institutions	Provide liquidity to depository institutions	Provide liquidity in US dollars to foreign banks	Provide Treasuries to primary dealers	Provide liquidity to primary dealers	Provide liquidity to primary dealers	Restore liquidity in the ABCP market	Enhance the liquidity of the commercial paper market	Support lending to small businesses and consumers	Reduce costs and increase availability of credit for housing	Reduce term premia in the long-term interest rates

Sources: Forms of Federal Reserve Lending, Federal Reserve New York; Credit and Liquidity Programs and the Balance Sheet, Board of Governors; Federal Reserve statistical release, H.4.1, Factors affecting reserve balances, Tables 1-8, Board of Governors. Notes: (1) Descriptive statistics computed on weekly averages over the life of the programme. (2) On February 18, 2010, the Federal Reserve announced that the typical maximum maturity on primary credit would be shortened to overnight, effective March 18, 2010. (3) Statistics computed on total primary credit. (4) On that date the facility was closed for new loan extensions against newly issued commercial mortgage-backed securities. (5) On September, 21th, 2011 the FOMC has announced the intention to purchase, by the end of June 2012, $400 billion of Treasury securities with maturity between 6 and 30 years and to sell an equal amount of Treasury securities with maturities of 3 years or less. (6) Purchases of US Treasury securities since March 25, 2009. Starting from August 11, 2010 it includes Treasuries purchases from the reinvestment of principal payments on Agency debt and Agency MBS. On September, 21th, 2011 the FOMC has announced the intention to reinvest principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities.

Figure 2: Unconventional measures adopted by the Fed in the pre-Lehman phase



In order to satisfy the exceptional needs for US dollar funding by foreign banks the Fed provided dollars to foreign central banks by means of temporary *Reciprocal Currency Agreements* (RCA; Table 1, column 3). These central banks, in turn, offered US dollar liquidity to their respective banking systems. Moreover, to alleviate pressures in the secured funding market the Fed also started the *Term Securities Lending Facility* (TSLF; Table 1, column 4) with which it lent US Treasuries to primary dealers against a wide range of less liquid securities.[13] Finally, with the *Single-Tranche OMO Program* (Table 1, column 5) and with the *Primary Dealers Credit Facility* (PDCF; Table 1, column 6) the Fed provided, respectively, emergency and long-term liquidity to primary dealers.[14]

Measures adopted by the ECB in the pre-Lehman phase (August 2007 - September 2008)

The ECB also implemented exceptional measures to fight back against the initial effects of the crisis. However, unlike the Fed, it was able to counteract shocks to the distribution of reserves in the banking system within its standard operational framework. This was due to two reasons first, the ECB manages its balance sheet so as to keep a large permanent liquidity deficit;[15] second, all depository institutions of the euro area have direct access to central bank's liquidity.[16]

The ECB accommodated banks' heightened preference for long-term funding straightforwardly by increasing the frequency and the liquidity allotted in its long-term refinancing operations (Figure 3).[17] Moreover, to counteract the excessive volatility of the overnight rate (Eonia) within the maintenance period, it satisfied banks' preference for early fulfilment of the reserve requirements (front-loading) by providing a relatively larger volume of funds in the first part of the maintenance period. Finally, the increased volatility in liquidity demand and the larger demand for US dollars were offset, respectively, by greater recourse to *fine-tuning operations* (Table 2, column 1) and through auctions of US dollar liquidity, available from the Fed *Reciprocal Currency Agreements* (Table 2, column 2).

The adoption of these measures was supplemented by a significant effort of communication aimed at maintaining a clear separation between monetary policy decisions and liquidity provision operations (the "separation principle"). To counteract the renewed volatility of the Eonia and the increase in money market spreads that followed the collapse of Bear Stearns in March 2008, the ECB introduced *supplementary long-term operations* (Table 2, column 3) with a maturity of six months.

[13] The Fed offers securities for loan from the SOMA portfolio also in normal times. This "standard" securities lending programme is collateralized with Treasuries and is conducted on an overnight basis.

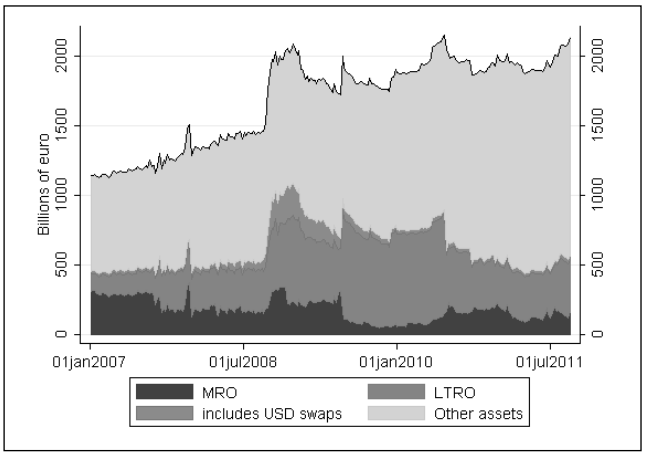
[14] The PDCF was intended to be a backstop facility. The credit extended through this facility was charged with a penalty rate and subject to a frequency-based fee after 45 days of use.

[15] The ECB satisfies this liquidity deficit through main and long-term refinancing operations. These operations are collateralized loans with maturities of one week and three months. Before the crisis the relative weight of these two operations was approximately two thirds and one third.

[16] Currently, about 2200 credit institutions have access to the Eurosystem refinancing operations.

[17] The impact of the more abundant provision of long-term funding on the total amount of reserves provided to the banking system was offset by a reduced supply of reserves in the main refinancing operations.

Figure 3: Unconventional measures adopted by the ECB in the pre-Lehman phase



Measures adopted by the Fed in the post-Lehman phase (September 2008- onward)

After the bankruptcy of Lehman Brothers in September 2008 the financial crisis became more severe and spread to the shadow banking system. In the US it quickly became clear that the provision of funds and high-quality securities to depository institutions and primary dealers would not be sufficient to avert a collapse of the financial system. The liquidity in critical non- bank markets evaporated and financial spreads reached unprecedented levels. To address these issues the Fed enhanced the non-standard measures adopted before Lehman's bankruptcy and implemented a series of new unconventional tools.

To understand the crucial role of this new set of measures it is useful to start with a stylized description of the functioning of the US financial system on the eve of the financial crisis. Under a standard banking system, banks generate loans using deposits or longer-term liabilities and hold them to maturity in their balance sheets. Given their crucial role in the economy, these institutions have direct access to central bank liquidity, enjoy government guarantees, but are also subject to a strict regulation that limits their balance-sheet exposure to credit and liquidity risks.

In the years before the outbreak of the financial crisis, the credit provision function was progressively moved into an unregulated shadow banking system where financial institutions made large profits by increasing the leverage of their business well above the limits permitted in the traditional system.[18] This alternative banking system is populated by a very heterogeneous group of financial institutions that are strictly interconnected and that conduct maturity, credit and liquidity transformation through a wide range of secured funding techniques such as asset-backed commercial papers (ABCP), asset-backed securities (ABS), collateralized debt obligations (CDO) and repos.[19]

[18] See Gorton (2010) and Pozsar et al. (2010).

[19] The shadow banking system includes special investment vehicles (SIVs), special purpose vehicles (SPVs), money market funds, hedge funds, monolines, investment banks, and many other non-bank financial institutions.

Table 2: Unconventional measures adopted by the ECB (August 2007 - September 2011)

	1	2	3	4	5	6	7	8	9	10	11
	Term Discount Window Program (TDWP)	Term Auction Facility (TAF)	Reciprocal Currency Agreements (RCA)	Term Securities Lending Facility (TSLF)	Single-Tranche OMO programme	Primary Dealers Credit Facility (PDCF)	ABCP Money Market Fund Liquidity Facility (AMLF)	Commercial Paper Funding Facility (CPFF)	Term Asset-Backed Securities Loan Facility (TALF)	Purchase of Agency Debt and Agency MBS	Purchases of long-term Treasuries
Announcement date	Aug. 17, 2007	Dec. 12, 2007	Dec. 12, 2007	Mar. 11, 2008	Mar. 11, 2008	Mar. 16, 2008	Sept. 19, 2008	Oct. 7, 2008	Nov. 25, 2008	Nov. 25, 2008	Mar. 18, 2009
Start date	Aug. 17, 2007	Dec. 17, 2007	-	Mar. 27, 2008	Mar. 27, 2008	Mar. 17, 2008	Sept. 22, 2008	Oct. 27, 2008	Mar. 17, 2009	Jan. 5, 2009	Mar. 25, 2009
End date	Mar. 18, 2010 (2)	Mar. 8, 2010	-	Feb. 1, 2010	Dec. 30, 2008	Feb. 1, 2010	Feb. 1, 2010	Feb. 1, 2010	Jun. 30, 2010(4)	Mar. 31, 2010	Jun. 30, 2011(5)
Participants	Depository institutions	Depository institutions	Foreign central banks	Primary dealers	Primary dealers	Primary dealers	Depository institutions, bank holding companies (domestic and international)	Eligible CP issuers	All US persons that owns eligible collateral	-	-
What are theyborrowing?	Funds	Funds	US dollars	US Treasuries	Funds	Funds Fund	s Funds		Funds	-	-
Collateral	Full range of Discount Window Collateral	Full range of Discount Window Collateral	Central banks pledge foreign currency and lend against collateral in their jurisdictions	US Treasuries, agencies, agencies MBS and all investment grade debt securities	US Treasuries, agencies, agencies MBS, but typically agencies MBS	Full range of tri-party repo system collateral	First-tier ABCP	Newly-issued 3-month unsecured and asset-backed CP from eligible US issuers	Recently originated US dollar-denominated AAA, ABS, CMBS and legacy CMBS	-	-
Term of the loan	up to 90 days	28 or 84 days	up to 3-month	28 days	28 days	Overnight	ABCP maturity date (max 270-day)	3 months	3 or 5 years	Outright purchases	Outright purchases
Frequency	Standing facility	Every other week, or as necessary (auction)	-	Every four weeks (auction)	Every week (auction)	Standing facility	Standing facility	Standing facility	Twice a month, alternating ABS and CMBS	-	-
Average impact on Fed balance sheet (1)	$29 bn	$206 bn	$90 bn	$80 bn	approx $80 bn.	$19 bn	$21 bn	$147 bn	$36 bn	$107 bn (Agency debt), $575 bn (Agency MBS)	$471 bn (6)
Max impact on Fed balance sheet (1)	$112 bn	$493 bn	$583 bn	$234 bn	$80 bn	$148 bn	$146 bn	$350 bn	$48 bn	$169 bn (Agency debt), $1074 bn (Agency MBS)	$1182 bn (6)
Objective	Provide liquidity to depository institutions	Provide liquidity to depository institutions	Provide liquidity in US dollars to foreign banks	Provide Treasuries to primary dealers	Provide liquidity to primary dealers	Provide liquidity to primary dealers	Restore liquidity in the ABCP market	Enhance the liquidity of the commercial paper market	Support lending to small businesses and consumers	Reduce costs and increase availability of credit for housing	Reduce term premia in the long-term interest rates

Sources: ECB Weekly Financial Statements; ECB Statistical Data Warehouse Eurosystem consolidated balance sheet.
Notes: (1) Descriptive statistics computed on weekly averages over the life of the programme. (2) Data from the balance-sheet item Claims on euro area residents denominated in foreign currency which includes US swaps.
(3) Date at which the last operations has been conducted. (4) A 6-month operation was reactivated on August, 10th, 2011. Descriptive statistics presented in the table do not take into account the impact of this operation on Eurosystem's balance sheet.

The fundamental weakness of this system, which had neither deposit guarantees nor direct access to central bank liquidity, and its exposure to the same type of bank runs that devastated the traditional banking system during the Great Depression, became apparent when in September 2008 the net asset value of some important money market funds fell below the target value of one dollar per share and these funds received massive requests for redemptions.[20] The strict interconnections among the different segments of the shadow banking system accelerated the transmission of the crisis and quickly affected the prices and the liquidity of other important instruments of this market (ABCP, ABS, CDO, etc). The existence of liquidity provision agreements between the institutions of the traditional and the shadow banking system suddenly also exposed the former to a strong liquidity shortage. In essence, the entire financial system of the US came very close to collapse.

With the unconventional measures adopted since mid-September 2008 the Fed has greatly extended the provision of temporary liquidity to the most important part of the shadow banking system. This was done (mainly) through three programmes.

With the *ABCP Money Market Fund Liquidity Facility* (AMLF; Table 1, column 7) the Fed provided short-term loans to depository institutions to finance purchases of high-quality ABCP from money market mutual funds, thus sustaining their prices by avoiding fire sales. A similar objective was pursued with the *Commercial Paper Funding Facility* (CPFF; Table 1, column 8), which provided a temporary liquidity backstop to issuers of commercial paper and was intended, in particular, to reduce investors' and borrowers' concerns about "roll-over risk" (Figure 4, left panel).

In contrast, the objective of the *Term Asset-Backed Securities Loan Facility* (TALF; Table 1, column 9) was to substitute public for private balance-sheet capacity in a period in which there were serious risks of a credit crunch owing to sharp deleveraging and high risk aversion. With this programme the Fed provided investors with long-term loans (3 to 5 years) for the purchase of newly issued triple-A rated ABS backed by consumer and small business loans. The facility was subsequently expanded to include newly issued highly rated commercial mortgage-backed securities (CMBS).

Observing the widening of the spreads on GSE debt and on GSE-guaranteed mortgages, in November 2008 the Fed announced a *programme of asset purchases of up to $100 billion in Agency debt and up to $500 billion in Agency MBS* (Table 1, column 10) to support the functioning of credit markets for housing. This decision aimed to reduce the cost and increase the availability of credit for house purchases. This, in turn, was expected to support the housing markets and improve conditions in the financial markets more generally.

In the first part of 2009, faced with a further weakening of the economy and a still gloomy outlook for the housing and mortgage markets, the Fed expanded its asset purchase programme, increasing the target of purchases of Agency debt and Agency MBS to $200 billion and $1.25 trillion respectively.

Moreover, to improve conditions in private credit markets, it also announced the intention to *purchase up to $300 billion of long-term Treasury securitie*s (the so-called QE1; Table 1, column 11) over the following six months.[21] To support the economic recovery, in August 2010, the Fed decided to keep its total holdings of securities constant by reinvesting principal payments from Agency debt and MBS in long-term Treasury securities and to roll over the holdings of Treasury securities as they matured. Faced with the slow recovery of output and employment, on November 2010 the Fed announced a further expansion of its balance sheet by purchasing a further $600 billion of long-term Treasury securities (the QE2).

These large-scale asset purchase programmes were adopted mainly at the point in which the federal funds rate had effectively reached the zero lower bound. In fact, in December 2008 the Fed lowered its official rate to a range between 0 and 0.25 per cent. Since then, the Fed has been providing

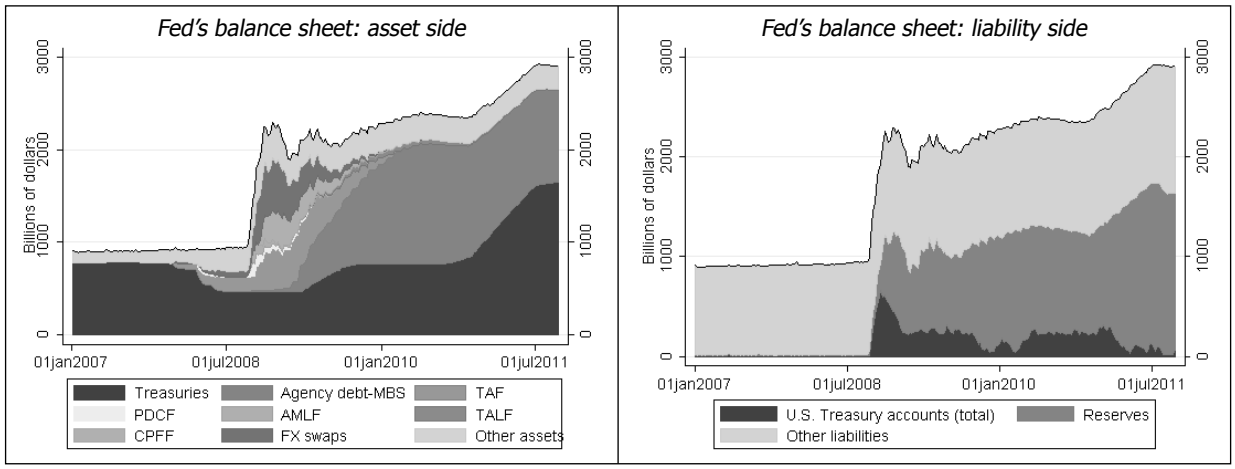
[20] A Money market fund investor typically expects to get back one dollar for every dollar invested, plus any interest or dividend earned by the fund.

[21] Sometimes QE1 is used also to refer to the purchase programme of MBS and agency debt that was expanded in March 2009 at the same time as the start of purchases of long-term Treasuries was announced. Throughout, we make a distinction between types of assets purchased according to the main objectives of the purchases.

forward guidance about the likely path of the Federal funds rate.[22] The Federal Open Market Committee meeting statement noted that "economic conditions are likely to warrant an exceptionally low level of the federal funds rate for some times". Since March 2009 the expression "for some time" has been replaced with "for an extended period" and in August 2011 it has announced that "economic conditions - including low rates of resource utilization and a subdued outlook for inflation over the medium run - are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013".

The new set of unconventional measures adopted after the collapse of Lehman and the extension of those introduced in the first phase of the crisis caused a sharp increase in the size of the Fed's balance sheet, which soared from around $1 trillion at the beginning of September 2008 to more than $2 trillion by the end of the same year. In the same period the reserve balances of depository institutions increased from around $10 billion to more than $800 billion (Figure 4, right panel). This sharp increase in reserves pushed the effective federal funds rate well below its target (Figure 1).

Figure 4: Main unconventional measures adopted by the Fed



Measures adopted by the ECB in the post-Lehman phase (September 2008 - onward)

With the deepening of the financial crisis after the collapse of Lehman Brothers, the interventions of the ECB also became bolder. Official rates were cut by 325 basis points between October 2008 and May 2009, to the historically low level of 1 per cent (Figure 1). At the same time, unconventional measures increased in size and scope, while continuing to operate mainly through the banking sector.

In October 2008, the ECB decided to conduct all its *refinancing operations with fixed rate tenders and full allotment* (FRFA; Table 2, column 5). Those procedures made the provision of liquidity to the banks unlimited (the availability of collateral being the only constraint) and led to a considerable increase in the central bank's balance sheet (Figure 3). The main objectives were to support the availability of credit to firms and households and to counteract the severe disruptions in the interbank market. To guarantee full access to the refinancing operations and to prevent fire sales of assets of lower quality, which would have accelerated the process of further deleveraging in the banks' balance sheets, the ECB also decided to enlarge the set of assets accepted as eligible collateral in its refinancing operations.

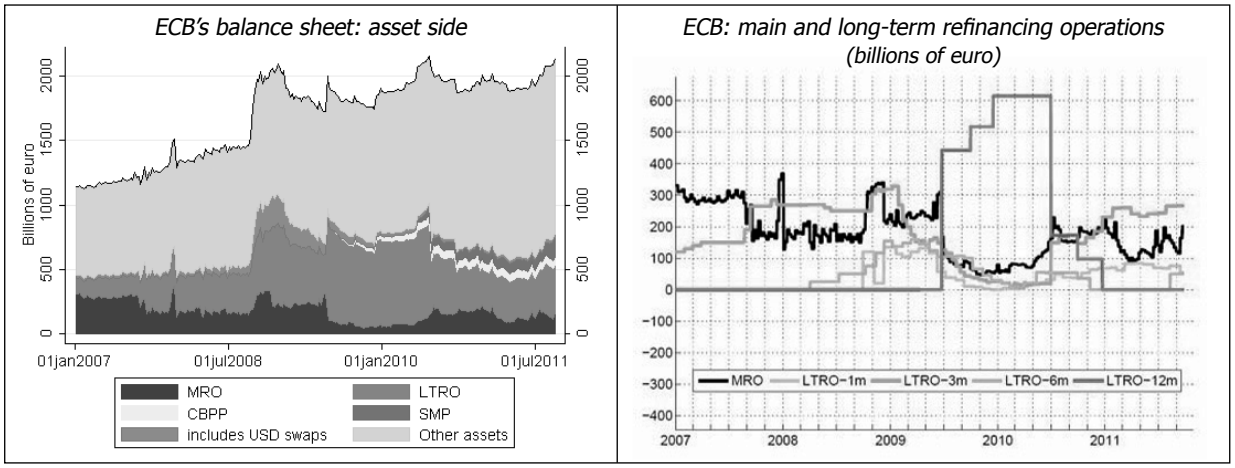
In addition, the ECB continued to provide liquidity in US dollars. In the weeks following the collapse of Lehman the contribution of these currency swaps rose to over 10 per cent of the size of the Eurosystem's consolidated balance sheet (around €250 billion; Figure 5, left panel).

[22] It is arguable whether communication of the likely future path of interest rates is a truly unconventional measure of monetary policy given that some central banks have adopted this communication strategy in normal times. Notwithstanding, we include it because it has been one of the Fed's monetary policy responses to the exceptional circumstances of the US economy and to the zero lower bound on short-term rates.

The length of the refinancing operations was further increased in May 2009, when the ECB announced three *1-year FRFA refinancing operations* (Table 2; column 6) to be held in June, September and December of the same year. The longer maturity of these operations was expected to restore the monetary transmission mechanism encouraging banks to provide credit to households and firms. In the first of these operations banks demanded an exceptional amount of liquidity (€442 billion; Figure 5, left panel). This implied a drop in the Eonia to levels close to the rate on the deposit facility (0.25 per cent; Figure 1) that was transmitted to all other money market rates.

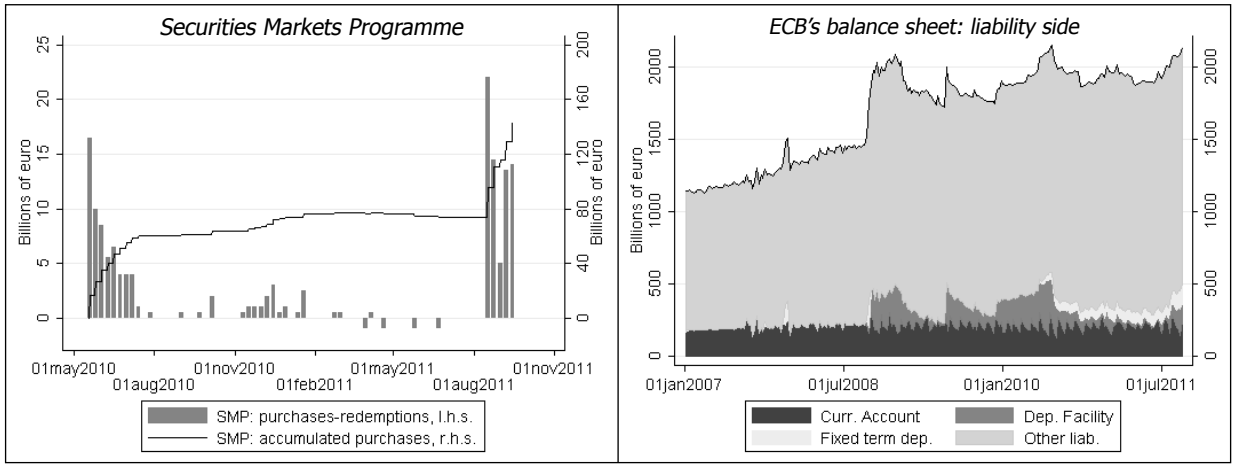
In May 2009 the ECB also decided to carry out a *Covered Bonds Purchase Programme* (CBPP; Table 2, column 7) to complement the liquidity management measures described above. The programme implied outright purchases, conducted in both the primary and the secondary market, of €60 billion of covered bonds issued by banks in the euro area, to be completed by June 2010. The aim of the CBPP was to revive this market segment, which had been particularly hard hit by the financial turbulence and had been one of the major sources of funds for banks before the crisis.

Figure 5: Main unconventional measures adopted by the ECB



The financial crisis of 2007 had a considerable and persistent effect on public deficits. In the spring of 2010 the sustainability of the public finance of some euro area countries caught the attention of investors. The functioning of several segments of the financial markets and, in particular, of some government bond markets became seriously impaired. To address this problem and contrast potential spillovers to other sovereign issuers the Governing Council of the ECB decided to implement a program of purchase of euro area private and public securities (*Securities Markets Programme*, SMP; Table 2, column 8), focused on those market segments that were particularly dysfunctional. The objective of this unconventional measure was to support an appropriate functioning of the monetary transmission mechanism. The purchases were heavy during the first phase of the programme and at the beginning of 2011. From February to July 2011 interventions have been very limited. On 7 August 2011 the Governing Council announced that it would again begin actively implementing the SMP. The decision was taken in view of the increased risk of some government debt markets becoming dysfunctional and tensions spreading to other markets in the absence of intervention (ECB (2011); Figure 6, left panel). Since then, substantial interventions were performed. This unconventional measure does not affect the monetary stance, since the ECB has been sterilizing its impact on the amount of outstanding liquidity through weekly fixed-term deposit operations (Figure 6, right panel).

Figure 6: Securities Markets Programme and fixed-term deposits



3. Unconventional monetary policy in theory

In this section we describe two channels through which the unconventional monetary policy is transmitted to the economy: the signalling and the portfolio-balance channel.

3.1 The signalling channel

The signalling channel is activated through central bank's communications informing the public about its intentions regarding the future evolution of short-term interest rates, the purchase of financial assets, or the implementation of other measures targeted at counteracting market dysfunctions. The efficacy of this channel relies on the credibility of the central bank and on the extent to which private expectations and confidence affect macroeconomic and financial market conditions.

Not all forms of communication that exploit the signalling channel should be seen as "unconventional" measures. Since the 1990s it has become increasingly clear that managing expectations is a crucial task of monetary policy; therefore, communication aimed at sharing with the public central bank views about the macroeconomic outlook and, in some cases, about the future evolution of short-term interest rates has evolved into a standard tool of monetary policy.[23] Thus, communication should be considered an unconventional tool of monetary policy only when it is used by a central bank to convey information or pursue objectives that go beyond its standard practice.[24]

In the literature the signalling channel has been highlighted as the mechanism to escape the zero lower bound on official interest rates. Krugman (1998) claims that when the zero lower bound binds, the central bank should follow an "irresponsibility principle", that is, convince the market that it will allow prices to raise so to increase inflationary expectations. Eggertsson and Woodford (2003) embed this result in the New Keynesian (NK) framework concluding that not only is the signalling channel (or, as they call it, the management of expectations) crucial, but it is the only channel that is effective. In the NK model long-term interest rates, on which firms' and households' consumption, investment and borrowing decisions are based, depend entirely on financial market participants' expectations about the future path of short-term rates.

[23] An exhaustive analysis of the role of communication in monetary policy is provided by Blinder, Ehrmann, Fratzcher, de Haan and Jansen (2008); Ferrero and Secchi (2009 and 2010) analyse the effects and the desirability of communication of the future interest rate path in "normal" times.

[24] Note that according to this definition certain types of communication can be conventional for some central banks and unconventional for others. This is certainly the case with the announcement of future policy intentions, which is an unconventional tool for most central banks but a conventional measure for central banks such as the Reserve Bank of New Zealand, the Norges Bank and the Swedish Riksbank.

As mentioned, during the financial crisis the Fed provided forward guidance about the likely path of the federal funds rate to promote economic recovery and price stability (see Section 2). However, the central banks did not explicitly commit to the irresponsibility principle advocated by Krugman (1998) and announced that the future official interest rate path would depend on the evolution of the macroeconomic outlook.[25] Clarida (2010) argues that this type of commitment, if not properly qualified, may in practice be confused by the public with a policy of discretion ("policy rates are expected to be low because and so long as output and inflation are expected to be low") which in case of perfect information is not expected to exert any influence on long-term interest rates. On the contrary, Walsh (2008) shows that, when the central bank is endowed with superior information, the provision of forward guidance about future interest rates is welfare-improving even when monetary policy is discretionary.

Time inconsistency may severely limit the effectiveness of the announcement of an interest rate path: a change in the size and composition of its balance sheet may help to overcome this obstacle. For instance, large purchases of long-term securities may strengthen the promise to keep short-term rates low for some time owing to the adverse effect that an increase in official interest rates would have on the health of the central bank's balance sheet (Bernanke, Reinhart and Sack 2004). The central bank could also enforce its commitment about future official interest rates by entering into more explicit contingent contracts with market participants. Tinsley (1998), for example, suggests that by selling short-horizon bond put options, the credibility of the central bank's policy would be enforced by binding contractual arrangements with private sector agents, who will be compensated for any future deviations from the policy terms designated in the contingent contracts.

The practical relevance of these mechanisms is questioned by Rudebusch (2011) who estimates that, notwithstanding its large bond purchases, the Fed's losses due to an increase in short-term interest rates would be almost negligible. Moreover, these losses would only be realized on the share of the portfolio of long-term securities that is not held to maturity. These estimates and the fact that the central bank is not a private institution with profitability as its main objective suggest that the effectiveness of such a device in preventing short-term rate increases by the central bank is arguable.

Communication aimed at reassuring markets on the central bank's active role during episodes of financial turbulence can also help to restore the functioning of the monetary transmission mechanism. For example, the announcement of the intention to intervene in illiquid markets provides a signal to market participants that the central bank stands ready to contrast undue volatility in asset prices and provide liquidity in case of necessity. By assuring markets about the central bank's role of lender of last resort and by providing an implicit guarantee of the intermediation role of the central bank, the announcement itself may influence market behaviour even before any action is taken.[26] The information released concerning the size, the speed and, more in general, the terms of the intervention is crucial for the effectiveness of the signalling channel. The central bank's optimal degree of transparency must trade off the credibility and effectiveness potentially gained with a very clear and transparent plan against the risks of providing inappropriate incentives to the market participants and of higher volatility due to not coming up to market expectations.

3.2 The portfolio-balance channel

The portfolio-balance channel is activated through central bank operations such as outright purchases of securities, asset swaps and liquidity injections, which modify the size and the composition of the balance sheet of both the central bank and the private sector. The central bank is the only economic player that can conduct this kind of intervention on a large scale since, in principle, it can expand its balance sheet indefinitely owing to its monopolistic power in the provision of monetary base.[27]

[25] "The [Federal Open Market] Committee's forward guidance has been framed not as an unconditional commitment to a specific federal funds rate path, but rather as an expectation that is explicitly contingent on economic conditions" Yellen (2011).

[26] Although it should be take into consideration that such an announcement may increase moral hazard and therefore contribute to risk-taking behaviour.

[27] The central bank is constrained in expanding its balance sheet only to the extent that this undermines its credibility.

The central bank's outright purchases and swap operations aim to influence prices in some specific dysfunctional segments of the financial market or to affect yields more widely. The latter is the case, for example, when the conventional monetary policy instrument is constrained at the zero lower bound and, to provide further stimulus to the economy, the central bank decides to purchase government bonds to reduce the returns on a wide range of financial assets. The efficacy of this channel hinges on the imperfect substitutability among private sector's balance sheet items, which arises in the presence of economic frictions (e.g. asymmetric information, limited commitment and limited participation), and on the impact that changes in the supply of private assets and liabilities have on individual decisions.[28]

Imperfect substitutability on the asset side of the private sector balance sheet has been proposed by the preferred-habitat theory, first introduced by Modigliani and Sutch (1966) and recently included in a more formal model for the interest rate term structure by Vayanos and Vila (2009). According to the preferred habitat view, whenever there is a group of investors with preferences for specific maturities (typically long-term, as is the case of pension funds and life- insurance companies), the net supply of securities at that maturity is a determinant of their yields. In this setup, changes in the net supply of assets of a given maturity by the central bank or government affect the yields of the assets. Moreover, when agents are heterogeneous, either because some of them are locked into their portfolio choices or because they have different degrees of risk-aversion (Ashcraft, Garleanu and Pedersen 2010) or different impatience to consume (Curdia and Woodford 2010), open market operations have distributional effects with potential influence on real activity and inflation.

The items on the liability side of the private sector balance sheet also become imperfect substitutes when the economic environment is characterized by the presence of information asymmetries or limited commitment. In this situation external funds tend to be charged with an extra return (with respect to the opportunity cost of internally generated funds) which depends, in general, on the severity of the friction and on the quality of the borrower's assets. In some cases external funds might even be rationed.[29] During a financial crisis, when the health of the balance sheet deteriorates and confidence collapses, the extra return charged on external funds might become very large and lenders might be willing to provide funds only for very short periods of time.

To avoid a collapse of credit availability the central bank can enhance its liquidity provision to depository institutions both to accommodate the increased demand for precautionary motive and to contrast the reduction in the circulation of reserves (Keister and Mc Andrews 2009; Freixas, Martin and Skeie 2009). To alleviate tensions associated with the liquidity mismatch between the asset and the liability side of private banks, it can also decide to provide liquidity for terms that are longer than normal. In this way the central bank sustains the provision of credit to the economy and reduces term spreads.

However, a too prolonged recourse to these unconventional measures might create market distortions and increase significantly the central bank's financial risk.[30] [31] Christiano and Ikeda (2011) provide one caveat associated with the use of unconventional measures, arguing that their effectiveness might depend on the specific set of financial frictions that affect economic behaviour.[32]

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[28] On the contrary central bank/government purchases are ineffective when financial assets are perfectly substitutable and changes in the composition of government's portfolio do not involve distortionary changes in taxes. Wallace (1981), Eggertson and Woodford (2003).

[29] There is a vast literature on the role of financial frictions in shaping economic dynamics. According to the credit channel theory the presence of financial frictions amplifies the effects of monetary policy on the real economy through the effects that policy decisions have on the health of the balance sheet of private agents and, in turn, on the external premium. For a review of this literature see Bernanke and Gertler (1995). More recent analyses include Cúrdia and Woodford (2011), De Fiore and Tristani (2009), Demirel (2009), Gertler and Karadi (2011), Gertler and Kiyotaki (2010) and Gerali, Neri, Sessa and Signoretti (2010).

[30] Gertler and Kiyotaki (2010) assume that unconventional monetary interventions entail some inefficiency cost. 28 This risk is mitigated by the fact that central banks supply loans only against collateral.

[31] They argue that with moral hazard and hidden effort, the unconventional measures that have been used during the recent crisis (equity injections and credit provision to financial intermediaries) might not be effective in restoring an appropriate provision of credit to firms and households.

[32] In the tables we only include papers that use an econometric approach, while the studies based on more anecdotal approach are only commented in the text. 31 See pages 5-7 and Table 1.

4. Unconventional monetary policy in practice

In this section we review the empirical literature on the effectiveness of the unconventional measures adopted by the Fed and the ECB. We classify the various studies according to whether they measure the impact of non-traditional tools (i) on financial variables or (ii) on macroeconomic variables.

The first of these two groups, which is presented in Section 4.1, is further split into four sub-categories depending on whether the measure analysed was first implemented before or after the bankruptcy of Lehman Brothers and on whether it was adopted by the Fed or by the ECB. A synthetic description of the methodology and of the main results of the various studies is reported in the tables at the end of each sub-section (Tables 3 to 5).30 In Section 4.2 we review the evidence on the effects on macroeconomic variables with a summary description provided in Table 6 for both the US and the euro area.

4.1 Effects of the unconventional measures on financial variables

Effects of the measures adopted by the Fed in the pre-Lehman phase

The empirical literature on the effectiveness of unconventional measures adopted by the Fed before the bankruptcy of Lehman has mainly focused on the Term Auction Facility, on the Term Securities Lending Facility and on the *Reciprocal Currency Agreements.31*

There is no formal analysis of the other measures, namely the *Term Discount Window Program*, the *Single-Tranche Open Market Program* and the *Primary Dealers Credit Facility*. However, the heavy recourse to this group of facilities suggests that they were perceived by depository institutions and by primary dealers as effective in alleviating the significant funding tensions to which they were exposed during the crisis.[33]

The *Term Auction Facility* (TAF) was intended to fight back against dysfunctionalities in the interbank market by providing collateralized long-term liquidity to depository institutions. Taylor and Williams (2010) assess its effectiveness by measuring the impact on the Libor-OIS spread. Their analysis is based on three hypotheses. First, the Libor-OIS spread is affected by a liquidity and a credit risk, which are independent of each other. Second, the credit risk can be approximated with measurable variables (CDS on financial institutions, Libor-Tibor spread, Libor-Repo spread). Third, the TAF may only influence the liquidity risk. Constructing on these assumptions they regress the Libor-OIS spread on different measures of credit risk and a dummy variable which is set to one on the days of announcement/implementation of the TAF. These regressions fail to find any significant impact of the TAF-dummies on the Libor-OIS spread and lead the authors to conclude against the effectiveness of this measure.

McAndrews, Sarkar and Wang (2008) and Wu (2010) suggest that the baseline specification used by Taylor and Williams (2010) to measure the impact of the TAF might be inappropriate, particularly if the effect of this facility on the Libor-OIS spread is permanent. They propose two alternative approaches. McAndrews et al. (2008) substitute the dependent variable with the first difference of the Libor-OIS spread. Wu (2010) sets the TAF-dummy equal to zero before the announcement of the programme and to one thereafter.[34] Both analyses overturn the original result and find that the TAF reduced the 3-month Libor-OIS spread by around 50 basis points. The analysis of McAndrews et al. (2008) provides two further pieces of evidence. First, both the announcements concerning the programme and its actual implementation were effective in reducing liquidity risks. Moreover, it also turns out that both domestic and international TAF operations (currency swaps) provided a significant contribution in alleviating tensions in the interbank market.

[33] Recourse to the Term Discount Window Facility and to the Primary Dealers Credit Facility reached a value close to $100 billion and $150 billion respectively after the bankruptcy of Lehman (Adrian, Burke and McAndrews 2009). Auctions associated with the Single-Tranche Open Market Program were characterized by very high bid-to- cover ratios (2.8 on average until August 2008).

[34] Wu (2010) also differs with respect to Taylor and Williams (2010) for a slightly different definition of banks' counterparty risk (first principal component of a large set of CDS on both commercial and investment banks) and for the hypothesis that bank's counterparty and liquidity risks might be correlated.

Christensen, Lopez and Rudebusch (2009) analyse the effectiveness of the TAF using a six-factor arbitrage free representation of term structures of risk-free (Treasuries) and risky the interest rates (financial bonds and Libor).[35] This approach allows the authors to disentangle the liquidity risk component implicit in Libor rates and to verify whether the TAF was effective in contrasting its increase. The counterfactual exercise that is reported in the paper suggests that the TAF lowered the liquidity risk component of 3-month Libor rates by around 70 basis points over the period December 2007 to mid-2008.

Thornton (2010) disputes this finding claiming that financial bonds and Libors are influenced by different credit risks. In particular, he argues that the narrowing of the Libor - financial bond spread observed after the implementation of this unconventional measure was not due to a reduction of liquidity premia in the interbank market but to an increase in the credit risk on financial bonds due to a more pessimistic view of the depth of the crisis.

Fleming, Hrung and Keane (2010) assess the effectiveness of the *Term Securities Lending Facility* (TSLF) focusing on the impact of the provision of Treasuries on the spread between Treasury repos and repos based on less liquid collateral. They regress repo rates and spreads on the amount of Treasuries made available through the TSLF programme taking into account the type of securities pledged as collateral and whether auctions were fully or under- subscribed. The results suggest that the TSLF was effective in contrasting tensions in the secured funding market and, in particular, in satisfying market participants' increased demand for Treasuries. According to one of the specifications presented in the paper, each extra billion of Treasuries provided through the TSLF reduced the "Agency debt-Treasury" and the "Agency MBS-Treasury" repo spreads by around 0.4 basis points on average. This implies an overall contraction of the spread of around 80 basis points.[36] The empirical analysis also shows that the effect of the TSLF on repo spreads was most noticeable in the case of fully subscribed operations, when the set of eligible collateral was broad and when the Treasury repo rate was far below the federal funds target rate.

Hrung and Seligman (2011) extend the analysis of Fleming et al. (2010) by taking into account that the availability of Treasuries was also affected by the Supplemental Financing Program (SFP), by changes in Government issuance, by the TARP, and by Fed's Open Market Operations (OMO). Their econometric analysis confirms that the impact of the TSLF on Treasury repo rates was significant (1 basis point for each billion of Treasuries made available to market participants) and that it was even larger during periods of intense market stress. Moreover, they also find that the TSLF was uniquely effective compared with other policies that influenced the availability of Treasuries and associate this evidence with the fact that TSLF operations were explicitly "directed" to dealers in the General Collateral repo market.

Baba and Packer (2009) study the impact of *Reciprocal Currency Agreements* on the foreign exchange (FX) swap market between the US dollar and the euro, the Swiss franc and the pound sterling. They found that the programme was effective in improving FX swap market dislocations, especially from mid-October 2008, when the Fed uncapped the amount of dollar liquidity provided. Goldberg et al. (2010), reporting formal research as well as more descriptive accounts from market participants, also conclude that dollar swap lines were effective in reducing dollar funding pressures.

Effects of the measures adopted by the ECB in the pre-Lehman phase

The flexibility of its operational framework has allowed the ECB to cope with the first phase of the crisis by modifying its modus operandi only marginally. As a consequence, the recourse to unconventional measures has been limited and has not attracted the interest of empirical researchers.

During this period the ECB made more frequent recourse to fine-tuning operations, accommodated banks' desire to front-load the reserve requirement, increased the relative provision of long-term liquidity,

[35] Three factors - constant, slope and curvature - are used to model the dynamics of "risk-free" Treasury rates. Two more factors are used to capture the counterparty risk implicit in financial bonds and the last factor is used to measure the liquidity risk component of the Libor. According to Christensen et al. (2009) liquidity premia affect Libor rates and financial bonds' yields in different ways because the holders of the latter class of assets have a higher tolerance than banks with regard to liquidity problems. Moreover, they also suggest that financial bond returns capture short-term credit risk more precisely than long-term bank CDS.

[36] 35 This effect was mainly due to an increase in Treasury repo rates, evidence that confirms that the TSLF was effective in addressing the shortage of government bonds and in contrasting the emergence of settlement problems in the repo market.

and offered US dollar funding to Eurosystem counterparties. These measures had two main objectives. First, to keep very-short-term money market interest rates close to the official rate; second, to counteract tensions in the euro-area money market and in US dollar funding markets. While the effectiveness of the ECB in achieving the latter target cannot be assessed without a formal analysis, the observation that in the first phase of the crisis the Eonia remained close to the official interest rate suggests that the decisions adopted by the ECB were useful in combating the volatility of the euro-area overnight rate.

Table 3: Measures adopted by the Fed in the pre-Lehman phase: effects on financial variables

Paper	Programme evaluated	Methodology	Variable of interest	Results	Notes
Taylor and Williams -2010	TAF	Event study	Libor-OIS spread	No significant impact on the Libor-OIS spread	Dependent variable in levels; TAF dummy equal to one on announcement days
McAndrews, Sarkar and Wang (2008)	TAF	Event study	First-difference of the Libor- OIS spread	50 bp reduction in the Libor- OIS spread; both announcement and implementation effective	Dependent variable in differences; TAF dummy equal to one on announcement and implementation days
Wu (2010)	TAF	Event study	Libor-OIS spread	50 bp reduction in the Libor- OIS spread	Dependent variable in levels; TAF dummy equal to one after announcement day
Christensen, Lopez and Rudebusch (2009)	TAF	Multifactor arbitrage-free model for the term structure; counterfactual analysis	Libor rate	70 bp reduction in the liquidity risk component of the 3-month Libor	-
Thornton (2010)	TAF	Event study	Ted spread	No effect on liquidity premium in the Libor market	-
Fleming, Hrung and Keane (2010)	TSLF	OLS regression	Levels of repo rates and spread between Treasury repos and repos based on other less liquid collateral	0.4 bp reduction in Agency Debt-Treasury and Agency MBS-Treasury repo spreads for each extra billion of Treasury lent	-
Hrung and Seligman-2011	TSLF	OLS regression	Spread between federal funds (both target and effective) and Treasury GC repos	1 bp reduction in Spread between federal funds (both target and effective) and Treasury GC repos for each billion of Treasury lent	Interaction terms show that the impact of TSLF was larger during period of stress
Baba and Packer-2009	RCA	Principal component analysis and EGARCH	Deviations from the covered interest parity in FX swap	30 pb reduction in EUR/ USD FX swap deviations	Sample period: Aug 2007-Jan 2009
Note: TAF = Term Auction Facility; TSFL = Term Securities Lending Facility; RCA = Reciprocal Currency Agreements.					

Effects of the measures adopted by the Fed in the post-Lehman phase

In this section we describe the empirical evidence on the effectiveness of the *ABCP Money Market Fund Liquidity Facility*, of the *Commercial Paper Funding Facility*, of the *Term ABS Loan Facility* and of the purchase of Agency debt, Agency MBS and long-term government bonds.[37]

The objective of the *ABCP Money Market Fund Liquidity Facility* (AMLF) was to support the liquidity of high-quality asset-backed commercial paper (ABCP) and to break the vicious circle between money

[37] See page 10 and Table 1.

market share redemptions and ABCP fire sales. Duygan-Bump, Parkinson, Rosengren, Suarez and Willen (2010) analyse both these aspects and conclude in favour of the effectiveness of this unconventional measure. In particular, using a diff-in-diff approach they show that, following the introduction of the AMLF, the reduction in redemptions was greater for those money market funds that owned a larger proportion of AMLF-eligible assets. Similarly, by comparing the yields on AMLF-eligible ABCP with those of otherwise equivalent AMLF-ineligible commercial paper they also conclude that the AMLF reduced the liquidity risk component of the former by around 80 basis points.[38]

The *Commercial Paper Funding Facility* (CPFF) provided a temporary liquidity back-stop to issuers of commercial paper and was intended, in particular, to limit investors' and borrowers' concerns about "roll-over risk". Anderson and Gascon (2009) and Adrian, Kimbrough and Marchioni (2010) observe that the heavy recourse to this facility and the fact that the implementation of the programme has prompted a significant increase in term commercial paper issuance and a sharp reduction in commercial paper spreads tend to support its effectiveness.[39]

A statistical assessment of the effects of the CPFF is provided by Duca (2011). He employs a VECM methodology to study the determinants of the relative use of bank loans and of debt funded by commercial paper by US firms since the early 1960s. He finds that up until the adoption of the CPFF, when corporate spreads rose, the use of commercial paper fell relative to bank loans, which could be funded with insured deposits. However, the fact that this link broke down after the implementation of the CPFF suggests that this measure may have prevented an even sharper fall in commercial paper.

With the *Term ABS Loan Facility* (TALF) the Fed provided investors with long-term loans for the purchase of newly issued high-quality ABS backed by consumer and small business loans and commercial mortgages. Agarwal et al. (2010) offer an extensive description of the ABS market and observe that the implementation of the programme was quickly followed by a recovery in ABS issuance and a reduction in the spreads between AAA-rated ABS and interest rate swaps of the order of 200-300 basis points.

Campbell et al. (2011) provide a more formal assessment of the effectiveness of the TALF with an event study approach. Their analysis is based on two assumptions. First, the announcements concerning the programme were unexpected. Second, they also postulate that, without the TALF the spreads between eligible ABS and broader financial market returns would have remained unchanged. Under these two assumptions, they study the dynamics of these ABS spreads in periods around TALF announcements, using both market and security level data. The analysis based on market level data suggests that the programme was effective. In particular, they find that the announcements led to a reduction in ABS and in CMBS spreads by, respectively, 10-60 and 50-150 basis points. The analysis based on security level data fails to find specific effects on ABS returns associated with its acceptance or rejection in the programme. The authors interpret this last evidence as suggesting that the TALF programme has affected overall market conditions for high-rate ABS without providing advantages to specific securities.

We now turn to the analysis of the effects of the *Large-Scale Asset Purchases of Agency debt and Agency MBS*. Stroebel and Taylor (2009) analyse the effect of the MBS purchases by the Treasury and the Fed with an event study methodology. In particular, they regress a measure of MBS spreads which controls for prepayment risk on different measures of credit-default risk of the underlying mortgages, on the percentage of outstanding MBS purchased at each point of the programme, and on a series of dummies that are intended to capture the effects of the announcements of the programme. Even if the results are somehow conflicting, they tend to suggest that the announcements concerning purchases in the secondary market had some effect and contributed to reduce spreads by around 30- 60 basis points. At the same time, they fail to find a relationship between the size of the purchases and the change in MBS spreads.[40]

[38] This analysis is based on the impact of the AMLF on the spread between returns on AMLF-eligible ABCP with those of the unsecured commercial paper issued by the sponsor of the same ABCP programme, which should be characterized by a similar credit risk.

[39] During the first quarter of implementation of the CPFF the spread associated with A2/P2 commercial paper, which was not eligible for the CPFF, remained substantially stable at around 500 basis points while the spreads of CPFF-eligible securities shrank from more than 200 to around 50-100 basis points.

[40] Since the Fed pre-announced both the size and the pace of the purchases, this evidence is not necessarily inconsistent with the hypothesis that the size might also matter since the markets are likely to front-load the effects.

The empirical pricing model adopted by Hancock and Passmore (2011) assumes that MBS yields are determined by long-term swap rates, a short-term spread between swaps and Treasuries, and a series of risk premia. The authors estimate this equation with pre-crisis data and use the estimated parameters to provide an out-of-sample assessment of the effects of the crisis on MBS yields. They are able to show that after the announcement of the MBS purchase programme the gap between actual yields on MBS and those predicted using parameters based on the pre-crisis sample (around 50 basis points) progressively shrank and, by the end of the first quarter of 2009, vanished completely. This evidence therefore suggests that the Fed's intervention improved the functioning of the MBS market.

Fuster and Willen (2010) apply an event study methodology on individual level mortgage data to assess the impact of the announcements concerning the purchase of Agency debt and MBS on the characteristics of newly issued mortgage loans and on the selection of the borrowers that apply for a mortgage. They find three main results. First, both the initial announcement and the subsequent changes to the programme led to significant reductions in the interest rates paid by borrowers. These reductions, however, were heterogeneous across mortgage contracts. Second, the intervention of the Fed coincided with a significant increase in borrowing activity, mainly for refinancing purposes as opposed to purchases of new houses. Third, the MBS programme generated a significant shift in borrowers' characteristics. In particular, refinancing activity became highly skewed towards borrowers with high credit scores. The authors conclude that the Agency debt and MBS purchase programme had a large effect on mortgage prices and jump-started activity in the primary market. Moreover, they also observe that the almost immediate market response to the announcement of the programme suggests that the effectiveness of this measure is not subject to "long and variable lags", as is the case with other consumer-targeted policies such as tax cuts.

We now focus on the empirical evidence on the effectiveness of *Large-Scale Asset Purchases of Treasuries* in lowering long-term interest rates. This issue was addressed in the literature even before the recent crisis, with largely inconclusive results. Early studies found that open market operations had very little impact on yields, supporting the view that the price of an asset does not depend on its relative supply. The most influential paper is that of Modigliani and Sutch (1967) on the effect of Operation Twist, the joint intervention in the government bond market by the Fed and the Treasury in 1961 aimed at reducing long-term interest rates while keeping short-term rates constant.[41] Their main finding is that the impact on term spreads is, at most, very modest. On the contrary, more recent analyses, such as Bernanke, Reihnart and Sack (2004), provide more optimistic results regarding the effectiveness of debt management operations. The Fed's purchases of Treasuries during the recent crisis spurred a series of new analyses. We classify these studies in two groups according to whether they adopt an event study approach or a more structural time series analysis. In the first group of studies, Gagnon et al. (2010) find that around the main announcements of QE1 10-year Treasury interest rates recorded a cumulative drop of about 90 basis points. The same result is documented by Yellen (2011b), who analyses a slightly different set of events. Krishnamurthy and Vissing-Jorgensen (2011) provide results for both QE1 and QE2, showing that Treasury and Agency debt yields displayed a cumulative reduction of more than 100 basis points in QE1 and around 20 points in QE2. The large difference between the responses in these two episodes suggests that there may be some factors, such as market conditions, liquidity or market expectations, which are not properly taken into account by this kind of study. Swanson (2011) provides estimates of the effects of QE2 by studying Operation Twist considering that the size of this programme as a fraction of the Treasury debt is comparable to that of QE2. His results suggest that the cumulative effect on 10-year Treasury yields would be around 15 basis points.[42]

The second group of studies uses time series methods, which require selecting stronger assumptions on the data. If causal links are properly identified, those methods allow the researcher to perform policy experiments. Overall, these studies tend to find that the Fed's purchases have a significant effect on

[41] Operation Twist was a quantitative policy in which the Fed purchased longer-term government notes while maintaining its official rate constant and the Treasury reduced the issuance of longer-term notes in favour of short- term securities.

[42] The fairness of this comparison is arguable as the ample difference between estimates of QE1 and QE2 in Krishnamurthy and Vissing-Jorgensen (2011) suggests that the size of the purchase programme is not the only variable that is relevant to their effectiveness. In particular, financial strains and low liquidity at the time of the operations as well as the zero lower bound on the short-term interest rates are other important factors that could influence the effectiveness of purchase programmes.

Treasury yields. In particular, a purchase of $400 billion of long-term securities sterilized with an equivalent issuance of short-term notes would reduce 10-year Treasury yields by between 14 and 67 basis points.[43]

The lowest value of this range is found by Hamilton and Wu (2010) using a model based on the "preferred habitat" theory as in Vayanos and Vila (2009). They show that their results hold even when the short-term rates are at the zero lower bound and the sterilization becomes irrelevant. Gagnon et al. (2010) find similar results adopting a model that explains 10-year term spread using business cycle indicators, measures of uncertainty about economic fundamentals, and the net public sector supply of Treasury bonds. Greenwood and Vayanos (2010) find a positive correlation between the maturity structure of US government debt and the associated interest rate term structure. According to their analysis a purchase of $400 billion of Treasury bonds would reduce long-term rates by around 40 basis points. The highest value of the range is found by D'Amico and King (2010) using data from a panel of yields at different maturities in the period in which QE1 was ongoing (March-October 2009).

The findings of both groups of studies must be interpreted with caution. Results from event studies are based on the hypothesis that announcements/actions are not anticipated, they are conditional on the specific market conditions on the day of the announcement, they usually rely on a small number of data points and, finally, they might be strongly affected by the choice of events that are included in the sample and by the hypothesis on the responsiveness of financial markets to news, i.e. the window over which changes are computed. Furthermore, even though high-frequency event studies allow measuring the correlation between changes in the supply of financial assets and variations in financial prices in a straightforward way, a causal interpretation is correct only insofar as policy announcements or actions are not a response to market conditions on that day. This note of caution is even more relevant when the analysis is based on time series data with a monthly or even lower frequency: since the supply of government bonds is influenced by the interest rate structure, the identification of the link of causality from the former to the latter requires strong and perhaps arguable hypotheses.

Summing up, the evidence on the effectiveness of purchases of Treasury bonds in lowering long-term interest rates suggests that central banks have some power, although considerable uncertainty still surrounds the exact quantification of the impact.

The evidence on the ability of the Fed to use *communication to control market expectations* about future short-term and, in turn, long-term interest rates is scant. According to Yellen (2011a), the statements of the December 2008 and January 2009 FOMC meetings suggesting that short-term rates would remain low "for some time" favoured a decline in market expectations about the one-year-ahead federal funds rate by about 90 basis points.

Courtois, Haltom and Hatchondo (2011) explore the possibility that the effectiveness of forward guidance could be enhanced by asset purchases which transmit information about the likelihood of policy interest rates remaining low for a long time. They find some evidence in support of this hypothesis. However, they also observe that the exact magnitude of the effect cannot be accurately evaluated as the announcement might also influence the risk premium implicit in financial assets from which market expectations are extracted.

[43] This is the experiment proposed by Hamilton and Wu (2010).

Table 4: Measures adopted by the Fed in the post-Lehman phase: effects on the financial variables

Paper	Program me evaluated	Methodology	Variable of interest	Results	Notes
Duygan-Bump, Parkinson, Rosengren, Suarez and Willen (2010)	AMLF	Difference-in- difference estimation	Spread between returns on ABCP of a given issuer and the returns of the unsecured commercial paper issued by the sponsor of the same ABCP programme	Reduction of about 80 bp in the yields on ABCP	-
Duca (2010)	CPFF	VEC model; linear regressions	Commercial paper – bank loan mix	Implementation of the CPFF coincided with a break in the relationship between the "commercial paper – bank loan mix" and the corporate - Treasury bond spread.	-
Campbell, Covitz, Nelson and Pence (2011)	TALF	Event study	Spreads of the ABS that were eligible for the TALF and spreads on broad market indices	Reduction of 10-60 bp in spreads of highly rated ABS after announcement in March 2009	-
Stroebel and Taylor -2009	Purchases of Agency debt and Agency MBS	Event study	MBS spread	Reduction of 30-60 bp in spreads on secondary markets after announcement of LSAP.	Results are conflicting across specifications and markets
Hancock and Passmore (2011)	Purchases of Agency debt and Agency MBS	Empirical pricing models (OLS regressions)	MBS yields, mortgage rates	Reduction of about 50 bp in undue risk premia in MBS yields. The gap between actual MBS yields and "counterfactual" projections based on pre-crisis data disappears by 2009-q1	-
Fuster and Willen -2010	Purchases of Agency debt and Agency MBS	Event study based on individual level mortgage application and origination	Effects on price and quantities of US primary mortgage market	Boost in market activity (mainly refinancing); significant reductions in mortgage rate for high-quality borrowers	-
Gagnon et al. (2010)	LSAP Treasuries	Event study; changes in yields in the days of announcement	2 yr- and 10-yr Treasury yields, 10-yr agency debt yield, 10-yr swap rate Baa corporate bond index yield	Change in 10-yr Treasury yields: -91 bp	Sample period: Nov 2008 - Nov 2009
Yellen (2011b)	LSAP Treasuries	Event study; changes in yields on the days of announcement	10-yr and 30-yr yields on Treasuries, TIPS, MBS and corporate bond yields	Change in 10-yr Treasury yields: -107 bp	Sample period: Nov 2008 – Mar 2009
Krishnamurthy and		Event study;	Treasury yields at various	Change in 10-yr Treasury yields:-100 (QE1); -30 (QE2)	Sample period: Nov 2008 - Mar 2009; Aug 2010 - Nov 2010
Vissing-Jorgensen -2011	LSAP Treasuries	changes in yields on the days of announcement	maturities, agency debt, MBS corporate yields & TIPS		
Swanson (2011)	LSAP Treasuries	Event study	10-yr Treasury yields	Change in 10-yr Treasury yields: -16 bp	Sample period: 1961-1962
Hamilton and Wu -2010	LSAP Treasuries	Times series study	10-yr Treasury yields	Following Fed purchase of $400bn of long-term Treasury securities and equivalent sale of short-term notes 10 yrs Treasury yields drop by 14 bp	Sample period: 1990-2007
Gagnon et al. (2010)	LSAP Treasuries	Times series study	Term premium on 10-yr Treasury yields	Impact on 10-yr Treasury yields following a 1% drop in the net supply of long-term government bonds over GDP: between -7 and -10 bp	Sample period: Jan 1985 – Jun 2008
Greenwood and Vayanos (2010)	LSAP Treasuries	Times series study	Treasury spreads: 5-yr over 1-yt and 20-yt over 1-yt	Following Fed purchase of $400bn in long-term Treasury securities and equivalent sale of short-term notes 5 over 1-yr spread (20 over 1-yr spreads) drops by 39 (74 bp)	Sample period: 1952-2006
D'Amico and King -2010	LSAP Treasuries	Panel data study	10-yr Treasury yields	Fed purchases $400bn in long- term Treasuries: -67 bp	Sample period: Mar 2009 – Oct 2009

Note: AMLF =ABCP Money Market Fund Liquidity Facility; TSFL= Term Securities Lending Facility; CPFF = Co mmercial Paper Funding Facili ty;
TALF = Term ABS Loan Facility; LSAP Treasuries = Large-scale asset purchases of Treasuries.

Effects of the measures adopted by the ECB in the post-Lehman phase

The evidence on the effectiveness of the unconventional measures adopted by the ECB is scarcer than for the US. Abbassi and Linzert (2011) analyze the evolution of Euribor rates at various maturities before and after August 2007. They show that between 2004 and mid-2007, their dynamics were determined to a large extent by future expectations about the overnight rate and they were not affected by the amount of outstanding liquidity. On the contrary after the outburst of the crisis, and in particular after the bankruptcy of Lehman, Euribor rates became sensitive to outstanding liquidity. According to their estimates the average increase in the outstanding liquidity offered by the Eurosystem (60% more than in the period 2004-2007) reduced the Euribor rates by around 100 bp. Moreover they also show that the announcement of the introduction of 12-month long-term refinancing operations had a further, although modest, downward effect on the 12-month Euribor.

Angelini, Nobili and Piccillo (2011) employ a panel data analysis based on individual bank data and exchange-level information on interbank loans. The main objective of their research is to verify if, after the outburst of the financial turmoil in August 2007, banks have become more reactive to borrowers' characteristics. They also provide an assessment of the effect of the adoption of the *Fixed-Rate Full-Allotment procedure* (FRFA) on money market rates. Their findings suggest that only the announcements related with the 1- and 3-month refinancing operations had a positive impact on market conditions, reducing the spread between interest rates on unsecured and secured loans by about 10-20 basis points. This evidence does not necessarily points toward a limited effect of the FRFA procedure since its first-order impact is likely to have been on the level of both secured and unsecured interbank interest rates.

Beirne et al. (2011) analyze the effects of the *Covered Bond Purchase Programme* (CBPP) on the issuance and on the yields of covered bonds. Using an extensive set of analytical approaches which includes event studies, cointegration analysis and linear regressions they find that the implementation of the CBPP had a positive impact on the outstanding amount of covered bonds. However the more muted impact on the overall amount of both covered and uncovered bond suggests a possible crowding out effect between these two classes of financial assets. The CBPP is also shown to have had a positive effect on secondary markets: in the second half of 2009 the spreads between the yields on covered and agency bonds in Germany and France fell by around 50 bp and even larger declines were observed in other countries of the euro area. A more formal linear regression analysis, which takes into account the effects of the sovereign crisis and of other factors, confirms this evidence, although suggesting a more limited impact on the spreads (between 10 and 20 bp).

There is yet no available econometric analysis on the effectiveness of the *Securities Markets Programme* (SMP). Anecdotal evidence and market participants' reports suggest that this programme has contributed to prevent a potential market meltdown in May 2010 and that it has been effective in addressing the severe dislocations that were spiralling out of control at that time. The identification and the exact quantification of the effects of the SMP, however, is prevented by the fact that its announcement coincided with the Ecofin decision to start a comprehensive package of measures (including the EFSF and the EFSM) aimed at assisting EU Member States under financial stress. Immediately after resuming the SMP in August 2011, the yields on government bonds of Italy and Spain dropped dramatically; afterwards, they stabilized, but on a relatively high level. It is too early to provide a robust evaluation of the effects of the purchases.

Table 5: Measures adopted by the ECB in the post-Lehman phase: effects on financial variables

Paper	Program evaluated	Methodology	Variable of interest	Results
Abbassi and Linzert (2011)	FRFA in refinancing operations	Event study; OLS regressions	Euribor rates	100 bp reduction in Euribor rates; significant (but limited) impact of the announcement of 12-month LTRO operations on 12-month Euribor
Angelini, Nobili and Piccillo (2010)	FRFA in refinancing operations	Panel data study based on interest rates on actual unsecured interbank loans (E-Mid)	Spread between unsecured and secured interbank loans	Around 10-20 bp reduction in the interbank spreads
Beirne et al. (2011)	CBPP	Event study, cointegration analysis and linear regressions	Issuance of covered bonds; spread between convered and agency bonds	Positive impact on the issuance of covered bonds; crowding out of uncovered bonds; around 10-20 bp reduction of the spread between covered and agency bonds
Note: FRFA =Fixed rate full allotment in refinancing operations; CBPP = Covered Bonds Purchase Program.				

4.2 Effects of the unconventional measures on macroeconomic variables

This section reviews the evidence on the effects on output, inflation and other relevant macroeconomic variables of the unconventional monetary policy measures put in place by the Fed and by the ECB during the recent crisis.

Ideally, in order to gauge the effectiveness of unconventional measures, one would like to answer the question "what would have happened to output and inflation had the unconventional monetary policy measures not been introduced?". Providing a convincing answer to such question is at best very difficult. For this reason the literature has generally tried to answer the related, but easier, question "what is the effect on output and inflation of a reduction in the long-term interest rates or credit spreads due to unconventional measures?".

Most of the studies that analyze the macroeconomic effects of the non-traditional measures adopt as a starting point of their analysis specific point estimates obtained from one of the papers presented in Section 4.1 or from narrative evidence. The channels through which the reduction in interest rates propagates to the real activity and prices are the usual ones: reduced borrowing costs that stimulate the investment and spending decisions; higher stock valuations that have positive wealth effects; depreciation of the nominal exchange rate, which stimulates the export sector. So, in principle, the transmission mechanism is apparently not very different from the one of a more conventional reduction in short-term rates.

The studies on the macroeconomic effects follow two approaches: VAR analysis, which imposes little structure on the data, and more structural models, such as medium-scale DSGE model or central banks' large-scale econometric models. Baumeister and Benati (2010) estimate a structural time-varying VAR and identify a "pure spread shock", which increases the long- term rates without affecting the short-term ones. They find that this type of shock has important effects on real activity and prices in several industrialized countries. Using the estimates by Gagnon et al. (2010) of the effects of LSAP program on the term premia in the US, they analyse the dynamics of output and inflation had the reduction in the term spread not happened. They claim that central bank's purchases have prevented a large deflation and a strong collapse of output. According to their median estimates, GDP would have contracted by 10% in the first quarter of 2009 and inflation would have likely remained negative in most of 2009.

Lenza, Pill and Reichlin (2010) adopt a similar approach to evaluate the impact of unconventional measures on the euro area economy. They estimate a large Bayesian VAR and assume that the reduction in the spread between unsecured and secured money market rates observed between November 2008 and August 2009 was entirely due to the non-standard measures of the ECB. By comparing the forecasts of the main macro variables conditional on the observed path of money market spreads and a no-policy scenario in which the spreads remained constant at the level of October 2008, they conclude that in the

absence of the ECB intervention credit dynamics would have been much more depressed. According to their estimates the growth rate of industrial production would have been 3 percentage points lower at mid-2010 and inflation would have been about 0.5 percentage point lower at the beginning of 2010. Some caution is required in interpreting these results, as the authors assume that after 2007 the coefficients of the reduced form representation have not changed.[44] Moreover, the no- policy scenario is constructed assuming that the entire reduction of the spread is attributable to unconventional measures, which may be questionable (at the same time the ECB cut decisively the official rates and government interventions were undertaken).

In a more recent paper, Giannoni, Lenza, Pill and Reichlin (2011), compare the actual dynamics of monetary and credit variables during the financial crisis with their forecasts (conditional on industrial production) obtained from a Bayesian VAR estimated on the pre-crisis data. The authors find that the prediction errors for some of these variables are statistically not significant and interpret this result as evidence of the success of the non-standard measures in insulating monetary and credit aggregates from the impact of the financial crisis.

Peersman (2011) uses a structural VAR to provide some stylized facts about the transmission of unconventional interventions in the euro area. The author defines an innovation to bank credit as an "unconventional monetary policy shock". The assumption is that ECB unconventional measures were able to boost bank credit volumes, through changes of the size and composition of its balance sheet. According to the evidence presented in the paper the transmission of the "unconventional" monetary shock has the same features of the transmission of standard monetary shock, namely a hump-shaped response of output and a permanent, but delayed, response of prices, although the propagation is in general more sluggish.

A second group of papers study the macroeconomic effects of unconventional measures using general equilibrium structural models. The main advantage of this approach is that a proper counterfactual can be constructed more easily without incurring in the Lucas' critique. The drawback is that these models are more difficult to estimate. Del Negro et al. (2010) build a fully-fledged DSGE model, including financial frictions à la Kiyotaki and Moore (2008). Calibrating this model to match features of the US economy, they find that the extraordinary monetary policy intervention of the Fed, that in the model is constructed as a swap of liquid for illiquid assets (the portfolio-balance channel), prevented a major collapse in output and the risk of persistent deflation. According to their model, this policy measure is especially effective when the economy reaches the zero lower bound.

Chung *et al.* (2011) measure the impact of the LSAP program using the FRB/US model, augmented to analyze portfolio-balance channel effects. The term premium in the model is assumed to be proportional to the discounted future expected Fed holdings of long-term securities as a ratio of nominal GDP. The model simulations have the advantage of considering not only the initial impact of the asset purchases but also the effects of the evolution of the program. They show that the LSAP program boosts output by almost 3% above the baseline in the second half of 2012, raises employment by about 3 million jobs and keeps inflation about 1 percentage point higher than in the no-intervention scenario. According to the model, this would have corresponded to a reduction in the federal funds rate, relative to the baseline, of about 300 basis points relative since early 2009.

Fuhrer and Olivei (2011) assume that the reduction in US long-term interest rates due to QE2 is quantifiable at around 20-30 basis points (as found in Gagnon et al., 2010 and Hamilton and Wu, 2010) and estimate its effect on real GDP and unemployment. Combining information from a VAR, the Boston Fed and the FRB/US models, they find that the implied increase in real GDP is around 60-90 basis points over two years, while the drop in the unemployment rate over the same period is slightly less than half a percentage point.

Some papers have focused on the effects of the unconventional measures on specific euro-area countries. Locarno and Secchi (2009) provide an assessment regarding the Italian economy. Their results suggest that the abundant provision of liquidity in the euro area reduced the spread between unsecured

[44] This is difficult to justify given the depth and strength of the financial crisis and the global recession observed in the following years.

and secured interbank rates by around 100 basis points and that this reduction was reflected in a similar decline in Italian short-term lending rates. The authors measure the impact of this interest rate change on output growth by means of the Bank of Italy Quarterly Model and conclude that the non-standard decisions of the ECB prevented a further decline of around 1 per cent in Italian output (cumulative over the three years 2008-2010). Given the evidence of some credit rationing during the crisis, they also observe that an assessment of the impact of the unconventional measures that neglected the effects on credit availability would significantly underestimate their importance.[45]

Table 6: Effects of the unconventional measures on macroeconomic variables

Paper	Country	Methodology	Description of the exercise	Macroeconomic effect		
				Output	Inflation	Other
Baumeister and Benati (2010)	US	Structural time- varying VAR	Identification of a "pure spread" shock (i.e. a shock that affects the long-term rate leaving the short-term rate unchanged). Simulation of the effects of the reduction in the spread estimated by Gagnon et al. (2010) on some macroeconomic variables.	GDP would have contracted by 10% in 2009q1	-	-
Lenza, Pill and Reichlin (2010)	Euro area	Large Bayesian VAR	Comparisons of conditional forecasts of some macroeconomic variables in the case in which the spreads between unsecured and secured money market interest rates had remained at the peak of October 2008.	Industrial production would have been 3 pp lower in mid-2010	Inflation would have been 0.5 pp lower at the beginning of 2010	Loans to non- financial corporations would have been 3 pp lower in mid-2009
Peersman -2011	Euro area	Structural VAR	Identification of "unconventional monetary policy shocks" as innovations to bank credit orthogonal to monetary policy. Analysis of the transmission mechanism of this shock.	Hump-shaped response of output after the shock. More sluggish propagation compared to a "conventional" monetary policy shock.	Permanent and delayed response of prices. More sluggish propagation compared to a "conventional" monetary policy shock.	-
Del Negro, Eggertsson, Ferrero and Kiyotaki (2010)	US	Calibrated DSGE model	Large-scale DSGE model with financial frictions. Assessment of the macroeconomic effects of a swap of liquid for illiquid assets by the central bank with and without the zero lower bound.	Output about 5 pp lower (in deviation from the baseline) after the shock	Inflation about 5 pp lower (in deviation from the baseline) after the shock	-
Chung et al. (2011)	US	FRB/US model	Simulation of the macroeconomic effects of central bank asset purchases in the large-scale macro-econometric model used at the Federal Reserve Board augmented with a term premium that depends on the net supply of assets.	Real GDP is boosted by almost 3% above the baseline in the second half of 2012	Inflation is 1 pp higher in 2012	Overall increase in employment by about 3 million jobs
Fuhrer and Olivei (2011)	US	VAR, Boston Fed and FRB/ US models	Study of the effects of purchases of $600 bn of long-term Treasuries	Real GDP should rise by 60-90 bp two years after the announcement.	-	Unemployment rate should decline by 30-45 bp over the two years.

Summing up, the research on the macroeconomic effects of unconventional monetary policy suggests that the interventions of the Fed and the ECB were crucial in avoiding a collapse in output and the threat of deflation. Although we share this general conclusion, in our view the magnitude of the stimulus is subject to large uncertainty, both on the upside and on the downside, for four reasons.

First, most results are based on estimates of the impact of the unconventional measures on long-term interest rates that are still very uncertain. Second, in most cases they are based on the assumption that the global crisis had no effect on the relationship between macroeconomic variables; this need not be the case, as uncertainty and loss of confidence could severely impair the normal functioning of the

[45] On the effects of credit rationing on the Italian economy during the recent crisis, see also Caivano et al. (2010) and Gaiotti (2011).

economy. Third, studies of the macroeconomic effects of unconventional measures that focus exclusively on their impact transmitted through financial prices (such as market spreads) may underestimate the overall effectiveness of the interventions in presence of credit rationing: they do not capture the possible benefits in terms of greater availability of credit and liquidity in the economy. Finally, most of models used do not feature a fully fledged financial system, which is necessary to make a sound inference about the effects of the unconventional measures.

5. Conclusions

The Fed and the ECB implemented a series of unconventional monetary measures aimed at avoiding a meltdown of the financial system and mitigating the effects of the turmoil on the real economy and on prices. The Fed modified its operational framework on many levels; the innovations implemented by the ECB were also substantial, but somehow less pervasive, due to a series of factors. First, the operational framework of the ECB was already very flexible before the crisis and therefore only modest modifications were needed. Second, in the US, capital markets play a more important role in providing credit to the economy than in the euro area. This implies that while the ECB could limit its efforts to improving and expanding the provision of funds to the banking system, the Fed had to resort to more innovative measures with broader scope. Third, in the US the impact of the crisis on the inflation outlook was more acute. This led the Fed to slash official interest rates to zero and to start a programme of asset purchases to reduce long-term yields and so provide further stimulus to the economy and avoid a deflation spiral. The difference in the size and scope of the unconventional measures adopted by the two central banks is reflected in the larger increase in the size of the Fed's balance sheet and in the more noticeable changes in its composition.

A deeper understanding of the relative role of the different unconventional measures in preventing disruptions and in restoring normal conditions in financial markets is a crucial ingredient for the selection of the instruments that should be included in the central banks' crisis toolbox. In this respect, the analysis of the theoretical underpinnings of the functioning of these measures and of the empirical evidence on the effectiveness of each of the specific unconventional measures adopted by the Fed and by the ECB can be of great help.

The literature suggests that unconventional interventions may affect economic variables through two channels of transmission: the signalling channel and the portfolio-balance channel. The first is activated through communication and allows the central bank to restore confidence in the financial markets and to influence private expectations about future policy decisions and, in turn, long-term interest rates. The second operates when assets, and liabilities, in the balance sheets of the private sector are imperfectly substitutable. In such a situation the central bank might resort to asset purchases and liquidity injections to influence the prices of a wide set of securities and to mitigate the impact of financial frictions on funding conditions.

The review of the existing empirical literature on the unconventional measures put in place by the Fed and the ECB since August 2007, and up to mid-2011, leads to the following considerations. First, as far as concerns the effects on financial market conditions, the available evidence suggests that most of the unconventional measures adopted by the Fed and the ECB have been effective: in some cases, the estimated effects are sizeable. In the US the adoption of the TSLF was helpful in counteracting the limited availability of Treasuries and coincided with a decline in the spread between Treasury repos and Agency MBS repos of around 80 basis points; a similar effect was exerted by the AMLF on the yields on asset-backed commercial paper; an even larger impact on ABS yields (around 200-300 basis points) is associated with the implementation of the TALF. As regards the effects of purchases of long-term Treasury bonds in the first round of quantitative easing, the estimates, based on time series models, suggest that long-term interest rates decreased by about 30-150 basis points. In the euro area the ECB's decision to provide liquidity to the banking system using an FRFA procedure is estimated to have reduced Euribor rates by around 100 bp, while the CBPP is estimated to have decreased the covered bond spreads by about 10-50 basis points.

Second, the degree of uncertainty that surrounds these results is very large, however. For example, the measurement of the effectiveness of the TAF in reducing the Libor-OIS spread ranges from zero to around 70 basis points depending on the econometric approach and on the specific variables adopted in the analysis. A similar range is observable in the measurement of the effects of the purchases of Treasuries on long-term interest rates (from 10 to more than 100 basis points). These differences are due to a large degree of heterogeneity in the selection of the variables used in the analysis and in the identification techniques. Further research is needed to better understand: (i) the determinants of the various risk premia that affect the returns on financial assets (e.g. counterparty, liquidity, term, etc.); (ii) how they are intertwined in normal times and during periods of financial stress; and (iii) how they can be influenced by unconventional measures of monetary policy. The availability of more sound theoretical underpinnings would help in the selection of the proxies for the risk premia and in the design of the appropriate econometric methodology. The classification of the transmission channels of unconventional measures, as illustrated in the first part of the paper, is a step in this direction, but further analysis is necessary.

Third, the available evidence on the macroeconomic effects suggests that the interventions of the Fed and the ECB were crucial in avoiding a larger collapse in output, persistent deflation and in sustaining credit growth. Still, the magnitude of the stimulus is very uncertain for four reasons. First, most macroeconomic results are inferred from very uncertain estimates of the impact of the unconventional measures on long-term interest rates. Second, they are based on the assumption that the crisis had no effect on the relationship between macroeconomic variables. Third, the existing studies may underestimate the effectiveness of the interventions because they do not fully capture the role of the unconventional measures in contrasting forms of credit rationing. Finally, the models used in the analyses generally lack a fully-fledged description of the financial system.

To sum up, the available evidence suggests that the central banks interventions were effective; they avoided a financial meltdown, in the presence of an impaired monetary transmission mechanism and, in the case of the Fed, a binding zero lower bound for interest rates. However, a definite assessment of the overall benefits and costs of unconventional measures is not yet possible. A fundamental issue, that is not addressed in this paper but is crucial to a comprehensive evaluation of the whole policy experiment, is the costs that central banks may incur to reverse their unconventional policies. It remains an issue to measure, and minimize, the distortions associated with prolonged use of non-market-based liquidity provision mechanisms; in the longer term, the withdrawal of those operations that have permanent effects on the central banks' balance sheets may pose some challenges.

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REQUIRED RESERVES AS A CREDIT POLICY TOOL[1]

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Abstract

This paper quantitatively investigates the role of reserve requirements as a credit policy tool. We build a monetary DSGE model with a banking sector in which an agency problem between households and banks leads to endogenous capital constraints for the latter. In this setup, a countercyclical required reserves ratio (RRR) rule that responds to expected credit growth is found to countervail the negative effects of the financial accelerator mechanism triggered by productivity and bank capital shocks. Furthermore, it reduces the procyclicality of the financial system compared to a fixed RRR policy regime. The credit policy is most effective when the economy is hit by a financial shock. A time-varying RRR policy reduces the intertemporal distortions created by the fluctuations in credit spreads at the expense of generating higher inflation volatility, indicating an interesting trade-off between price stability and financial stability.

JEL Classification: E44, E51, G21, G28

Keywords: Banking sector, time-varying reserve requirements, macroeconomic and financial shocks

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1. Introduction

Policymakers in both advanced and emerging countries have been exercising a variety of measures to mitigate the transmission of financial disruptions to the real sector. To that end, frictions in the financial sector and macroprudential policy instruments have been the focal point of the recent literature on macroeconomic dynamics and policy. Among many policy tools, reserve requirements have recently been used extensively as a macroprudential policy tool in several countries. Among others, China, Brazil, Malaysia, Peru, Colombia, and Turkey are some of the countries that have used this policy tool mainly to curb excessive credit growth in upturns and to ease financial constraints in downturns, along with other reasons.[5] The main objective of these countries is to employ reserve requirements either as a monetary policy tool to achieve price stability or as a macroprudential policy tool to foster financial stability, or sometimes both. In this paper, we explicitly focus on the second objective: financial stability.

As Montoro and Moreno (2011) note, central banks use reserve requirements to achieve financial stability in the following manner. They can raise reserve requirements to contain credit growth in the boom part of the business cycle in order to counteract financial imbalances in the economy. In an economic downturn, they can lower reserve requirements to utilize reserve buffers accumulated during the boom part, having the banking sector extend more credit to nonfinancial businesses. Therefore, reserve requirements can be used as a countercyclical policy instrument to ease credit fluctuations in the financial sector and, hence, to stabilize the real economy.

The goal of this study is to investigate the effectiveness of reserve requirements that respond to expected credit growth in moderating the real and financial cycles of an economy. We do so in a model in which real and financial fluctuations are amplified by a financial accelerator mechanism. Specifically, we explore the stabilizing role of reserve requirements as a credit policy tool in the transmission of productivity and financial shocks. The results suggest that a timevarying reserve requirement policy mitigates the fluctuations in key macroeconomic variables in response to macroeconomic and financial shocks and improves welfare vis-á-vis a fixed reserve requirement policy.

We build a monetary dynamic stochastic general equilibrium (DSGE) model in which the financial intermediation between depositors and nonfinancial firms is explicitly described, as in Gertler and Karadi (2011). In this model, the amplification of total factor productivity (TFP) shocks is larger due to the so-called financial accelerator mechanism built in endogenous capital constraints faced by financial intermediaries. Endogenous capital constraints emerge from an agency problem assumption, which posits that banks might divert a fraction of assets that they have expanded to nonfinancial firms. When this action is realized by depositors, a bank run is initiated, causing the bank to liquidate. Therefore, the contracting problem between depositors and banks requires an incentive compatibility condition to hold (i.e., the liquidation value of banks must be larger than or equal to the amount of diverted funds). As expected, in this environment, depositors abstain from providing as much funds as they would have provided in the absence of this agency problem.

We modify the basic financial intermediation framework to one in which "money" is modeled via a cash-in-advance constraint. Consequently, the central bank meets the summation of cash demand of workers and the "nominal" reserves demand of bankers by supplying the monetary base. The resulting money market clearing condition creates room for fluctuations in the inflation rate, induced by movements in reserve requirements, which then feed back into the cash-in-advance constraint of workers, with real effects. Therefore, the time-varying required reserves policy renders inflation much more volatile compared to a fixed reserves policy.[6] This finding suggests that in this setup, there is a trade-off between price stability and financial stability.

We abstract from nominal rigidities and use a simplistic monetary policy setup to focus solely on the "financial stability" considerations of the central bank, as highlighted by the Central Bank of the Republic of Turkey (to be discussed in greater detail in section 2) and other monetary policy authorities

[5] See Gray (2011), Lim et al. (2011), Montoro (2011), Montoro and Moreno (2011), and Glocker and Towbin (2012) for a discussion of country experiences.

[6] Endogenously determined short-term nominal interest rates will also be more volatile compared to a Taylor rule setup.

around the globe. Therefore, we do not resort to a discussion of inflation targeting (indeed, nominal interest rates are endogenous) or the Friedman rule, since monetary policy is summarized by a constant monetary base growth that is calibrated to the historical data. Nevertheless, the recent global financial turmoil has established that financial stability is warranted for the effective transmission of monetary policy, and the coordination of macroprudential and monetary policies has been at the center of policy debates (for examples, see Angelini et al. (2012) and Beau et al. (2012)). Indeed, macroprudential and macroeconomic policies might not always reinforce each other, depending on the sources of shocks to the economy (Angelini et al. (2012) and Kannan et al. (2012)).

We calibrate the model to the Turkish economy, which has been exemplifying the use of reserve requirements as a credit policy tool since the end of 2010 (see figure 1). In particular, the Central Bank of the Republic of Turkey (henceforth, CBRT) has increased the weighted average of the required reserves ratio (henceforth, RRR) from 5% to 13% between October 2010 and April 2011, in a stepwise manner. This period also coincides with the aftermath of the second phase of quantitative easing implemented by monetary authorities in a number of advanced economies. Evidently, this period is characterized by an increase in the risk appetite of global investors and excessive credit growth in economies such as Turkey. On the other hand, the same measure of the RRR was reduced to about 10% around November 2011 by the CBRT following the debt crisis of the Euro area to ease the domestic credit markets.

Our quantitative exercise involves comparing a fixed RRR economy in which the RRR is calibrated to its long-run value preceding the interventions of the CBRT and the time-varying RRR economy in which the RRR is countercyclical with respect to expected credit growth.[7] We also simulate the model under moderate and aggressive required reserves policies in order to understand the strength of the credit policy tool. Moreover, we consider required reserves policies that respond to asset price growth and output growth rather than credit growth to assess the effectiveness of alternative policies in stabilizing the real and financial cycles of the economy. We then compute optimal credit policy intensity by using an exogenous loss function, which includes the variabilities of credit, output and the required reserves ratio as its arguments. Finally, we conduct sensitivity analysis by changing key parameters of the benchmark model regarding the financial sector in order to evaluate the effectiveness of reserve requirements as a credit policy tool in different economic structures.

The paper has three main results. First, a countercyclical required reserves policy mitigates the negative effects of the financial accelerator mechanism triggered by adverse TFP and bank capital shocks on key macroeconomic and financial variables in comparison with a fixed reserves policy. As a result, we conclude that RRRs might be used as a credit policy tool in an economy that exhibits financial frictions. Second, a time-varying reserve requirement policy is always welfare superior to a fixed reserve requirement policy under both shocks. Furthermore, loss function comparisons indicate that the central bank should optimally take a more aggressive stance in varying the RRR when the economy is hit by both TFP and financial shocks than the case in which it is solely hit by the former. Finally, the effectiveness of the policy increases as financial frictions become more severe. Thus, the effect of a time-varying required reserves policy is bigger in a high-risk economy with a less effcient financial system where loan-deposit spreads are higher and the leverage of the banking sector is lower.

We acknowledge that canceling reserve requirements altogether might improve the aggregate welfare of the economy. Mostly for precautionary reasons, however, positive reserve requirements do exist in practice, although this still does not necessarily prove that they are optimal. Therefore, since it is beyond the scope of this paper, we do not bring any microfoundation to this institutional framework.[8] Indeed, from another perspective, our optimal policy results imply that the distortion created by reserve requirements might be reduced if they are implemented in a time-varying manner.

The workings of the model might be elaborated in greater detail as follows. An adverse TFP shock reduces the demand of financial intermediaries for equity and drives down its price. The collapse in asset prices feeds back into the endogenous capital constraints of intermediaries and causes banks' net

[7] We also conduct an analysis of a model economy with a zero required reserves policy. However, since the dynamics of this case strongly resemble those of the fixed RRR economy, we do not include it in the paper in order to save space.

[8] Christensen et al. (2011) and Angelini et al. (2012) follow a similar route when analyzing countercyclical capital requirements for macroprudential purposes.

worth to decline, eroding banks' funding resources. Accordingly, the shortage in loanable funds, which manifests itself as a rise in credit spreads, combined with the collapse in asset prices, causes investment to decline substantially. When the RRR is fixed, the dynamics of reserves resemble those of deposits.

When the countercyclical RRR policy is in place, the fall in bank credit led by the adverse TFP shock calls for a reduction in the RRR. This induces banks to substitute loans for reserves on the assets side of the balance sheet, because the cost of raising external finance is lower with a smaller RRR. Accordingly, the larger supply of funds extended by banks mitigates the collapse in investment and asset prices, countervailing the financial accelerator mechanism. This also limits the rise in credit spreads, which is an intertemporal distortion created by financial frictions in the consumption-savings margin of workers. The downward response of RRR reduces the demand for monetary base and shoots up inflation on impact. Therefore, the credit policy mitigates the financial accelerator at the expense of higher inflation. However, since this immediate surge is transitory and driven by the reserves policy, the model implies an undershooting of inflation in the following periods. This implies a substitution of consumption for leisure, which is a credit good in this model on the part of forward-looking households and labor supply increases, in contrast with the fixed RRR economy. Increased labor supply, combined with a stronger trajectory for capital, significantly mitigates the collapse in output.

We also consider an adverse financial shock in the form of an exogenous decline in the net worth of financial intermediaries as in Hancock et al. (1995), Brunnermeier and Pedersen (2009), Cúrdia and Woodford (2010), Iacoviello (2010), Meh and Moran (2010), Mendoza and Quadrini (2010), and Mimir (2011). This shock crudely captures loan losses, asset write-downs, or asset revaluations that we observe in the recent financial crisis.

Although the initial decline in banks' net worth led by the financial shock is exogenous, second-round effects will amplify the collapse in the internal finance of banks. This creates a shortage of bank credit and drives a drop in both investment and the price of capital. Banks then increase their demand for external financing (i.e., increase their deposit demand) to compensate for the decline in bank net worth. This causes reserves to increase and drives down inflation, pointing out a difference from the case of TFP shocks on part of the nominal dynamics. Yet, since the shock is transitory, inflation overshoots in the period following the shock, and workers' expectations regarding the hike in future inflation cause hours to decline substantially on impact. Therefore, output collapses together with investment.

Credit policy in response to financial shock calls for a reduction in the RRR and is again inflationary in the sense that the reduction in inflation on impact becomes substantially lower. Accordingly, overshooting in inflation becomes less as well, limiting the collapse in hours. In this manner, the analysis shows that the countercyclical RRR policy has a stabilizing effect in response to financial shocks in addition to TFP shocks and might be used by the central bank as a macroprudential policy tool.

Related Literature

The financial friction ingredients of our analytical framework do not lead to a concept of systemic risk but rather to a scheme of imperfect financial intermediation between borrowers and savers. Nevertheless, abstracting from systemic risk is unfortunately a caveat suffered by a set of numerous contributions in the recently growing macro-finance literature, as pointed out by Angelini et al. (2012). Furthermore, the number of studies that tend to provide a comprehensive analysis of the systemic risk gets even smaller when conventional macroeconomic policy tools are introduced alongside macroprudential policy measures.[9] On the other hand, it is arguably very difficult to identify through what channels the macroprudential policy actions taken by policymakers in real life succeed in reducing the systemic risk of an economy. Consequently, throughout the theoretical and quantitative analysis, we abstain from labeling our reserve requirements policy design as a macroprudential policy measure, but rather call it a credit policy measure, the goal of which is to maintain financial stability. Indeed, it is not misleading to think that financial stability is perceived as a prior in containing systemic risk by policymakers who implement

[9] For examples, see Benigno et al. (2010), Jeanne and Korinek (2010), Mendoza and Quadrini (2010), Benigno et al. (2011), Brunnermeier and Sannikov (2011), and Christensen et al. (2011), among others.

liquidity, capital, and credit measures (as documented by Lim et. al (2011)) for that matter.[10]

Our work is mostly related to the studies of Montoro (2011) and Glocker and Towbin (2012), who analyze the role of reserve requirements as a macroprudential policy tool. Montoro (2011) introduces countercyclical RRR policy tools in an otherwise standard New Keynesian setting, which is extended with collateral and liquidity constraints as in Kiyotaki and Moore (2008) and maturity mismatch frictions as in Benes and Lees (forthcoming). He finds that RRRs contain the procyclicality of the financial system in response to demand shocks, but not under supply shocks.

Glocker and Towbin (2012) augment required reserves as an additional policy instrument, and variations in loans as an additional target, into a New Keynesian open economy model with financial frictions that are modeled in the spirit of Bernanke et al. (1999). Their results imply that reserve requirements favor the price stability objective only if financial frictions are nontrivial, and they are more effective if there is a financial stability objective and debt is denominated in foreign currency. The main differences between our work and these papers are that we model financial frictions à-la Gertler and Karadi (2011), who introduce an agency problem between depositors and bankers, and involve the equity financing of nonfinancial firms.[11] Deviating from the study of Montoro (2011) we find RRRs to be partly stabilizing even under supply shocks. An important deviation from the work of Glocker and Towbin (2012) is that we also explore the role of RRRs in response to financial shocks.

Other than the two mostly related studies mentioned above, this paper is naturally related to the recently growing macro-finance literature that analyzes alternative macroprudential policy tools. Among these, Angeloni and Faia (2009) introduce capital requirements alongside responses to asset prices or leverage in the short-term interest rule, using a DSGE model that involves banks modeled as in Diamond and Rajan (2001). They find that monetary policy should respond to asset prices or leverage, and capital requirements should be mildly countercyclical. Christensen et al. (2011) explore the role of countercyclical bank capital regulations in an environment where systemic risk is exogenously introduced via a positive relationship between the aggregate banking sector loans-to-GDP ratio and the likelihood of banking sector default. Within this setup, they find that time-varying bank capital regulations reduce the volatilities of real variables and bank lending, as opposed to time-invariant regulation. Angelini et al. (2012) analyze the interaction of capital requirements with conventional monetary policy within the setup of Gerali et al. (2010), which extends the combination of the models studied by Iacoviello (2005) and Christiano et al. (2005) to one that includes a stylized banking sector. As in Glocker and Towbin (2012), they study cases in which macroprudential policy is augmented with monetary policy, and they consider macroprudential modifications to loss functions of the central bank by adding the volatility of loans-to-GDP ratio to it. They find that lack of cooperation among the two policymakers leads to suboptimal results and that macroprudential policy might have asymmetric welfare implications across borrowers/savers/entrepreneurs. Kannan et al. (2012) introduce exogenous loan-deposit spreads to the framework of Iacoviello (2005) and analyze the impact of macroprudential policy that has a first-order impact on these spreads alongside conventional monetary policy. They find that the effectiveness of macroprudential policies crucially depends on the sources of (whether financial or supply side) disturbances to the economy.

Our study differs from these classes of papers, first, by the microfoundations that it brings to the modeling of banks and, second, by its abstraction from monetary policy to focus on the role of reserve requirements in maintaining financial stability. Additionally, different from the studies that analyze capital requirements, credit policy in the form of countercyclical reserve requirements focuses on the composition of the assets side of the balance sheet rather than its size. A noteworthy similarity, on the other hand, is that financial stability policies are most effective when financial shocks are nontrivial. However, our results conflict with the finding that macroprudential policies might even lead to undesirable outcomes when only conventional shocks are considered (as in Angelini et al. (2012) and Kannan et al. (2012)). We find that, although its impact gets smaller, a countercyclical reserve requirement policy still reduces the volatility of real and financial variables, and the procyclicality of the financial system in response to TFP shocks in isolation.

[10] Gilchrist and Zakrajšek (2012) illustrate that monetary policy response to credit spreads, as a means to maintain financial stability, countervails the adverse impact of financial disruptions on macroeconomic variables.

[11] This study analyzes the role of public intermediation of funds in times of financial repression.

Our work also has linkages to the frameworks studied in Cúrdia and Woodford (2011) and Kashyap and Stein (2012) in which the remuneration of reserves has been studied. Yet, it is obvious that the reserves policy studied in these papers is more related to the central bank balance sheet considerations of the Federal Reserve at the onset of the subprime financial crisis and does not focus on containing excessive credit growth, in contrast with the focus of our work. From another perspective, the descriptive work of Gray (2011) on recent reserve requirement policy experiences also relates to the current paper.

The rest of the paper is organized as follows. In section 2, the Turkish experience of the implementation of macroprudential policies is briefly discussed. Section 3 describes the model economy and characterizes the equilibrium. In section 4, quantitative analysis regarding the dynamics introduced by macroeconomic and financial shocks is undertaken. Section 5 analyzes the impact of the countercyclical reserve requirements policy on model dynamics and welfare. Section 6 conducts a sensitivity analysis on key parameters of the model, and finally, section 7 concludes.

2. Turkish Experience of the Implementation of Macroprudential Policies

As listed in the cross-country study of Lim et al. (2011), Turkey is among the group of countries that exemplify the use of macroprudential policies in the midst and the aftermath of the recent financial crisis. Due to the sharp reversal in global capital flows during the downturn, the focus of these policies has been directed to the provision of foreign currency denominated liquidity. Specifically, Lim et al. (2011) document (i) relaxing the currency mismatch regulations (i.e., enabling domestic currency earning borrowers to borrow in foreign currency), (ii) easing financial institutions' ability to meet liquidity ratios, and (iii) limitations on the distribution of financial firms' profits, among the policy responses of Turkish authorities during 2008-2009. Following these actions, in order to institutionalize the awareness of the need for financial stability, the Financial Stability Committee (FSC) was constituted in 2011, under the leadership of the Banking Regulation and Supervision Agency (BRSA) with members from the Undersecretariat of Treasury, the CBRT, the Capital Markets Board of Turkey, and the Savings Deposit Insurance Fund. The FSC maintained better communication among policymakers with a different focus, yet each authority reserved the discretion to implement its own policy measures without the necessity of seeking broad consensus among the members of the committee.[12]

The current paper is more focused on the macroprudential measures taken by Turkish authorities in the aftermath of the financial crisis. The CBRT governor, Erdem Başçı, lists financial stability among the pillars of economic growth, along with price stability and productivity growth (see Başçı (2012)). Financial stability considerations for emerging economies are especially highlighted following the effort of advanced economies to cope with the financial turmoil, which has induced a substantial rise in the risk appetite of international investors and accordingly has rendered global capital flows excessively volatile. In that respect, the CBRT has implemented a policy mix to curb excessive credit growth and exchange rate volatility in response to the strong capital inflows in the last quarter of 2010. At that point, it started using required reserves as a macroprudential tool, and the first action was to stop paying interest to the required reserves. Following the omission of the reserves remuneration, the weighted average of the required reserves ratio gradually increased from 5% to 13.3% during the period 2010:Q4-2011:Q1, mainly to slow down the accelerated credit growth (CBRT (2012-14)). Moreover, the reserve requirement ratios have been changed asymmetrically with respect to the maturity and currency composition of deposits, specifically to (i) extend the deposit maturities and (ii) induce a substitution from foreign currency to Turkish lira denominated deposits in the banking system (CBRT (2012-14)). In order to facilitate the liquidity management of banks, the CBRT also introduced an option for the banks to keep a portion of their Turkish lira liability reserves in foreign currency (CBRT (2012-14), Başçı (2012)).

[12] Beau et al. (2012) provide a section in which the institutional frameworks adopted by the United States, the United Kingdom, and the European Union are discussed in terms of the implementation of macroprudential policies. Arguably, the governance of macroprudential policies in Turkey is similar to that in the European Union in that the European Systemic Risk Board is independent from the European Central Bank (as the BRSA is independent from the CBRT in Turkey), but does not possess ultimate control over all macroprudential policy measures (the CBRT being in full charge of, for example, currency/maturity composition and the level of reserve requirements).

The CBRT extended the set of its policy tools by using the interest rate corridor (the lending/ borrowing rate window in the overnight market) in addition to the standard interest rate policy (one-week repo rate). This policy was enacted to affect short-term interest rates in a flexible framework and to take timely actions in response to changes in the global risk appetite. In particular, following quantitative easing in advanced economies, the corridor has been widened downward to keep short-term market rates more volatile (CBRT (2011-IV), Başçı (2012)). In this sense, as mentioned by Lim et al. (2011), this policy served as a means of capital controls, since it slowed down inflows. It also served for macroprudential purposes, because excessive capital inflows translate to excessive domestic credit growth in an economy such as Turkey's. On the other hand, reflecting a time-varying nature, the interest rate corridor has been shifted upward following the Eurozone debt crisis (CBRT (2012-IV), Başçı (2012)), which has driven a reduction in the global risk appetite. In this case, the higher level and the lower volatility of short-term market rates have been maintained in order to mitigate the impact of capital flow reversals.[13]

Finally, the BRSA has complemented the macroprudential (credit and liquidity) measures taken by the CBRT by bringing additional regulations to the banking sector regarding leverage as well as credit. In the first and second quarters of 2011, the BRSA increased the risk weight of certain types of loans so that banks would reduce these types of credit in order to match the capital adequacy ratio set by the BRSA (minimum 8%).[14] Moreover, the loan-loss provisions were increased for banks that extend more than a certain level of high loan-to-value ratio credit. These regulatory steps have boosted the impact of the CBRT measures, and the year-on-year credit growth has slowed from about 40% in 2011:Q3 to 15% by 2012:Q3 (see Başçı (2012)).[15]

In this paper, among the macroprudential tools used by Turkish authorities, we are interested in focusing on the role of reserve requirements in maintaining financial stability in response to conventional TFP shocks, as well as financial shocks that tend to capture exogenous disturbances faced by the financial system (such as reversals in the investors' risk appetite). Accordingly, we proceed to the next section in which a monetary DSGE model of banking is constructed.

3. The Model

The model economy is inhabited by households, banks, final goods producers, capital producers, and a government. Time is discrete. Two financial frictions characterize the economy. First, market segmentation ensures that households that are the ultimate savers in the economy cannot directly lend to nonfinancial firms. This assumption makes the banking sector essential for transferring funds from savers (households) to borrowers (final goods producers). Second, the banking sector is characterized by credit frictions that are modeled à la Gertler and Karadi (2011). Households face a cash-in-advance constraint, which makes them hold real balances, leading to the existence of monetary equilibria. Finally, banks are sub ject to time-varying reserve requirements imposed by the central bank, which react countercyclically to expected credit expansion in the economy. Below is a detailed description of the economic agents that reside in this model economy.

3.1. Households

The population consists of a continuum of infinitely lived identical households. We assume that each household is composed of a worker and a banker who perfectly insure each other. Workers supply

[13] Increasing reserve requirements prior to this regime change was essential because by doing so, the CBRT rendered itself the net lender in the overnight market. This way, when it decides to carry out a traditional auction (instead of a quantity auction) in the overnight funding market, it could raise the average cost of central bank funding, way above the benchmark policy rate, which can be adjusted only once a month.

[14] The Turkish banking system has been considerably conservative in complying with the regulations enacted by the BRSA since the aftermath of the domestic financial turmoil of 2001. Indeed, the actual risk weighted capital adequacy ratio of the Turkish banking system is currently around 16%, which is much higher than the regulatory minimum.

[15] The introduction of a wide overnight interest corridor by the CBRT has illustrated that the effectiveness of reserve requirement hikes on increasing the cost of extending credit for banks is dampened, if the rate at which the central bank provides as much liquidity as the banking system demands is close to the policy rate. See BRSA (2011) for the details of the collective policy measures taken by the BRSA and the CBRT during the excessive capital inflows era and the developments thereafter.

labor to the final goods producers and deposit their savings in the banks owned by the banker member of other households.[16]

A representative household maximizes the discounted lifetime utility earned from consumption, c_t, and leisure, l_t,

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t\right), \tag{1}$$

where $0 < \beta < 1$ is the sub jective discount factor and E is the expectation operator. Households face the real flow budget constraint,

$$c_t + b_{t+1} + \frac{M_{t+1}}{P_t} = w_t(1 - l_t) + R_t b_t + \frac{M_t}{P_t} + \Pi_t + \frac{T_t}{P_t}, \tag{2}$$

where b_t is the beginning of period t balance of deposits held at commercial banks, P_t is the general price level, w_t is the real wage earned per labor hour, R_t is the gross risk-free deposits rate, Π_t is the profits remitted from the ownership of banks and capital producers, and T_t is a lump-sum transfer remitted by the government.

Households face a cash-in-advance constraint that reflects the timing assumption that asset markets open first as in Cooley and Hansen (1989):

$$c_t \leq \frac{M_t}{P_t} + \frac{T_t}{P_t} + R_t b_t - b_{t+1}. \tag{3}$$

The solution of the utility maximization problem of households leads to the optimality conditions below:

$$u_c(t) = \beta E_t\left\{R_{t+1} u_c(t+1)\right\} \tag{4}$$

$$\frac{u_l(t)}{P_t w_t} = \beta E_t\left\{\frac{u_c(t+1)}{P_{t+1}}\right\}. \tag{5}$$

Condition (4) is a standard consumption-savings optimality condition, which equates the marginal benefit of consumption to the expected discounted benefit of saving in deposits. Equation (5), on the other hand, is a nonstandard consumption-leisure optimality condition, due to the existence of the cash-in-advance friction, which transforms the trade-off between the two into an intertemporal one. Specifically, increasing leisure demand by one unit reduces savings in cash by $\frac{P}{P'} = \frac{1}{1+\pi'}$ future units because the yield of cash balances is deflated by inflation. Therefore, the utility cost of leisure is measured only in terms of future utility forgone by facing a tighter cash-in-advance constraint in the next period.

3.2. Banks

The modeling of the financial sector closely follows that in Gertler and Karadi (2011) except for the shocks to bank net worth. The key ingredients are as follows. At the beginning of period t, before banks collect deposits, an aggregate net worth shock hits the balance sheet of banks. Let ω_t represent the financial soundness of the banking sector. Innovations to ω_t, then, shall be shocks to bank net worth. Consequently, $\omega_{tn}\tilde{n}_{jt}$ becomes the effective net worth of the financial intermediary. For notational convenience, hereafter, we denote $\omega_{tn}\tilde{n}_{jt}$ by n_{jt}. Hence, n_{jt} is the net worth of bank j at the beginning of period t after the net worth shock hits. We de note the period t balance sheet of bank j as

$$q_t s_{jt} = (1 - rr_t) b_{jt+1} + n_{jt}. \tag{6}$$

The right-hand side of the balance sheet denotes the resources of bank j, namely, net worth, n_{jt}, and deposits, b_{jt+1}, needed to finance its credit extension to nonfinancial firms, $q_t s_{jt}$. The loans to firms

[16] This assumption is useful in making the agency problem that we introduce in section 3.2 more realistic.

serve as state-contingent claims s_{jt} toward the ownership of firms' physical capital demand and are traded at the market price q_t. Note that the bank can only loan $(1 - rr_t)$ fraction of deposits to the firms, where rr_t is the required reserves ratio (RRR) set by the central bank as we describe below. Next period's net worth, n_{jt+1}, will be determined by the return earned on assets and the cost of liabilities. Therefore,

$$n_{jt+1} = R_{kt+1} q_t s_{jt} - R_{t+1} b_{jt+1} + rr_t b_{jt+1} \tag{7}$$

where R_{kt+1} is the gross real return earned from purchased firm equity, and R_{t+1} is the risk-free cost of borrowing from worker $i \neq j$. Since required reserves do not pay any real return, reserve balances are multiplied by one.[17] Solving for b_{jt+1} in equation (7) and substituting it in the balance sheet of banker j (i.e., equation (6)), we obtain the net worth evolution of a financial intermediary as

$$n_{jt+1} = \left[R_{kt+1} - \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right] q_t s_{jt} + \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) n_{jt}. \tag{8}$$

Bankers have a finite life and survive to the next period with probability $0 < \theta < 1$.[18] At the end of each period, $1 - \theta$ measure of new bankers are born and are remitted $\frac{\epsilon}{1-\theta}$ fraction of the net worth owned by exiting bankers. Given this framework, the bankers' objective is to maximize the present discounted value of the terminal net worth of their financial firm, V_{jt}, by choosing the amount of claims toward the ownership of nonfinancial firms' physical capital demand, s_{jt}. That is,

$$V_{jt} = \max_{s_{jt}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} \Big\{ \left[R_{kt+1+i} - \left(\frac{R_{t+1+i} - rr_{t+i}}{1 - rr_{t+i}} \right) \right] q_{t+i} s_{jt+i} + \left(\frac{R_{t+1+i} - rr_{t+i}}{1 - rr_{t+i}} \right) n_{jt+i} \Big\} \tag{9}$$

where $\beta^{i+1} \Lambda_{t,t+1+i} = \beta^{i+1} \frac{u_c(t+1+i)}{u_c(t)}$ is the $1 + i$ periods ahead stochastic discount factor of house holds.

The key feature of the financial sector unfolds around a moral hazard problem between banks and households. In this model of banking, households believe that banks might divert λ fraction of their total assets for their own benefit. This might be thought of as investing part of $q_t s_{jt}$ in excessively risky projects that go bankrupt eventually and not paying back the corresponding liability to the depositor. In this case, the depositors shall initiate a bank run that leads to the liquidation of the bank altogether. Therefore, the bankers' optimal plan regarding the choice of sjt at any date t should satisfy an incentive compatibility constraint,

$$V_{jt} \geq \lambda q_t s_{jt} \tag{10}$$

to prevent liquidation by bank runs. This inequality suggests that the liquidation cost of bankers, V_{jt}, from diverting funds should be greater than or equal to the diverted portion of the assets, $\lambda q_t s_{jt}$. By using an envelope condition and algebraic manipulation, one can write the optimal value of banks as

$$V_{jt}^* = \nu_t q_t s_{jt}^* + \eta_t n_{jt}^* \tag{11}$$

and obtain the recursive objects,

$$\nu_t = E_t \left\{ (1-\theta)\beta \Lambda_{t,t+1} \left[R_{kt+1} - \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right] + \theta \beta \Lambda_{t,t+1} \chi_t \nu_{t+1} \right\} \tag{12}$$

and

[17] The zero real return earned from required reserves actually implies that the central bank is remunerating reserves with a nominal rate equal to the rate of inflation. This is indeed consistent with the experience of commercial banks in Turkey, since their local currency denominated reserves have been remunerated with a nominal return in line with the rate of inflation in the period 2002:1-2010:3. For the remuneration rates, see www.tcmb.gov.tr/yeni/bgm/dim/TLzorunlukarsilikfaizorani.html.

[18] This assumption ensures that bankers never accumulate enough net worth to finance all their equity purchases of nonfinancial firms via internal funds so that they always have to borrow from households in the form of deposits.

$$\eta_t = E_t \left\{ (1-\theta)\beta\Lambda_{t,t+1} \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) + \theta\beta\Lambda_{t,t+1}\varrho_t\eta_{t+1} \right\} \tag{13}$$

where $\chi_t = \frac{q_{t+1}s_{jt+1}}{q_t s_{jt}}$, and $\varrho_t = \frac{n_{jt+1}}{n_{jt}}$ represent growth rates of bank loans and net worth, respectively.[19] Accordingly, equations (12), and (13) represent the marginal values of making new loans and accumulating net worth for the banks, in order. As the spread between R_k and R gets larger, the marginal value of making loans to nonfinancial firms increases. On the other hand, since the risk-free deposit rate is the opportunity cost of raising funds by borrowing from households, as R gets larger, the marginal benefit of accumulating net worth increases. The ratio of required reserves, rr, decreases the marginal benefit of making loans, since it reduces the returns to making new loans, $\left[R_{kt+1} - \left(\frac{R_{t+1}-rr_t}{1-rr_t}\right)\right]$, and increases the marginal value of accumulating net worth, since it increases the return to accumulating net worth, $\left(\frac{R_{t+1}-rr_t}{1-rr_t}\right)$, *ceteris paribus.*

One can obtain the following by combining equations (10) and (11):

$$v_t q_t s_{jt} + \eta_t n_{jt} \geq \lambda q_t s_{jt} \tag{14}$$

Our methodological approach is to linearly approximate the stochastic equilibrium around the deterministic steady state. Therefore, we are interested in cases in which equation (14), an equilibrium condition of the model, is always binding. Given that $\eta_t n_{jt}$ is strictly greater than zero, $v_t \geq \lambda$ would imply a strict inequality in (14). Therefore, $v_t < \lambda$ should hold for (14) to be an equality. This would be the case in which banks have made enough loans until the marginal value of increasing loans falls short of the fraction of these assets that they are willing to divert. Consequently, $v_t \geq \lambda$ corresponds to a case in which the amount of loans made is small enough that the marginal benefit of making new loans is greater than the fraction of diverted assets.

The existence of a well-behaved equilibrium also necessitates that v_t be greater than zero for the banks to extend loans to nonfinancial firms at any date t. Therefore, we make sure that under reasonable values of parameters, $0 < v_t < \lambda$ always holds in our model. This modifies equation (14) into an endogenous capital constraint for banks as follows:

$$q_t s_{jt} = \frac{\eta_t}{\lambda - \nu_t} n_{jt} = \kappa_t n_{jt} \tag{15}$$

This is the case in which the loss of bankers in the event of liquidation is just equal to the amount of loans that they can divert. This endogenous constraint, which emerges from the costly enforcement problem described above, ensures that banks' leverage shall always be equal to $\frac{\eta_t}{\lambda - \nu_t}$ and is decreasing with the fraction of funds (λ) that depositors believe that banks will divert.

We confine our interest to equilibria in which all households behave symmetrically so that we can aggregate equation (15) over j and obtain the following aggregate relationship:

$$q_t s_t = \kappa_t n_t \tag{16}$$

where $q_t s_t$ and n_t represent aggregate levels of banks' assets and net worth, respectively. Equation (16) shows that aggregate credit in this economy can only be up to an endogenous multiple of aggregate bank capital. Also, fluctuations in asset prices (q_t) will feed back into fluctuations in bank capital via this relationship. This will be the source of the financial accelerator mechanism in our model.

The evolution of aggregate net worth depends on that of the surviving bankers (n_{et+1}) and the start-up funds of the new entrants (n_{nt+1}):

$$n_{t+1} = n_{et+1} + n_{nt+1} \tag{17}$$

The start-up funds for new entrants are equal to $\frac{\epsilon}{1-\theta}$ fraction of exiting banks' net worth, $(1-\theta)n_t$. Therefore,

[19] Derivations of equations (11), (12), and (13) are available in the technical appendix.

$$n_{nt+1} = \epsilon n_t \tag{18}$$

Bankers' net worth evolution, (8), the capital constraint, (16), and the fact that θ fraction of bankers survive to the next period yield a net worth evolution condition for surviving bankers as follows:

$$n_{et+1} = \theta \left\{ \left[R_{kt+1} - \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right] \kappa_t + \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right\} n_t \tag{19}$$

Finally, equations (18) and (19) can be summed up to obtain the evolution of net worth for the entire banking system:

$$n_{t+1} = \left\{ \theta \left(\left[R_{kt+1} - \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right] \kappa_t + \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right) + \epsilon \right\} n_t \tag{20}$$

Dividing both sides of equation (20) by n_t implies that the growth of aggregate net worth depends positively on loan-deposit spreads, endogenous bank leverage, risk-free deposits rate, survival probability, and the fraction of start-up funds. On the other hand, the impact of RRR on net worth accumulation depends on the two opposing effects discussed above: a higher rr_t *decreases* returns to making loans to nonfinancial firms and *increases* returns to accumulating net worth, *ceteris paribus*. However, since bank leverage is greater than one (i.e., $\kappa > 1$), any change in the former is amplified as equation (20) suggests. Consequently, an increase in rrt decreases the aggregate net worth growth of the banking system.

3.3. Firms

Firms produce the consumption good by using physical capital and labor as production factors. They operate with a constant returns to scale technology $F(k, h)$ that is subject to total factor productivity shocks, z_t,

$$y_t = exp(z_t)F(k_t, h_t) \tag{21}$$

where

$$z_{t+1} = \rho_z z_t + \epsilon_{zt+1} \tag{22}$$

with zero mean and constant variance innovations, ϵ_{zt+1}.

Firms finance capital at date t by issuing claims s_t to financial intermediaries at the price of capital and acquire capital k_{t+1} from capital producers. Therefore,

$$q_t s_t = q_t k_{t+1} \tag{23}$$

where qt is the market price of the firms' equity and capital.

The banks' claim against the ownership of the firm pays out its dividend via the marginal product of capital in the next period. Hence, the cost of credit to the firm is state contingent. Indeed, the cost of credit to the firm must satisfy

$$R_{kt} = \frac{z_t F_k(k_t, h_t) + q_t(1 - \delta)}{q_{t-1}}. \tag{24}$$

Finally, the optimal labor demand of the firm must satisfy the usual static condition,

$$w_t = exp(z_t)F_h(k_t, h_t), \tag{25}$$

which equates the marginal product of labor to its marginal cost.

3.4. Capital Producers

Capital producers are introduced in order to obtain variation in the price of capital, which is necessary for the financial accelerator mechanism to operate. To that end, capital producers provide physical capital to the firms, repair the depreciated capital, and incur the cost of investment. Consequently, the optimization problem of capital producers is,

$$\max_{i_t} q_t k_{t+1} - q_t(1-\delta)k_t - i_t \tag{26}$$

subject to the capital accumulation technology,

$$k_{t+1} = (1-\delta)k_t + \Phi\Big(\frac{i_t}{k_t}\Big)k_t \tag{27}$$

where the function Φ(•) represents the capital adjustment cost. The optimality condition that emerges from the solution to this problem is the well-known q relation that pins down the price of capital,

$$q_t = \Big[\Phi'\Big(\frac{i_t}{k_t}\Big)\Big]^{-1}. \tag{28}$$

3.5. Government

The government is responsible for (i) meeting workers' and bankers' cash-in-advance and required reserves demands, respectively, and (ii) setting the credit policy rule. For the former, it controls the supply of monetary base M_{0t+1}, and for the latter, it determines the required reserves ratio rr_t.

The monetary base grows at the constant rate μ, that is,

$$M_{0t+1} = exp(\mu)M_{0t} \tag{29}$$

The growth of the monetary base is remitted to households in the form of lump-sum transfers, T_t.[20] Therefore, $T_t = \Big(exp(\mu) - 1\Big)M_{0t}$.[21]

In order to contain the financial accelerator mechanism, the government uses required reserves as a credit policy rule. Specifically, the required reserves ratio is assumed to follow a trajectory that reacts to the expected growth rate of bank credit at date t + 1, compared to its level in the current period, that is,

$$rr_t = \bar{rr} + \phi E_t\Big[\log(q_{t+1}s_{t+1}) - \log(q_t s_t)\Big] \tag{30}$$

where $\bar{rr}$ is the steady-state value of the required reserves ratio and ϕ > 0. Consequently, as discussed in section 3.2, the central bank increases the effective profit from extending new loans (i.e., reduces rr_t when credit in the aggregate economy is expected to shrink and vice versa). Stabilizing the stock of credit is expected to smooth fluctuations in credit spreads that emerge due to the existence of financial frictions. Since credit spreads are a measure of intertemporal distortions in this model, the overall economy's welfare level is expected to be higher when this credit policy rule is in place as opposed to fixing $rr_t = \bar{rr}$.

Money market clearing necessitates that

$$M_{0t+1} = M_{t+1} + P_t rr_t b_{t+1} \tag{31}$$

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[20] We model monetary policy in a simplistic manner in order to isolate the impact of required reserves policy described below. We also abstain from modeling disturbances to money growth because they produce implausible inflation dynamics in a cash-in-advance model of a flexible price environment.

[21] Perfect insurance within family members of households ensures that the increase in real balances and reserves demand is lumped into T_t, which does not alter the optimality conditions of the utility maximization problem.

where P_t is the general price level of the consumption good. Since the left-hand side of equation (31) is exogenously determined by the central bank, equilibrium in the money market might call for adjustments in the price level in response to fluctuations in reserves. The dynamics of inflation driven by these fluctuations shall then feed back into the intertemporal consumption leisure margin and have real effects via the cash-in-advance constraint shown by equation (3).

3.6. Competitive Equilibrium

Notice that the nominal monetary base and prices grow constantly in this model, which renders the equations listed above nonstationary. Therefore, following Cooley and Hansen (1989), we make the model stationary by applying the following normalizations: $\widehat{P_t} = P_t/M_{0t+1}$ and $\hat{m}_t = M_{t+1}/(\widehat{P_t}M_{0t+1})$, and then solve the model locally around a deterministic steady state.

A competitive equilibrium of this model economy is defined by sequences of allocations $\{c_t, k_{t+1}, i_t, l_t, h_t, s_t, n_t, n_{et}, n_{nt}, b_{t+1}, \Lambda_{t,t+1}, \nu_t, \eta_t, \kappa_t, \rho_{t,t+1}, \chi_{t,t+1}, \hat{m}_{t+1}, \pi_t\}_{t=0}^{\infty}$, prices $\{q_t, R_{kt+1}, R_{t+1}, w_t, \widehat{P_t}\}_{t=0}^{\infty}$, the shock process $\{z_t\}_{t=0}^{\infty}$, and the government policy $\{rr_t\}_{t=0}^{\infty}$ that satisfy the optimality conditions of utility maximization of workers, net worth maximization of bankers, profit maximization of firms and capital producers, and the market clearing for the consumption good and money. A complete set of these conditions may be found in Appendix B.

4. Quantitative Analysis

The benchmark model is calibrated to Turkish economy, which is representative of using reserve requirements as a credit policy instrument since the last quarter of 2010. This reduces to fixing the long-run value of RRR to its value preceding the credit policy intervention of the CBRT and calibrating the response parameter in the credit policy rule, equation (30), in order to match the volatility of RRR following the intervention. In order to investigate the dynamics of the model, we apply perturbation methods in approximating equilibrium conditions linearly by using the software DYNARE.[22]

With the parameterized economy, we first investigate the impact of the RRR on the long-run values of key real and financial variables to see how it affects banks' incentives and financing decisions. Second, we illustrate the role of the financial accelerator driven by credit frictions in the banking sector. Third, we study the dynamics of the model led by productivity and bank capital shocks. In the next section, we focus on the impact of credit policy, designed as a countercyclical RRR rule on model variable volatilities and the procyclicality of the financial system. To that end, we investigate changes in the policy aggressiveness and targets. After exploring optimal policy intensities for alternative specifications, we conduct sensitivity analysis by changing the key parameters of the benchmark model regarding the financial sector in order to evaluate the effectiveness of reserve requirements as a credit policy tool.

4.1. Calibration of the Benchmark Model

The parameter values used in the quantitative analysis are reported in Table 1. Some of the preference and production parameters are standard in the business cycle literature. The share of capital in the production function is set to 0.4. The capital adjustment cost parameter is taken to be 6.76 to match the annual elasticity of price of capital with respect to an investment-capital ratio of 1, as in Bernanke et al. (1999). We use a standard value of 2 for relative risk aversion, γ, as in Angeloni and Faia (2009). The relatively nonstandard value of 3 for inverse of the Frisch elasticity of labor, υ, is used as in Glocker and Towbin (2012) to compare our findings with this mostly related study. We take the quarterly discount factor, β, as 0.9885 to match the 2006-2011 average annualized real deposit rate, 4.73%, in Turkey. We pick the relative utility weight of labor, ψ, to fix hours worked in steady state, $\overline{h}$, at one-third of the available time. The quarterly depreciation rate of capital is set to 3.7% to match the 1987-2011 average annual investment to capital ratio of 14.8% in Turkey (Source: CBRT).

[22] Loss function analysis in section 5.4 uses second-order approximation of equilibrium conditions.

Parameters related to the financial sector are calibrated to match the financial statistics of the Turkish economy in the period 2006-2011. We set ϵ to 0.0005 so that the proportional transfer to newly entering bankers is 1.3% of the aggregate net worth. We pick the fraction of diverted funds, λ, and the survival probability, θ, simultaneously to match the following two targets: an average interest rate spread of 48 basis points, which is the historical average of the difference between the quarterly commercial and industrial loan rates, and the quarterly deposit rate from 2006:Q1 to 2011:Q4, and an average capital adequacy ratio of 16%, which is the historical average of Turkish commercial banks' capital adequacy ratio for the same period.[23] The resulting values for λ and θ are 0.514 and 0.9625, respectively. The benchmark model involves a credit policy rule illustrated in equation (30), which does not alter the steady state of the model but affects the dynamics around it. The level of weighted RRR preceding the macroprudential intervention by the CBRT is 5% (see figure 1). Therefore, we calibrate the long-run value of RRR to 0.05 in the baseline model. The value of the response parameter of the credit policy rule, ϕ, is calibrated to 3.28 in order to match the standard deviation of RRR of 2.33% for the Turkish economy in the period 2010:Q4-2012:Q2.[24] The time series average of the growth rate of monetary base for the period 2006:Q1-2011:Q4 is 4.46% (Source: CBRT). Therefore, we set μ = 0.0446.

Regarding the shock processes, we follow the standard Solow residuals approach to construct the productivity shocks. Using the production function, we obtain

$$z_t = \frac{y_t}{K_t^{\alpha} H_t^{1-\alpha}}. \tag{32}$$

Using the empirical series for output, y_t, capital, K_t, and labor, H_t, we use equation (32) to obtain the z_t series. Then we construct the log-deviation of the TFP series by linearly detrending the log of the z_t series over the period 1988:Q2-2011:Q2. Similar to the construction of productivity shocks, the ω_t series are constructed from the law of motion for bank net worth, which is given by

$$\omega_t = \frac{1}{\theta[(R_{kt+1} - R_{t+1})\frac{\eta_t}{\lambda - \nu_t} + R_{t+1}] + \epsilon} \frac{\widetilde{n}_{t+1}}{\widetilde{n}_t} \tag{33}$$

Using the empirical series for net worth, n_t, credit spreads, $R_{kt+1} - R_{t+1}$, leverage, $\frac{\eta_t}{\lambda - \nu_t}$, and gross deposit rate, R_{t+1}, we use equation (33) to obtain the ω_t series.[25] Then we construct the log-deviation of the ω_t series by linearly detrending the log of these series over the period 2006:Q1-2012:Q2. The innovations to ω_t are net worth shocks.

After constructing the z_t and ω_t series, we estimate two independent AR(1) processes for both series:

$$log(z_{t+1}) = \rho_z log(z_t) + \epsilon_{t+1}^z \tag{34}$$

$$log(\omega_{t+1}) = \rho_\omega log(\omega_t) + \epsilon_{t+1}^\omega, \tag{35}$$

where $\epsilon_{z,t+1}$ and $\epsilon_{\omega,t+1}$ are i.i.d. with standard deviations σ_z and σ_ω, respectively. We found ρ_ω to be statistically insignificant at a 5% significance level. Therefore, the resulting parameters are ρ_z = 0.9821, σ_z = 0.0183, ρ_ω = 0, and σ_ω = 0.0531. Consequently, net worth shocks might be thought as financial disturbances due to transitory conditions such as sharp reversals in the risk appetite of investors, unexpected loan losses, or balance sheet shocks that bankers face.[26] Notice that although the shock process is white noise, its effects on bank capital would be persistent due to the propagation via capital constraints that feed back into the law of motion for bank net worth.

[23] The legal target of the risk-weighted capital adequacy ratio set by the BRSA in Turkey is 8%, however, in practice, commercial banks in Turkey maintain 16% for this ratio.

[24] This is the period in which the CBRT changed the RRR for macroprudential purposes

[25] We do not input the series of reserve requirement ratios into this empirical equation because the observed credit spreads and deposit rates would endogenously reflect the impact of reserves.

[26] On bank capital shocks, see Hancock et al. (1995), Brunnermeier and Pedersen (2009), Cúrdia and Woodford (2010), Iacoviello (2010), Meh and Moran (2010), Mendoza and Quadrini (2010), and Mimir (2011).

4.2. Functional Forms

Preferences: We use a standard utility function that is constant relative risk aversion (CRRA) in consumption and separable in leisure:

$$u(c_t, l_t) = \frac{c_t^{1-\gamma}}{1-\gamma} - \psi \frac{(1-l_t)^{1+\nu}}{1+\nu}, \tag{36}$$

where $\gamma > 1$, ψ, $\nu > 0$.

Production: Firms produce according to a constant returns to scale Cobb-Douglas production function:

$$exp(z_t)F(k_t, h_t) = exp(z_t)k_t^{\alpha} h_t^{1-\alpha}, \tag{37}$$

where $0 < \alpha < 1$.

Capital Producers: Capital producers are sub ject to a convex adjustment cost function:

$$\Phi\Big(\frac{i_t}{k_t}\Big) = \frac{i_t}{k_t} - \frac{\varphi}{2}\Big[\frac{i_t}{k_t} - \delta\Big]^2. \tag{38}$$

4.3. Impact of Reserve Requirements on Banks' Incentives

Figure 2 plots the key real and financial variables' steady-state values as a function of different long-run values of RRR and shows how it affects bankers' financing decisions. First, as illustrated in section 3.2, RRR reduces the growth of aggregate net worth. Furthermore, an increase in rr_t would potentially induce banks to demand more deposits in order to make up for the required reserves, which do not pay any real return. These two effects will induce bankers to substitute external financing, b_{t+1}, for internal financing, n_t, when RRR is higher, resulting in a higher leverage ratio as evidenced by the bottom left panel of figure 2. A higher leverage ratio (i.e., $\frac{b_{t+1}}{n_t}$) for the banking system would then increase its exposure to external financing and cause financial frictions to become more severe, potentially resulting in higher loan-deposit spreads, as can be seen from the bottom middle panel of figure 2.

The bottom right panel of figure 2 indicates that on the assets side of the balance sheet, an increase in RRR induces banks to substitute required reserves for bank loans for these reasons: (i) they are obliged to increase reserves, and (ii) the return to making new loans to nonfinancial firms gets smaller. This would result in a reduction in investment (see the top right panel of figure 2), since the intermediated funds to the real sector shrink (see the top middle panel of figure 2).

The steady-state analysis is helpful to gain insight on how reserve requirements might affect the workings of financial frictions in the model. In the following section, we explore the impact of the financial accelerator on key real variables and study the impact of the long-run level of RRR on the amplification of TFP shocks.

4.4. Amplifying Effect of Financial Frictions

In this section, we compare the dynamics of key real variables (output, investment, asset prices) and credit spreads in response to adverse technology shocks under *(i)* the benchmark economy, *(ii)* an economy that involves financial frictions but no required reserves, and *(iii)* the standard cash-in-advance model with no financial frictions.[27] Although the comparison of *(ii)* and *(iii)* isolates the impact of financial frictions, the comparison of *(i)* and *(ii)* is focused on understanding the impact of the steady-state required reserves level on model dynamics. In figure 3, the three economies are represented by the dotted straight, dashed, and straight plots, respectively.

[27] Financial shocks cannot be studied in this experiment because when financial frictions are absent, banks become a veil and bank capital is not defined.

A comparison of the dashed (which essentially coincides with the dotted straight plots) and straight plots shows that the collapse in output, investment, price of capital, and loan-deposit spreads in response to a one-standard-deviation negative TFP shock is amplified when financial frictions are in place. We especially want to highlight the more than doubling in the reduction of investment, quadrupling in the decline in asset prices, and 300 basis points of increase in the credit spreads in annualized terms. The last increase is even more striking because in the economy with no financial frictions, there is no arbitrage between the return to capital and the return to deposits. The evident amplification is due to the banks' reduced demand for deposits in case of lower productivity. This stems from the decline in the return to state-contingent equity issued by firms when productivity is lower. As a result, the price of equity issued by firms is depressed, which results in a collapse in the value of funds provided to them. Consequently, firms acquire less capital and investment declines more. On the other hand, the long-run level of the RRR does not seem to have any significant impact on the dynamics of the model, since the dashed and dotted straight plots coincide with each other.[28]

In the next section, we additionally introduce financial shocks over the business cycle and disentangle their relative importance via variance decomposition analysis.

4.5. Variance Decomposition

We report the variance decomposition of key model variables under the existence of both shocks in table 2.[29] As expected, financial shocks are found to derive much of the variation in deposits, net worth, bank leverage, and credit spreads. On the other hand, their less emphasized role in driving the variation in asset prices and bank credit (which is strongly affected by the price of capital) is due to the well-known transmission of productivity shocks via return to capital, which shifts the demand for capital and distorts its price.

It is striking to see that despite TFP shocks having a first-order effect on output, financial shocks still explain one-fifth of the variation in this variable. Additionally, the financial accelerator mechanism that operates via bank capital constraints renders the explanatory power of financial shocks for the variation in investment as nontrivial (about 47%). Another important finding is that financial shocks explain almost all of the variation in inflation (which feeds back into the labor-leisure decision via the cash-in-advance constraint). This is mostly due to the insignificance of TFP shocks on the monetary variables in a flexible price environment and the highlighted role of financial shocks in driving the variation in deposits, which directly determine the reserves demand with a constant RRR. In the following sections, we analyze model dynamics driven by TFP and net worth shocks in greater detail and explore how alternative reserve requirement policy rules affect these dynamics.

5. Credit Policy

We now analyze the implications of the RRR policy on the dynamics of real, financial, and monetary variables. In figures 4 and 5, we compare the dynamics of these variables in response to onestandard-deviation negative TFP and net worth shocks, respectively. In the figures, the dashed plots correspond to the benchmark economy with the countercyclical RRR rule, and the straight plots correspond to an economy with a fixed RRR. The dynamics of the economy with no reserves closely resemble those with a fixed RRR. Therefore, for space considerations, we do not discuss them here and only present the comparison of the fixed RRR economy with the benchmark economy that displays a countercyclical RRR.[30] Unless stated otherwise, the numbers in the y-axes correspond to percentage deviations of variables from their long-run values. For the case of inflation and RRR, we plot percentage *point changes* and for the case of credit spreads we plot *basis point changes* in annualized terms.

[28] Notice that the fluctuations in these two cases are around different steady states because the long-run value of RRR is different across economies.

[29] RRR is assumed to be positive but fixed in order not to obscure the variance decomposition analysis.

[30] The dynamics of the economy with no reserves are available upon request.

5.1. Impulse Response Experiments

TFP Shocks

The general observation that emerges from figure 4 is that the time-varying RRR policy dampens the impact of the financial accelerator on key macroeconomic real and financial variables at the expense of higher inflation in response to TFP shocks.

In the economy with fixed RRR, as expected, households reduce their demand for consumption and supply of deposits in response to the adverse TFP shock, since output and the profits that accrue from the ownership of banks and capital producers are lower. On the banks' side, the reduced TFP highlights the reduction in the profitability of equity loans to firms, inducing them to reduce their demand for deposits.

Under the fixed RRR economy, as figure 4 shows, the net worth of banks collapses about 5.75%, reflecting the feedback effect of a 0.8% decline in asset prices through the endogenous capital constraint of banks, represented by equation (16). The decline in net worth, in accordance with the decline in deposits, downsizes the total financing for nonfinancial firms (see figure 4). However, since the decline in bank capital is larger than that of the value of bank assets, the model implies a countercyclical bank leverage, which increases by 5%. On the other hand, the scarcity of funds for firms shoots up loan-deposits spreads by about 300 basis points in annualized terms (see the middle right panel of figure 4). The reduction in the quantity of equities traded and the collapse in asset prices trigger a downsizing in bank credit of about 1%. As a combined outcome of these dynamics, investment falls by 3.5% and output declines by about 1.75%.

The nominal price level increases (the bottom panel of figure 4) because the economy is now less productive in generating output. Hence, inflation increases by 0.2 percentage points, causing the real balances demand to decline and the consumption velocity of the monetary base to increase by about 1%.

Now, we explain how the credit policy defined by a countercyclical RRR rule mitigates the impact of the financial accelerator on key macroeconomic real and financial variables (see the dashed plots in figure 4). Since bank credit declines in response to the adverse TFP shock, the policy rule implies a reduction in the RRR by about 1 percentage point, which can be seen in the bottom left panel of the figure. This reduces the cost of extending credit for banks and induces a substitution from reserves balances to loans on the assets side of their balance sheets. Consequently, the stronger demand for firm equity stabilizes its price on impact, and the peak of decline in the equity price becomes about 0.2% less than that in the fixed RRR economy. The substitution in the balance sheets of banks, combined with the better outlook of asset prices, reduces the collapse in bank credit from 1% to 0.3%. Accordingly, the trough points of output and investment are 1.6% and 0.5% above their level in the fixed RRR economy, respectively.

The support of the central bank via lower reserve requirements causes credit spreads to rise by about 225 basis points less compared to the fixed RRR economy over five quarters. We emphasize this finding because credit spreads introduce an intertemporal wedge into the savings decision of the aggregate economy and are created by financial frictions. The relatively muted response of spreads stems from the reduced decline in return to firm equity. The stronger outlook of the economy is also reflected by the balance sheets of banks, and bank capital declines by 5% less compared to the fixed RRR economy. It even stays above its long-run level for about 20 quarters, since RRR is lower than its long-run value for about 30 quarters. The immediate implication of the stronger trajectory of net worth is a rise of virtually zero in bank leverage on impact (against a 5% hike with fixed RRR), even implying a decline of up to 2% caused by the increase in bank capital.

The substantial collapse in reserves demand (about 20%) reduces the demand for total monetary base, and since money supply is exogenously determined by the central bank, the price of money declines to restore equilibrium in the money market (see equation (31)). This amplifies the upward response of inflation obtained in the fixed RRR economy (see the bottom panel of figure 4). However, since this immediate surge is transitory and driven by the reserves policy, the model implies an undershooting of inflation in the coming seven quarters. This implies a substitution of consumption for leisure on the part of forward-looking households, and labor supply increases by 2% more in comparison to the fixed RRR

economy (see the top panel of figure 4). Hence, we obtain the stabilizing impact of the countercyclical RRR rule on the dynamics of output displayed in the top left panel of figure 4. Consistent with these findings, demand for real balances collapses on impact but outweighs its steady-state level along the transition, and consumption velocity increases by 12% more than the fixed RRR economy.

To sum up, the countercyclical RRR policy mitigates the impact of the financial accelerator triggered by TFP shocks on real and financial variables at the expense of higher inflation. In a nutshell, this is due to the increased incentives of bankers to make more loans, as well as the role that reserves play in the monetary base.

Financial Shocks

In this section, we explore how countercyclical reserve requirements perform in response to financial disturbances in the form of net worth shocks as described in section 4.1. When they are adverse, these shocks are intended to capture loan losses, asset write-downs, or asset revaluations that we observe in financially repressed periods. As stated in section 1, they might also be thought of as a sharp reversal in the risk appetite of investors, which is an exogenous factor that threatens the financial stability of a country such as Turkey.

Although the initial decline in banks' net worth driven by these shocks is exogenous, second round effects endogenously trigger an adverse financial accelerator mechanism. The initial fall in the net worth reduces the amount of bank credit that can be extended to nonfinancial firms, since banks are not able to compensate the decline in their internal financing with households' deposits. Since nonfinancial firms finance their capital expenditures via bank credit, there will be a drop in investment and, hence, in the price of capital. The value of intermediary capital depends on asset prices. The endogenous decline in asset prices leads to a further deterioration in banks' net worth, creating an adverse feedback loop of falling aggregate demand, declining asset prices, and deteriorating intermediary balance sheets. We analyze the effects of this shock in the model economy with fixed RRR policy and then illustrate the mitigating effects of time-varying RRR policy on real, financial, and monetary variables in figure 5.

In the economy with fixed RRR, the negative net worth shock immediately reduces bank capital by 12% on impact (see the middle left panel of figure 5). Although deposits rise due to banks' increased demand for deposits to compensate for the decline in their internal financing, the deterioration of bank capital causes total financing by financial intermediaries to shrink. This translates into a reduction in bank credit in the form of equity purchases to firms by 1.25% on impact. As the demand for firms' shares is lower, the price of equity falls by 1%. This amplifies the exogenous impact of the financial shock via the endogenous capital constraint of banks and explains the substantial decline of 12% in the net worth. The decline in bank capital raises their leverage by 10%. Induced by the shortage in credit and the collapse in asset prices, credit spreads rise by 500 basis points in annualized terms. This in turn causes firms to severely cut back their investment (by about 4.2%) due to lower bank credit and the higher cost of financing.

The increase in bank deposits driven by banks' effort to compensate for the net worth loss increases reserves balances by 1% in the fixed RRR economy. This creates an excess demand for the monetary base, and inflation declines on impact by 0.6 percentage points (see the bottom panel of figure 5). However, since the shock is transitory, inflation overshoots by 0.7 percentage points in the period that follows the shock, and workers' expectations regarding the hike in future inflation cause hours to decline by 2.2% on impact. Therefore, output shrinks by 1.25% as shown in the top left panel of the figure. The dynamics of real balances demand and the consumption velocity of the monetary base resemble the expected implication of the dynamics of inflation.

In the model economy with credit policy, the time-varying rule induces a fall in the RRR of about 0.6 percentage points, since bank credit declines in response to the negative financial shock. Reserves immediately drop by 11% and almost completely eliminate the collapse in inflation. Most importantly, the dynamics of reserves move inflation in such a way as to induce hours and, accordingly, output to increase on impact (see the bottom and top panels of figure 5).

Following the reduced cost of making equity loans to firms, banks substitute away their assets from reserves to firm equity; therefore, the initial decline in bank credit is 1% smaller. As the demand for firm equity is higher in the model with credit policy, the 1% reduction in the price of equity in the economy with fixed a RRR policy is almost totally eliminated. This reinforces the intermediary capital via the leverage constraint and reduces the collapse in bank net worth by 7%. We emphasize this finding that the credit policy reduces the amplified impact of the financial shock on bank capital by more than 50%. Accordingly, the rise in credit spreads is 300 basis points lower in annualized terms, and bank leverage increases by 5% instead of 10%. As another favorable outcome, investment falls by 3% less than the decline in the fixed RRR economy over five quarters. To sum up, we obtain the result that a countercyclical reserve requirements policy that has a first-order impact on the balance sheets of financial intermediaries proves effective in response to financially repressed periods in which balance sheets of banks deteriorate.

In the next section, we analyze the operational role of credit policy by changing the response intensity of RRR to the aggregate credit growth.

5.2. Credit Policy Intensity, Volatilities, and Procyclicality of Financial System

We assess the role of credit policy intensity by changing the response parameter ϕ in the RRR rule, equation (30). We call a credit policy regime that generates a standard deviation of the policy variable, RRR, of 3.50% (1.17%), which is 50% larger (smaller) than that in the benchmark economy, 2.33%, as *aggressive (moderate).* Naturally, ϕ is recalibrated in each case to generate those volatilities for the policy variable.[31] In both experiments, both TFP and financial shocks are in place.

The first column of table 3 gives a list of key real, financial, and monetary variables and correlations of loan-deposit spreads growth and credit growth with output growth. Columns 2-5 report the standard deviations of these variables and values of correlation coefficients under (i) fixed RRR (ϕ = 0), (ii) moderate credit policy regime (ϕ = 1.45), (iii) benchmark credit policy regime (ϕ = 3.28), and (iv) aggressive credit policy regime (ϕ = 4.79). The success of credit policy is assessed by its ability in (i) reducing volatilities of model variables and (ii) reducing the procyclicality of the financial system. The latter goal is actually paving the way to the first goal because policymakers have reached a broad consensus that a procyclical financial system amplifies the impact of various shocks that the economy faces, as mentioned by Lim et al. (2011).

Consistent with the impulse response analysis of the previous section, even the moderate policy regime is considerably successful in reducing volatilities of key model variables at the expense of higher inflation volatility. We emphasize the more than 50% decline in the volatilities of net worth, bank leverage, and credit spreads and the more than 30% decline in the volatilities of investment, bank credit, and asset prices. The comparison of columns 3-5 indicates that as the credit policy gets more aggressive, the volatility of output, investment, bank credit, loan-deposit spreads, and asset prices gets even smaller. Notice that since reserve requirements have a strong impact on banks' deposits demand and monetary base, the volatility of deposits and inflation increases as credit policy gets more aggressive. Considering the money market equilibrium condition represented by equation (31), higher volatility in reserves, led by the credit policy rule, induces higher volatility in inflation to restore equilibrium in the money market.[32] Simultaneously, hours become more volatile, since inflation feeds back into the intertemporal consumption-leisure optimality condition, (5). Finally, although negligibly small, bank net worth becomes more volatile, because of the increased effort of banks' rebalancing between internal and external finance in response to the change in the reserve requirements.

The last two rows of table 3 report the business cycle statistics regarding the cyclicality of the financial system. A quick glance at the last two rows in the second column suggests that the financial system is strongly *procyclical* under the fixed RRR regime; that is, in bad times, the borrowing terms for nonfinancial firms deteriorate substantially (implied by the strong negative correlation between

[31] Standard deviations of model variables are computed over sufficiently long simulations of the approximated decision rules. When simulations are sufficiently long, the moments of the simulated data converge to their theoretical counterparts.

[32] It is straightforward to predict that the volatility of nominal interest rates (which are not set by a monetary policy authority, but rather are determined endogenously) increases in this case as well.

loan-deposit spreads growth and output growth of -86%), and the magnitude of intermediated funds diminishes (implied by the strong positive correlation between bank credit growth and output growth of 96%). Comparing these numbers to the last two rows of columns 3-5 shows that countercyclical RRR policy essentially renders credit spreads almost $acyclical$ (i.e., correlation reduces to negative 2% for the benchmark regime) and reduces the procyclicality of bank credit substantially (i.e., correlation reduces to 79% for the benchmark regime).

To summarize, a countercyclical reserve requirements policy that is designed to stabilize credit is operational in mitigating the adverse impact of the financial accelerator. In particular, the credit policy mitigates the amplified responses to TFP and net worth shocks under the existence of financial frictions, and reduces the procyclicality of the financial system that helps to fuel this mechanism.

5.3. Alternative Reserve Requirement Policies

As we discuss in the introduction, stabilizing credit growth does not necessarily have a systemic risk-reducing role in this model because systemic risk is not modeled in the first place. Yet, there is a strong case for studying this kind of reserve requirement policy because (i) numerous policymakers in Turkey and others have used time-varying reserve requirements among other measures to countervail excessive credit growth (for a comprehensive list of macroprudential policy practices across countries, see Lim et al. (2011)), and (ii) countercyclical reserve requirements that stabilize credit are also found to stabilize loan-deposit spreads, a wedge in the consumption-savings margin of this economy.[33]

In this section, for completeness, we make an extension and consider alternative macroeconomic target variables for the reserve requirement policy rule. We then compare the performance of these alternative regimes with the benchmark policy. To that end, table 4 is constructed to include no required reserves (column 2) and alternative policy rules that aim to stabilize output (column 5) and asset prices (column 6), in addition to the benchmark policy that aims to stabilize credit (column 4). In each policy regime (other than the no-reserves case), the policy response parameter ϕ is recalibrated to match the volatility of the RRR observed during which the CBRT has intervened (2010:Q4-2012:Q2).[34] We assess the performance of each policy regime again by focusing on the volatilities of key model variables and the procyclicality of the financial system vis-á-vis the economy with fixed RRR (column 3).

The main message of table 4 is clear: a countercyclical reserve requirement policy that aims to stabilize either output or asset prices reduces the volatility of key real and financial variables at the expense of higher inflation volatility along the mechanism that we lay out in section 5.1. Specifically, credit stabilization outperforms output stabilization because volatilities are reduced more at the expense of less volatile inflation (see columns 4 and 5). Asset price stabilization, on the other hand, outperforms credit stabilization but at a negligible level (see columns 4 and 6). Another observation is that the economy with a positive and time-invariant RRR displays at most slightly lower volatilities than the economy with no required reserves (see columns 2 and 3). Lastly, credit and asset prices stabilization are more effective in reducing the procyclicality of the financial system than output stabilization (see the last two rows of table 4). This result resembles the findings of Faia and Monacelli (2007), Gilchrist and Saito (2008), and Angeloni and Faia (2009), who find that monetary policy authority should respond to asset prices when financial frictions are relevant. When reserve requirements countercyclically respond to asset prices, the adverse feedback effects of the financial accelerator that operate via endogenous bank capital constraints are mitigated.[35]

One other avenue to explore is to understand the relative impact of shocks on the performance of alternative reserve requirements policy rules in reducing the volatilities in model variables and the procyclicality of the financial system. To that end, we replicate table 4 by shutting down financial shocks to shed light on the importance of this shock. The findings are reported in table 5. The findings are striking in

[33] Indeed, stabilizing credit spreads in this way is analogous to stabilizing distortionary consumption taxes in the usual Ramsey framework.

[34] Accordingly, equation (30) is modified to be $rr_t = \bar{rr} + \phi E_t\Big[\log(y_{t+1}) - \log(y_t)\Big]$, and $rr_t = \bar{rr} + \phi E_t\Big[\log(q_{t+1}) - \log(q_t)\Big]$, respectively.

[35] Indeed, responding to credit partly resembles responding to asset prices because credit is defined as the market value of capital claims issued by production firms that are traded at the asset price of capital.

the sense that not only are the volatilities of model variables lower, but also the effectiveness of alternative countercyclical required reserves policies in reducing these volatilities diminishes substantially.[36] Most notably, the capability of alternative policies in reducing the countercyclicality of loan-deposit spreads is hindered significantly when there are no financial shocks. Focusing on the *credit policy,* one observes that the success of the reserve requirements policy in reducing the procyclicality of credit is severely hampered. Consequently, we argue that financial shocks, in the form of balance sheet disturbances faced by banks, make a good case for introducing countercyclical reserves policies regardless of the choice of target variable among bank credit, output, or asset prices.

To summarize, countercyclical reserve requirements are robustly found to countervail the impact of the financial accelerator in the current setup when alternative macroeconomic targets (that are popularly adopted by policymakers) are considered. Moreover, this type of policy design becomes more crucial when financial shocks are considered. With the guidance of our positive assessment of reserve requirement policies that are employed by several central banks around the globe, we now proceed to assessing their performance on the optimality grounds in the next section.

5.4. Optimal Credit Policy Intensity

In this section, we discuss the possible objectives and the credit policy instrument of the central bank and search for the optimal intensity of this policy tool. We follow the exogenous loss function approach, following a vast literature. This approach also helps us find an optimal level of the intensity of credit policy. Otherwise, the welfare-maximizing level of the policy intensity and the volatility of the required reserves policy at that intensity are infinite, since there is no real cost of adjusting the required reserve ratio aggressively and frequently.

Let us assume that the central bank's objective is to minimize an exogenously given loss function. Since we focus on the financial stability objective of the central bank, its loss function targeting financial stability reads

$$L = E[\lambda_y \sigma^2_{\hat{y}} + \lambda_{qs} \sigma^2_{\hat{qs}} + \lambda_{rr} \sigma^2_{\Delta rr}] \quad \lambda_y \geq 0, \lambda_{qs} \geq 0, \lambda_{rr} \geq 0, \tag{39}$$

where $\sigma^2_{\hat{y}}$, $\sigma^2_{\hat{qs}}$, and $\sigma^2_{\Delta rr}$ are theoretical variances of the log-deviations of output and total credit from their steady-state values, and of the changes in the credit policy instrument (i.e., the required reserves ratio), respectively. λ_y, λ_{qs}, and λ_{rr} reflect the policymaker's sub jective weights of output stability, credit stability, and the stability of the policy instrument.

We put the variability of total credit into the loss function to be consistent with the fact that a central bank with a financial stability objective may want to prevent abnormal credit expansions and contractions to contain disruptive credit fluctuations.[37] We set its policy weight, λ_{qs}, to 1 following Glocker and Towbin (2012). Moreover, we include the variability of the policy instrument in the loss function, since the central bank wants to keep the fluctuations in the required reserves ratio at reasonable levels. If we do not include it in the loss function, optimal credit policy renders excessive volatility in the required reserves ratio. Therefore, we set λ_{rr} to 1 to make sure that the central bank is quite conservative about changing the required reserves ratio. Finally, regarding the policy weight of output stability, we set λ_y to 0.5 following Angelini et al. (2012).

Figure 6 displays the loss values for all model economies as a function of the policy intensity parameter, ϕ. These model economies are the credit policy regime, the asset prices policy regime, and the output policy regime under only TFP and both shocks, respectively. We also plot each policy economy as separate panels in figure 7 to see more transparently the inverted U-shape of loss functions associated with each policy. These plots also give us the ability to pin down the optimal reserve requirement response to credit growth, asset prices growth, and output growth under different sets of shocks.

[36] Consistent with the variance decomposition results reported in table 2, the volatility of inflation under timeinvariant reserves policy economies is reduced sharply when there are no financial shocks.

[37] Reinhart and Rogoff (2008) and Borio and Drehmann (2009) argue that excessive credit expansions help predict financial crises.

Figure 7 shows that under only TFP shocks and under both shocks, credit policy is the least costly policy, whereas output policy is the most costly one in terms of loss values. The top left panel of the figure indicates that the optimal intensity of reserve requirement policy that responds to credit growth under only TFP shocks and both shocks is equal to 1.6842 and 1.9211, respectively. As expected, the central bank should take a more aggressive stance if the economy is hit by both productivity and financial shocks. This result is still true when asset price and output policies are considered. The top right panel of the figure shows that the optimal ϕ of the RRR policy that responds to asset prices growth under only TFP shocks and both shocks is equal to 1.9211 and 2.3947, respectively. Lastly, the bottom panel illustrates that the optimal ϕ of the RRR policy that responds to output growth under only TFP shocks and both shocks is equal to 0.7368 and 0.9737, respectively. If we compare the optimal policy intensity across different types of policies, we find that the central bank should be the least aggressive in the case of the output policy and should be the most aggressive in the case of the asset prices policy.[38]

Table 6 shows the loss values associated with each alternative policy rule. For each policy rule, the policy intensity parameter, ϕ, is calibrated at its benchmark value. The first row of the table displays the loss values under only TFP shocks. The time-varying credit and asset prices policies give loss values that are lower than the fixed reserves policy, whereas the time-varying output policy gives the highest value, indicating that the former policies dominate the fixed reserves policy and the output policy emerges as the worst. The second row of the table shows the loss values under both shocks. In this case, the fixed reserves policy gives the highest loss value, implying that all time-varying policies dominate the fixed reserves policy when both shocks hit the economy.

Here, we should note that we do not include the loss value associated with zero required reserves policy in the table in order to have a meaningful comparison across different policies. This is because there are first-order level differences between the no-reserves economy, the couple of fixed required reserves economies, and the credit policy economies. Therefore, we think that it is more intuitive to compare economies with positive required reserves in terms of volatility effects.

We should also emphasize that the second best of this model economy features a zero RRR policy, which is also confirmed by solving the optimal Ramsey problem of this economy. In other words, constrained efficiency implies that under financial frictions in the banking sector, the second best can be achieved only by a zero required reserves ratio.[39] This is straightforward to predict, since the magnitude of intermediated funds is going to be larger with no reserves, as we discuss in section 4.3. Nevertheless, as mentioned in the introduction, we take the existence of positive RRRs as an institutional feature of the real world, and bringing a microfoundation to their existence is beyond the scope of this paper (as in Angeloni and Faia (2009), Christensen et al. (2011), and Angelini et al. (2012) on the analysis of capital requirements). Indeed, our exercise illustrates how a central bank can replace a time-invariant required reserves policy with a time-varying required reserves policy rule to bring the economy closer to its second best. This completes the analysis of optimal credit policy and in the next section, we carry out sensitivity analysis on the key parameters regarding financial frictions in the model.

6. Sensitivity Analysis

In this section, we explore the impact of key model parameters on the effectiveness of credit policy in maintaining macroeconomic and financial stability. The comparisons are based on the implied volatilities of key model variables under fixed and time-varying reserve requirement policy regimes when TFP and financial shocks are realized over sufficiently long simulations of the model economy. The results are reported in table 7. In all columns of the table, we change one parameter at a time and recalibrate the response parameter ϕ to match the volatility of the observed RRR. We leave the other parameters the same as in the benchmark model. We fix the way in which the central bank responds to shocks in order to prevent the arbitrarily strong or weak policy responses that might emerge for the benchmark value of ϕ when the sensitivity parameter of interest is tweaked. If the steady-state levels of bank leverage and credit spreads differ from the benchmark case for an alternative parameter level, we report the new steady-state values of these variables below the parameter value.

[38] Recall that the steady state of all of these economies is identical.

[39] The first best of this model economy is achieved when both monetary and financial frictions are removed.

For that matter, we run credit policy for alternative values of (i) the fraction of diverted funds, λ, which is used to target the long-run value of credit spreads, determining the severity of financial frictions in the banking sector (top panel), (ii) the survival probability, θ, which is used to target the long-run value of bank leverage and the riskiness of the financial sector (middle panel), and (iii) the capital adjustment cost parameter, φ, which affects the transmission of shocks to the real sector via fluctuations in asset prices that are propagated by endogenous capital constraints of financial intermediaries (bottom panel). In each related column, the recalibrated value of ϕ is reported.[40]

Fraction of Diverted Funds, λ: An increase in the fraction of diverted funds corresponds to an economy in which financial frictions are more severe because the moral hazard problem between banks and households becomes more intense. This is reflected as a smaller long-run value for bank leverage and a larger long-run value for credit spreads compared to the benchmark model. A smaller bank leverage is due to the tighter endogenous capital constraints faced by banks. Accordingly, tighter credit constraints result in higher credit spreads faced by nonfinancial firms. A comparison of the last two columns in the top panel of table 7 with columns 3-4 of table 4 reveals that when λ is larger, the credit policy (with the same policy variable volatility as in the benchmark model) is more effective in reducing the volatilities of output, consumption, investment, bank credit, and asset prices. Therefore, the importance of reserve requirement policies is enhanced when financial frictions become more severe. Notice also that a lower response parameter for the required reserves rule is generating the same volatility in the RRR. This means that when financial frictions are stronger, the responsiveness of the central bank increases as well.

Survival Probability, θ: A larger value for survival probability reduces the long-run value of bank leverage because bankers can accumulate more net worth during their finite life. Consequently, stronger internal financing results in lower credit spreads in the long run. Coming to simulation results, the effectiveness of credit policy in reducing the volatilities of output, consumption, investment, bank credit, and asset prices is enhanced when steady-state bank leverage is smaller as a result of higher survival probability.

Capital Adjustment Cost Parameter, φ: The value of the capital adjustment cost parameter is especially important because it affects the transmission of the financial accelerator mechanism to the asset prices without changing the steady state of the model. Specifically, when $\varphi = 0$, asset prices do not fluctuate at all and the second-round effects of the financial accelerator do not operate via banks' capital constraints. As a result, a smaller φ reduces the propagation of the financial accelerator in the model. The comparison of the last four columns in the bottom panel of table 7 shows that credit policy is much more effective in reducing the volatilities of all macroeconomic and financial variables when asset prices are more responsive to volatilities in bank capital (i.e., when φ is larger). This explanation is consistent with the impulse responses as well. Figure 8 reproduces the impulse responses of model variables led by a one-standard-deviation negative TFP shock in the fixed reserves (straight plots) and time-varying reserves (dashed plots) economies when $\varphi = 0.5$. A comparison of figure 8 with figure 4 reveals two facts: (i) the straight plots in the former display less response in bank net worth, leverage, bank credit, credit spreads, and asset prices to the negative TFP shock, and (ii) the dashed plots again in the former illustrate that credit policy operates much less effectively in stabilizing financial variables when the propagation of the financial accelerator is dampened.[41]

7. Discussion and Conclusion

Using reserve requirements to achieve financial stability has certain advantages and drawbacks. The main advantages are that (i) it is one of the two main policy tools that most central banks can use, (ii) the central bank does not directly face any costs, since reserve requirements effectively alter the financial sector's own balance sheet in order to provide liquidity to the system, and (iii) they might be used as a tax that affects the loan-deposit spreads on the banking system in order to alter the cost of making loans if loan growth is a policy concern. Among some drawbacks of using reserve requirements are that (i) they put depository institutions at a competitive disadvantage compared to unregulated financial institutions,

[40] Notice that the recalibrated values for ϕ vary in the range of [2.7,4.13], whereas the benchmark value for this parameter is 3.28.

[41] Investment is more volatile when φ is lower precisely because less of the adjustment to the adverse TFP shock comes through asset price changes.

(ii) they might be circumvented by the banking sector to an extent that alternative ways of credit creation such as syndicated loans and currency swaps, which are not sub ject to reserve requirements, are used, and (iii) as stated in Lim et al. (2011), despite being raised to prevent predatory lending, increasing required reserves might render access to credit by prudent (but small-to-medium-size) firms too difficult, and lastly, (iv) required reserves might be substituted by overnight borrowing from the central bank if overnight borrowing rates are not too high (i.e., interest rate corridor is narrow). Our judgment is that policymakers around the globe are assessing the effectiveness of reserve requirements by considering these pros and cons.

One can assess the effectiveness of reserve requirements as a financial stability tool through their effects on credit spreads and bank credit in the nonfinancial sector. Other things being equal, we conjecture that the countercyclical implementation of reserve requirement ratios mitigates the decline in credit growth and accordingly moderates the rise in credit spreads in economic downturns, curbing excessive credit growth in boom periods.

To that purpose, we build a quantitative monetary DSGE model with a banking sector that is sub ject to time-varying reserve requirements imposed by the central bank and endogenous capital constraints due to an agency problem. We model reserve requirements as an exogenous policy rule that countercyclically responds to expected credit growth in the financial sector. We consider the effects of two different types of shocks: productivity and financial shocks. For each type of shock, we find that the time-varying required reserve ratio rule mitigates the negative effects of adverse shocks amplified by the financial accelerator mechanism on real and financial variables. In each case, it reduces the intertemporal distortions created by the credit spreads at the expense of generating higher inflation, pointing out the clear trade-off between price stability and financial stability faced nowadays by many central banks. It also reduces the volatilities of key variables such as output, consumption, investment, bank credit, loan spreads, and asset prices, indicating the role of reserve requirements as a credit policy instrument. Finally, we find that a time-varying reserve requirement policy achieves a higher welfare than a fixed reserve requirement policy.

This study illustrates that when financial frictions are important, monetary policy that adopts reserve requirement ratios as a credit policy instrument might have real effects even if there are no nominal rigidities. Yet, a number of caveats, shortcomings, and further research avenues need to be discussed. First, in order to avoid the curse of dimensionality, we resort to perturbation techniques instead of global approximation methods in the solution of the theoretical model. This prevents us from analyzing occasionally binding incentive compatibility constraints that might affect the dynamics of credit spreads. Second, one can introduce liquidity shocks in order to bring a microfoundation to holding reserves to rationalize the optimality of positive reserve requirements. Third, it might also be interesting to focus on the trade-off between price stability and financial stability in a framework in which an interest rate feedback rule is introduced under nominal rigidities as in Christiano et al. (2005) and Smets and Wouters (2007). Introducing such trade-offs might be essential in adopting welfare measures based on consumers' utility rather than resorting to ad hoc loss functions. Lastly, it might also be worthwhile to study an open economy model to explicitly consider the effects of international capital flows in the design of required reserves policies, rather than capturing them partially by net worth shocks. This is because reversals in the risk appetite of global investors have a tendency to create credit cycles in emerging economies such as Turkey. Indeed, international capital flows have been pointed out as being among the motivating reasons for using reserve requirement policies by the CBRT in the aftermath of the recent crisis (see CBRT (2011-IV) and Lim et al. (2011)). Therefore, an extension of the current model including open economy features might yield important avenues for the researcher on the study of reserve requirements as a credit policy tool.

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Appendix A: Banks' Profit Maximization Problem

Let us conjecture that the bank's franchise value is given by

$$V_{jt} = \nu_t q_t s_{jt} + \eta_t n_t \tag{40}$$

Comparing the conjectured solution for V_{jt} to the expected discounted terminal net worth yields the following expressions:

$$\nu_t q_t s_{jt} = E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left[R_{kt+1+i} - \left(\frac{R_{t+1+i} - rr_{t+i}}{1 - rr_{t+i}} \right) \right] q_{t+i} s_{jt+i} \tag{41}$$

$$\eta_t n_{jt} = E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left[\frac{R_{t+1+i} - rr_{t+i}}{1 - rr_{t+i}} \right] n_{jt+i} \tag{42}$$

Let ESP_{t+i} stand for $\left[R_{kt+1+i} - \left(\frac{R_{t+1+i} - rr_{t+i}}{1 - rr_{t+i}} \right) \right]$, and let RR_{t+i} stand for $\left[\frac{R_{t+1+i} - rr_{t+i}}{1 - rr_{t+i}} \right]$. Therefore,

$$\nu_t q_t s_{jt} = E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} ESP_{t+i} q_{t+i} s_{jt+i} \tag{43}$$

$$\eta_t n_{jt} = E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} RR_{t+i} n_{jt+i} \tag{44}$$

We write ν_t and η_t recursively using the above expressions. Let us begin with ν_t. To ease the notation, let us drop expectations for now:

$$\nu_t = \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} ESP_{t+i} x_{t,t+i} \tag{45}$$

where $x_{t,t+i} = \frac{q_{t+i} s_{jt+i}}{q_t s_{jt}}$. Let us separate (45) into two parts:

$$\nu_t = (1-\theta)\beta \Lambda_{t,t+1} ESP_t + \sum_{i=1}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} ESP_{t+i} x_{t,t+i} \tag{46}$$

Rearrange the second term on the right-hand side of expression (46):

$$\nu_t = (1-\theta)\beta \Lambda_{t,t+1} ESP_t + \beta \Lambda_{t,t+1} \theta x_{t,t+1} \sum_{i=0}^{\infty} (1-\theta)\theta^{i+1} \beta^{i+1} \Lambda_{t+1,t+2+i} ESP_{t+1+i} x_{t+1,t+1+i} \tag{47}$$

The infinite sum on the right-hand side of equation (47) is the one-period updated version of equation (45), given by

$$\nu_{t+1} = \sum_{i=0}^{\infty} (1-\theta)\theta^{i+1} \beta^{i+1} \Lambda_{t+1,t+2+i} ESP_{t+1+i} x_{t+1,t+1+i} \tag{48}$$

where $x_{t+1,t+1+i} = \frac{q_{t+1+i} s_{jt+1+i}}{q_{t+1} s_{jt+1}}$

Hence, we can rewrite (47) with expectations as follows:

$$\nu_t = E_t[(1-\theta)\beta \Lambda_{t,t+1} ESP_t + \beta \Lambda_{t,t+1} \theta x_{t,t+1} \nu_{t+1}] \tag{49}$$

Let us continue with η_t. To ease the notation, let us drop expectations for now:

$$\eta_t = \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} RR_{t+i} z_{t,t+i} \tag{50}$$

where $z_{t,t+i} = \frac{n_{jt+i}}{n_{jt}}$. Let us separate (50) into two parts:

$$\eta_t = (1-\theta)\beta\Lambda_{t,t+1}RR_t + \sum_{i=1}^{\infty}(1-\theta)\theta^i\beta^{i+1}\Lambda_{t,t+1+i}RR_{t+i}z_{t,t+i} \tag{51}$$

Rearrange the second term on the right-hand side of expression (51):

$$\eta_t = (1-\theta)\beta\Lambda_{t,t+1}RR_t + \beta\Lambda_{t,t+1}\theta z_{t,t+1}\sum_{i=0}^{\infty}(1-\theta)\theta^{i+1}\beta^{i+1}\Lambda_{t+1,t+2+i}RR_{t+1+i}z_{t+1,t+1+i} \tag{52}$$

The infinite sum on the right-hand side of equation (51) is the one-period updated version of equation (49), given by

$$\eta_{t+1} = \sum_{i=1}^{\infty}(1-\theta)\theta^{i+1}\beta^{i+1}\Lambda_{t+1,t+2+i}RR_{t+1+i}z_{t+1,t+1+i} \tag{53}$$

where $z_{t+1,t+1+i} = \frac{n_{jt+1+i}}{n_{jt+1}}$.

Hence, we can rewrite equation (51) with expectations as follows:

$$\eta_t = E_t[(1-\theta)\beta\Lambda_{t,t+1}RR_t + \beta\Lambda_{t,t+1}\theta z_{t,t+1}\eta_{t+1}] \tag{54}$$

The profit maximization problem by a representative bank is given by

$$V_{jt} = \max_{s_{jt}} E_t \sum_{i=0}^{\infty}(1-\theta)\theta^i\beta^{i+1}\Lambda_{t,t+1+i}ESP_{t+i}q_{t+i}s_{jt+i} + RR_{t+i}n_{jt+i} \tag{55}$$

$$\text{s.t.} \quad V_{jt} \geq \lambda q_t s_{jt} \qquad (\mu_t) \tag{56}$$

where μ_t is the Lagrange multiplier associated with the incentive compatibility constraint. Using the conjectured solution for V_{jt} above, we can rewrite the intermediary's maximization problem using the Lagrangian,

$$Ł = \nu_t q_t s_{jt} + \eta_t n_{jt} + \mu_t[\nu_t q_t s_{jt} + \eta_t n_{jt} - \lambda q_t s_{jt}] \tag{57}$$

The first-order conditions with respect to s_{jt} and μ_t are given, respectively, by

$$(1+\mu_t)\nu_t q_t = \mu_t \lambda q_t \tag{58}$$

$$V_{jt} - \lambda q_t s_{jt} = 0 \tag{59}$$

Rearranging (58) gives us the following expression:

$$\nu_t = \frac{\mu_t \lambda}{(1+\mu_t)} \tag{60}$$

Therefore, we establish that the incentive compatibility constraint binds (μ_t > 0) as long as the expected discounted marginal gain of increasing bank assets is positive.

Appendix B: Competitive Equilibrium Conditions

The following are the optimality and market clearing conditions that are satisfied in a competitive equilibrium as defined in section 3.6:

$$\Lambda_{t,t+1} = \frac{u_c(t+1)}{u_c(t)} \tag{61}$$

$$1 = \beta E_t R_{t+1} \Lambda_{t,t+1} \tag{62}$$

$$c_t = \frac{exp(\mu) - 1 + \hat{m}_t \hat{P}_t}{\hat{P}_t exp(\mu)} + R_t b_t - b_{t+1} \tag{63}$$

$$\frac{u_l(t)}{w_t \hat{P}_t} = \beta E_t \left\{ \frac{u_c(t+1)}{\hat{P}_{t+1} exp(\mu)} \right\} \tag{64}$$

$$\kappa_t = \frac{\eta_t}{\lambda - \nu_t} \tag{65}$$

$$q_t s_t = \kappa_t n_t \tag{66}$$

$$q_t s_t = (1 - rr_t) b_{t+1} + n_t \tag{67}$$

$$\varrho_{t,t+1} = \left(R_{kt+1} - \frac{R_{t+1} - rr_t}{1 - rr_t} \right) \kappa_t + \frac{R_{t+1} - rr_t}{1 - rr_t} \tag{68}$$

$$\chi_{t,t+1} = \varrho_{t,t+1} \frac{\kappa_{t+1}}{\kappa_t} \tag{69}$$

$$n_{et} = \theta \varrho_{t-1,t} n_{t-1} \tag{70}$$

$$n_{nt} = \epsilon n_{t-1} \tag{71}$$

$$n_t = n_{et} + n_{nt} \tag{72}$$

$$\nu_t = E_t \left\{ (1-\theta) \beta \Lambda_{t,t+1} \left(R_{kt+1} - \frac{R_{t+1} - rr_t}{1 - rr_t} \right) + \beta \Lambda_{t,t+1} \theta \chi_{t,t+1} \nu_{t+1} \right\} \tag{73}$$

$$\eta_t = E_t \left\{ (1-\theta) \beta \Lambda_{t,t+1} \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) + \beta \Lambda_{t,t+1} \theta \varrho_{t,t+1} \eta_{t+1} \right\} \tag{74}$$

$$w_t = exp(z_t) F_h(k_t, h_t) \tag{75}$$

$$R_{kt} = \frac{exp(z_t) F_k(k_t, h_t) + q_t(1-\delta)}{q_{t-1}} \tag{76}$$

$$k_{t+1} = (1-\delta)k_t + \Phi\Big(\frac{i_t}{k_t}\Big)k_t \tag{77}$$

$$q_t = \Big[\Phi'\Big(\frac{i_t}{k_t}\Big)\Big]^{-1} \tag{78}$$

$$exp(z_t)F(k_t, h_t) = c_t + i_t \tag{79}$$

$$s_t = k_{t+1} \tag{80}$$

$$1 = l_t + h_t \tag{81}$$

$$exp(\pi_t) = exp(\mu)\frac{\widehat{P_t}}{\widehat{P_{t-1}}} \tag{82}$$

$$z_{t+1} = \rho_z z_t + \epsilon_{zt+1} \tag{83}$$

$$rr_t = \bar{rr} + \phi E_t\Big[\log(q_{t+1}s_{t+1}) - \log(q_t s_t)\Big] \tag{84}$$

$$\frac{1}{\widehat{P_t}} = \hat{m}_{t+1} + rr_t b_{t+1} \tag{85}$$

Table 1: Parameter Values in the Benchmark Model

Description	Value	Target
Preferences		
Quarterly discount factor (β)	0.9885	Annualized real deposit rate (4.73%)
Relative risk aversion (γ)	2	Angeloni and Faia (2009)
Inverse of the Frisch elasticity (ν)	3	Glocker and Towbin (2012)
Relative utility weight of leisure (ψ)	46.16	Hours worked (0.33)
Production Technology		
Share of capital in output (α)	0.4	Labor share of output (0.64)
Capital adjustment cost parameter (φ)	6.76	Elasticity of price of capital w.r.t. investment-capital ratio of 0.25
Depreciation rate of capital (δ)	0.037	Average annual ratio of investment to capital (14.8%)
Government		
Steady-state value of RRR ($\bar{rr}$)	0.05	Pre-macroprudential policy period
Adjustment parameter in the RRR rule (ϕ)	3.28	Standard deviation of RRR for 2010:Q4-2012:Q2 (2.33%)
Growth rate of monetary base (μ)	0.0446	Time series average for 2006:Q1-2011:Q4
Financial Intermediaries		
Fraction of diverted loans (λ)	0.514	Annual commercial & industrial loan spread (1.96%)
Prop. transfer to the entering bankers (ϵ)	0.0005	1.33% of aggregate net worth
Survival probability of the bankers (θ)	0.9625	Capital adequacy ratio of 16% for commercial banks
Shock Processes		
Persistence of TFP process (ρ_z)	0.9821	Estimated persistence from detrended $logTFP_t = rz\ logTFP_{t-1} + \epsilon_{zt}$
Std. deviation of productivity shocks (σ_z)	0.0183	Estimated standard deviation from detrended $logTFP_t = rz\ logTFP_{t-1} + \epsilon_{zt}$
Std. deviation of financial shocks (σ_ω)	0.0531	Relative volatility of bank capital w.r.t. output for 2003:Q1-2011:Q4 (1.24)

Table 2: Variance Decomposition of Model Variables

Variable	TFP Shocks	Financial Shocks
Real Variables		
Output	78.32	21.68
Consumption	94.38	5.62
Investment	53.13	46.87
Hours	1.11	98.89
Financial Variables		
Credit	56.20	43.80
Deposits	22.80	77.20
Net worth	18.19	81.81
Leverage	15.89	84.11
Credit spread	32.47	67.53
Asset prices	52.84	47.16
Monetary Variables		
Inflation	3.92	96.08

Table 3: Impact of Credit Policy on Volatilities and Financial System Procyclicality

	Fixed Reserves	Moderate[a]	Benchmark	Aggressive[a]
	$\phi = 0$	$\phi = 1.45$	$\phi = 3.28$	$\phi = 4.79$
Variable	$\sigma_{rr} = 0$[b]	$\sigma_{rr} = 1.17\%$	$\sigma_{rr} = 2.33\%$	$\sigma_{rr} = 3.50\%$
Volatilities				
Real Variables				
Output	2.51	1.92	1.70	1.60
Consumption	1.38	1.36	1.27	1.23
Investment	6.15	3.83	3.36	3.14
Hours	2.13	2.23	2.32	2.38
Financial Variables				
Credit	1.81	1.15	1.03	0.97
Deposits	1.88	1.36	1.65	1.94
Net worth	17.19	6.91	6.96	6.98
Leverage	15.71	6.56	6.67	6.73
Credit spread	0.58	0.29	0.27	0.26
Asset prices	1.56	0.97	0.85	0.79
Monetary Variables				
Inflation	0.20	0.24	0.30	0.35
Cyclicality of Financial System				
$\rho(\Delta_{spread}, \Delta_{GDP})$[c]	-0.86	-0.08	-0.02	0.04
$\rho(\Delta_{credit}, \Delta_{GDP})$[c]	0.96	0.67	0.79	0.80

[a] *Column 3 (5) is obtained by recalibrating φ to reduce (increase) the volatility of the reserve requirement rule by 50% compared to the benchmark model.*

[b] *σrr stands for the standard deviation of required reserves ratio over simulated series.*

[c] *$\rho(\Delta_{spread}, \Delta_{GDP})$ ($\rho(\Delta_{credit}, \Delta_{GDP})$) represents the correlation coefficient of loan-deposit spreads (credit) growth and output growth.*

Table 4: Impact of Alternative Policy Rules on Volatilities and Financial System Procyclicality

	No Reserves	Fixed Reserves	Credit Policy	Output Policy[a]	Asset Prices Policy[a]
	$\bar{rr} = 0$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$
Variable	$\phi = 0$	$\phi = 0$	$\phi = 3.28$	$\phi = 1.84$[b]	$\phi = 4.98$[b]
Volatilities					
Real Variables					
Output	2.65	2.51	1.70	1.93	1.64
Consumption	1.39	1.38	1.27	1.28	1.22
Investment	6.66	6.15	3.36	4.63	3.28
Hours	2.58	2.13	2.32	3.42	2.42
Financial Variables					
Credit	1.95	1.81	1.03	1.36	1.02
Deposits	1.99	1.88	1.65	1.93	1.70
Net worth	18.39	17.19	6.96	8.26	7.03
Leverage	16.78	15.71	6.67	7.71	6.75
Credit spread	0.68	0.58	0.27	0.33	0.27
Asset prices	1.69	1.56	0.85	1.17	0.83
Monetary Variables					
Inflation	0.23	0.20	0.30	0.39	0.32
Cyclicality of Financial System					
$\rho(\Delta_{spread}, \Delta_{GDP})$	-0.85	-0.86	-0.02	-0.39	0.03
$\rho(\Delta_{credit}, \Delta_{GDP})$	0.97	0.96	0.79	0.83	0.70

[a] Columns 5 and 6 are obtained by solving the model by replacing equation (30) by $rr_t = \bar{rr} + \phi E_t [log(y_{t+1}) - log(y_t)]$ and $rr_t = \bar{rr} + \phi E_t [log(q_{t+1}) - log(q_t)]$, respectively.

[b] Under each reserves policy regime, φ is recalibrated to match the standard deviation of RRR (2.33%) during the intervention period.

Table 5: Alternative Policy Rules on Volatilities and Financial System Procyclicality without Financial Shocks

	No Reserves	Fixed Reserves	Credit Policy	Output Policy	Asset Prices Policy
	$\bar{rr} = 0$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$
Variable	$\phi = 0$	$\phi = 0$	$\phi = 3.5^a$	$\phi = 1.895^a$	$\phi = 5.35^a$
Volatilities					
Real Variables					
Output	2.13	2.14	1.65	1.87	1.58
Consumption	1.37	1.38	1.27	1.30	1.22
Investment	4.16	4.19	3.04	4.25	2.96
Hours	0.21	0.20	2.30	3.39	2.44
Financial Variables					
Credit	1.24	1.24	0.92	1.24	0.91
Deposits	0.84	0.85	1.60	1.78	1.61
Credit spread	6.74	6.82	0.92	2.63	0.88
Asset prices	5.77	5.84	1.41	2.59	1.39
Net worth	0.34	0.31	0.11	0.15	0.12
Leverage	1.05	1.06	0.77	1.08	0.74
Monetary Variables					
Inflation	0.05	0.04	0.31	0.39	0.32
Cyclicality of Financial System					
ρ(Δspread, ΔGDP)	-0.96	-0.96	-0.56	-0.64	-0.42
ρ(Δcredit, ΔGDP)	0.97	0.97	0.92	0.83	0.69

[a] *Under each reserves policy regime, ϕ is recalibrated to match the standard deviation of RRR (2.33%) during the intervention period.*

Table 6: Loss Values under Alternative Policy Rules

	Fixed Reserves Policy	Credit Policy	Output Policy	Asset Prices Policy
	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$
Loss values	$\phi = 0$	$\phi = 3.28^a$	$\phi = 1.84^a$	$\phi = 4.98^a$
Under only TFP shocks	4.3613e-04	3.9560e-04	5.8147e-04	4.1233e-04
Under both shocks	6.4556e-04	4.6789e-04	4.8579e-04	6.4341e-04

[a] *Under each reserves policy regime, ϕ is calibrated to match the standard deviation of RRR (2.33%) during the intervention period.*

Table 7: Sensitivity of Credit Policy to Selected Model Parameters

	Fixed Reserves	Credit Policy	Fixed Reserves	Credit Policy
	$\lambda = 0.25$	$\lambda = 0.25$	$\lambda = 0.75$	$\lambda = 0.75$
	$(\bar{\kappa} = 12.85)$a		$(\bar{\kappa} = 4.28)$	
Variable	$(\overline{R_k - R} = 27$ bs. pt.)[a]	$\phi = 3.73$[b]	$(\overline{R_k - R} = 67$ bs. pt.)	$\phi = 2.82$
Real Variables				
Output	2.25	1.61	2.79	1.81
Consumption	1.37	1.29	1.43	1.28
Investment	4.78	2.87	7.39	3.86
Hours	1.11	2.28	2.96	2.37
Financial Variables				
Credit	1.42	0.88	2.15	1.17
Deposits	1.04	1.50	2.90	1.97
Net worth	20.91	6.49	15.90	7.19
Leverage	19.78	6.46	14.18	6.73
Credit spread	1.06	0.36	0.42	0.23
Asset prices	1.21	0.72	1.87	0.97
Monetary Variables				
Inflation	0.11	0.32	0.28	0.29
$\rho(\Delta spread\ ,\ \Delta GDP\ )$	-0.88	-0.02	-0.86	-0.01
$\rho(\Delta credit\ ,\ \Delta GDP\ )$	0.96	0.86	0.97	0.68
	$\theta = 0.955$	$\theta = 0.955$	$\theta = 0.97$	$\theta = 0.97$
	$(\bar{\kappa} = 7.56)$		$(\bar{\kappa} = 4.96)$	
Variable	$(\overline{R_k - R} = 52$ bs. pt.)	$\phi = 3.355$	$(\overline{R_k - R} = 43$ bs. pt.)	$\phi = 3.11$
Real Variables				
Output	2.40	1.68	2.70	1.75
Consumption	1.38	1.27	1.40	1.28
Investment	5.63	3.25	6.91	3.56
Hours	1.75	2.31	2.70	2.35
Financial Variables				
Credit	1.66	1.00	2.02	1.08
Deposits	1.53	1.60	2.46	1.78
Net worth	17.58	6.79	16.68	7.13
Leverage	16.23	6.57	15.01	6.73
Credit spread	0.53	0.23	0.68	0.34
Asset prices	1.43	0.82	1.75	0.90
Monetary Variables				
Inflation	0.17	0.31	0.26	0.30
$\rho(\Delta spread\ ,\ \Delta GDP\ )$	-0.87	-0.04	-0.86	0.02
$\rho(\Delta credit\ ,\ \Delta GDP\ )$	0.96	0.83	0.97	0.73
	$\varphi = 0.5$	$\varphi = 0.5$	$\varphi = 13.75$	$\varphi = 13.75$
	$(\bar{\kappa} = 6.25)$		$(\bar{\kappa} = 6.25)$	
Variable	$(\overline{R_k - R} = 48$ bs. pt.)	$\phi = 4.13$	$(\overline{R_k - R} = 48$ bs. pt.)	$\phi = 2.7$
Real Variables				
Output	2.64	2.08	2.42	1.60
Consumption	1.16	1.12	1.58	1.40
Investment	7.43	5.36	5.20	2.52
Hours	2.28	2.19	2.03	2.35
Financial Variables				
Credit	0.84	0.69	2.79	1.36
Deposits	1.37	1.29	2.25	1.86
Net worth	8.34	6.63	24.16	7.13
Leverage	7.94	6.54	21.72	6.68
Credit spread	0.31	0.30	0.78	0.27
Asset prices	0.14	0.10	2.63	1.27
Monetary Variables				
Inflation	0.22	0.25	0.19	0.31
$\rho(\Delta spread\ ,\ \Delta GDP\ )$	-0.85	0.03	-0.87	0.03
$\rho(\Delta credit\ ,\ \Delta GDP\ )$	0.61	0.46	0.97	0.81

[a] *The terms in parentheses denote the implied long-run level of bank leverage and credit spreads, respectively.*
[b] *For each sensitivity experiment, φ is recalibrated to match the standard deviation of RRR (2.33%) during the intervention period.*

Figure 1: Evolution of Required Reserve Ratios in Turkey

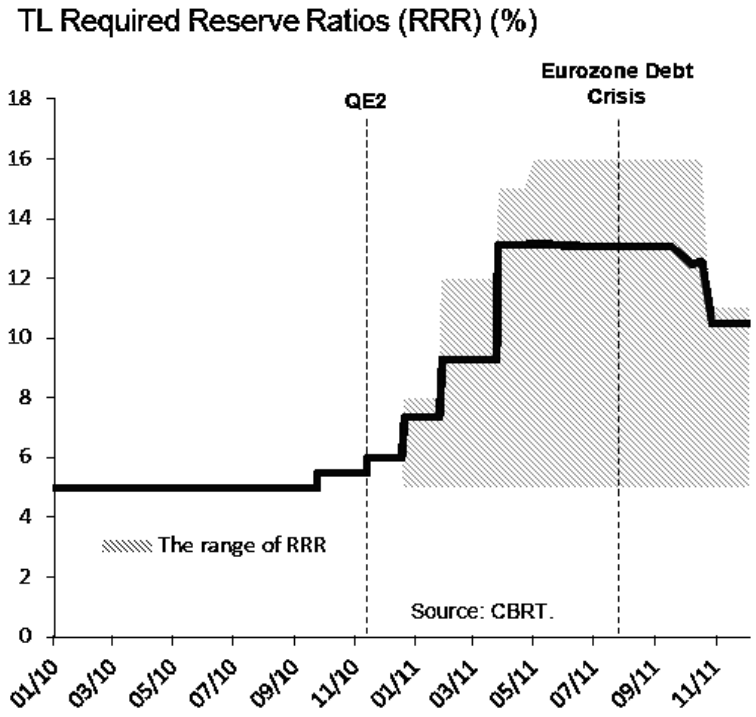


Figure 2: Steady-State Implications of Reserve Requirement Ratio

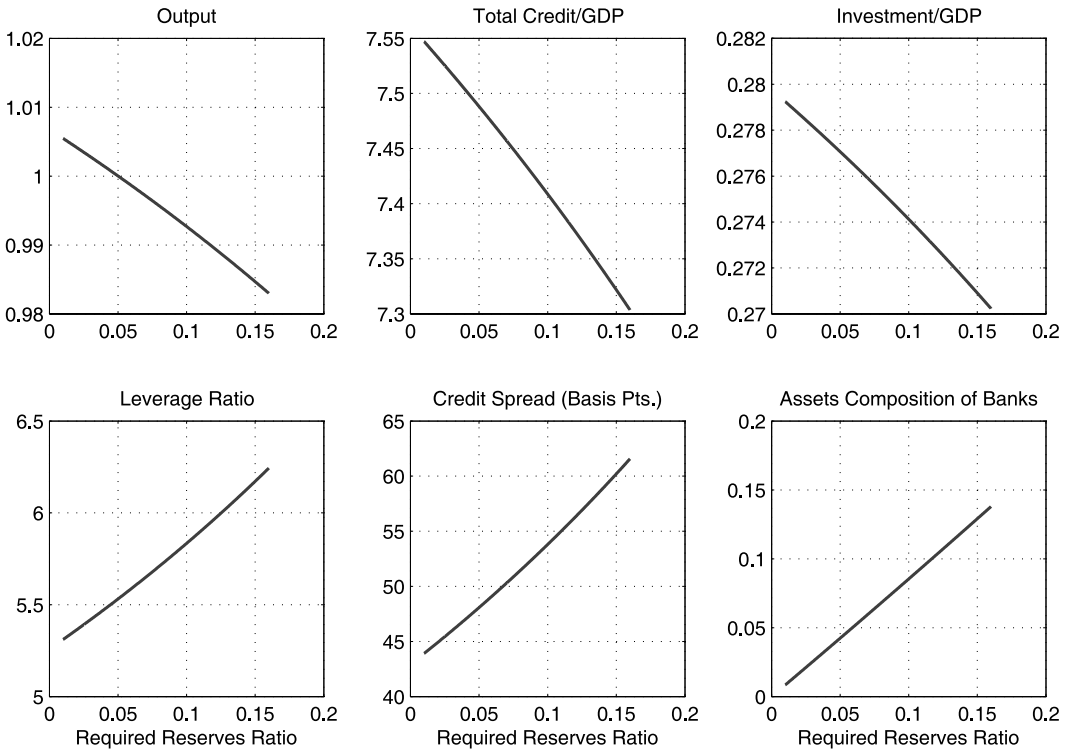


Figure 3: 1-σ Negative Productivity Shock

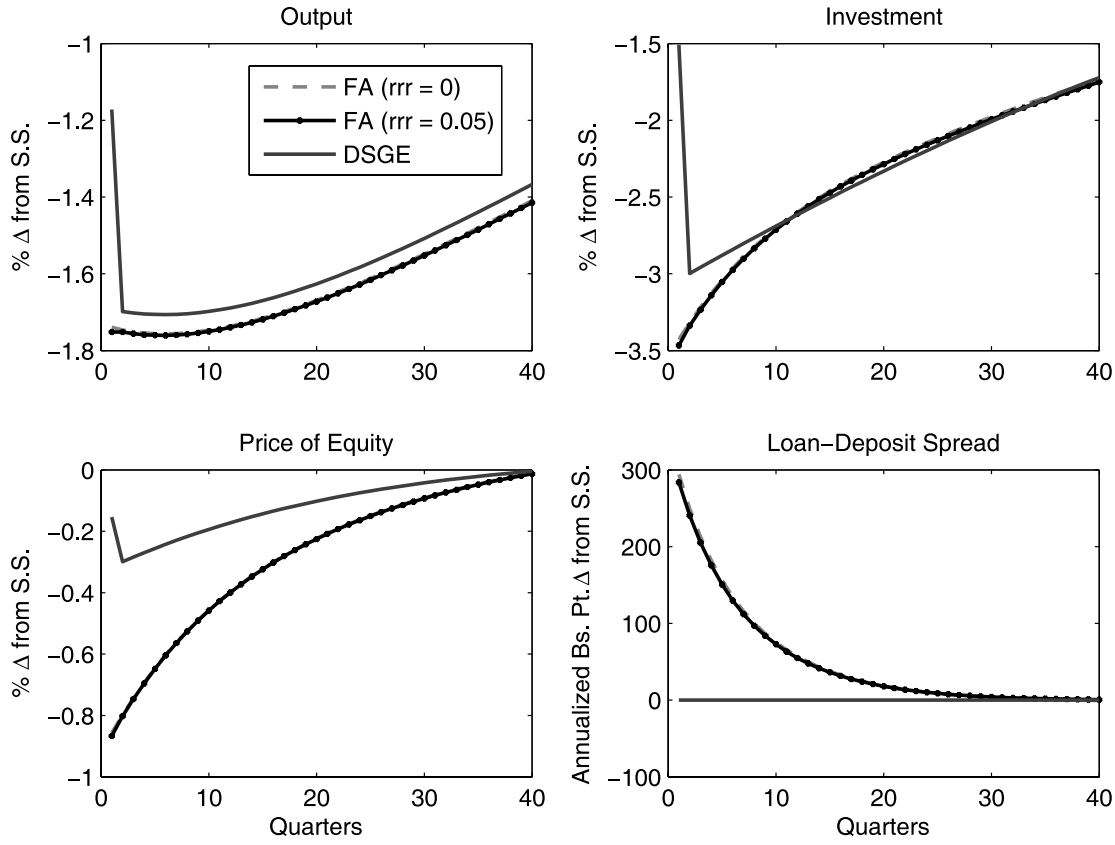


Figure 4: Impulse Responses Led by a 1-σ Adverse TFP Shock

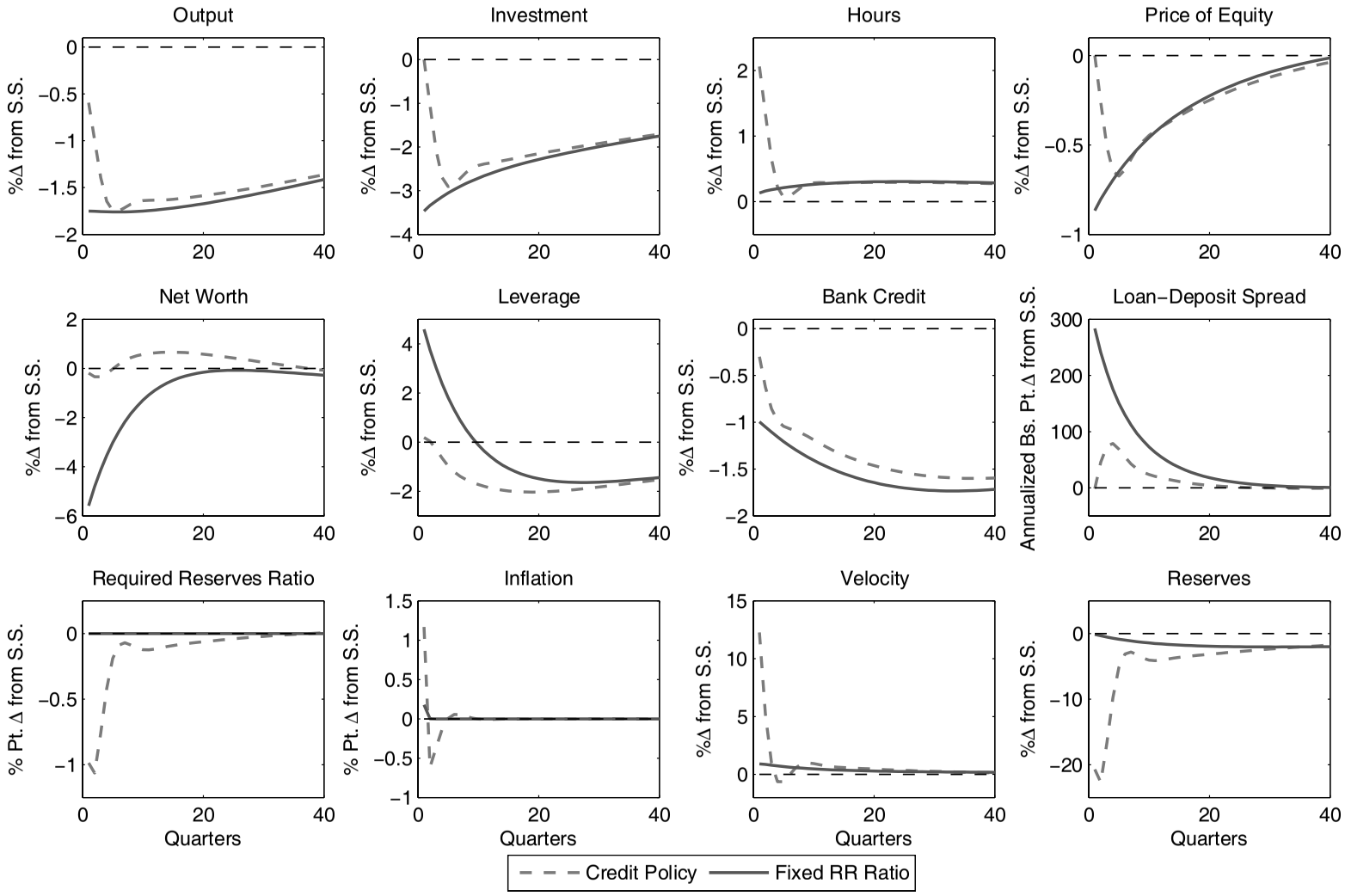


Figure 5: Impulse Responses Led by a 1-σ Adverse Financial Shock

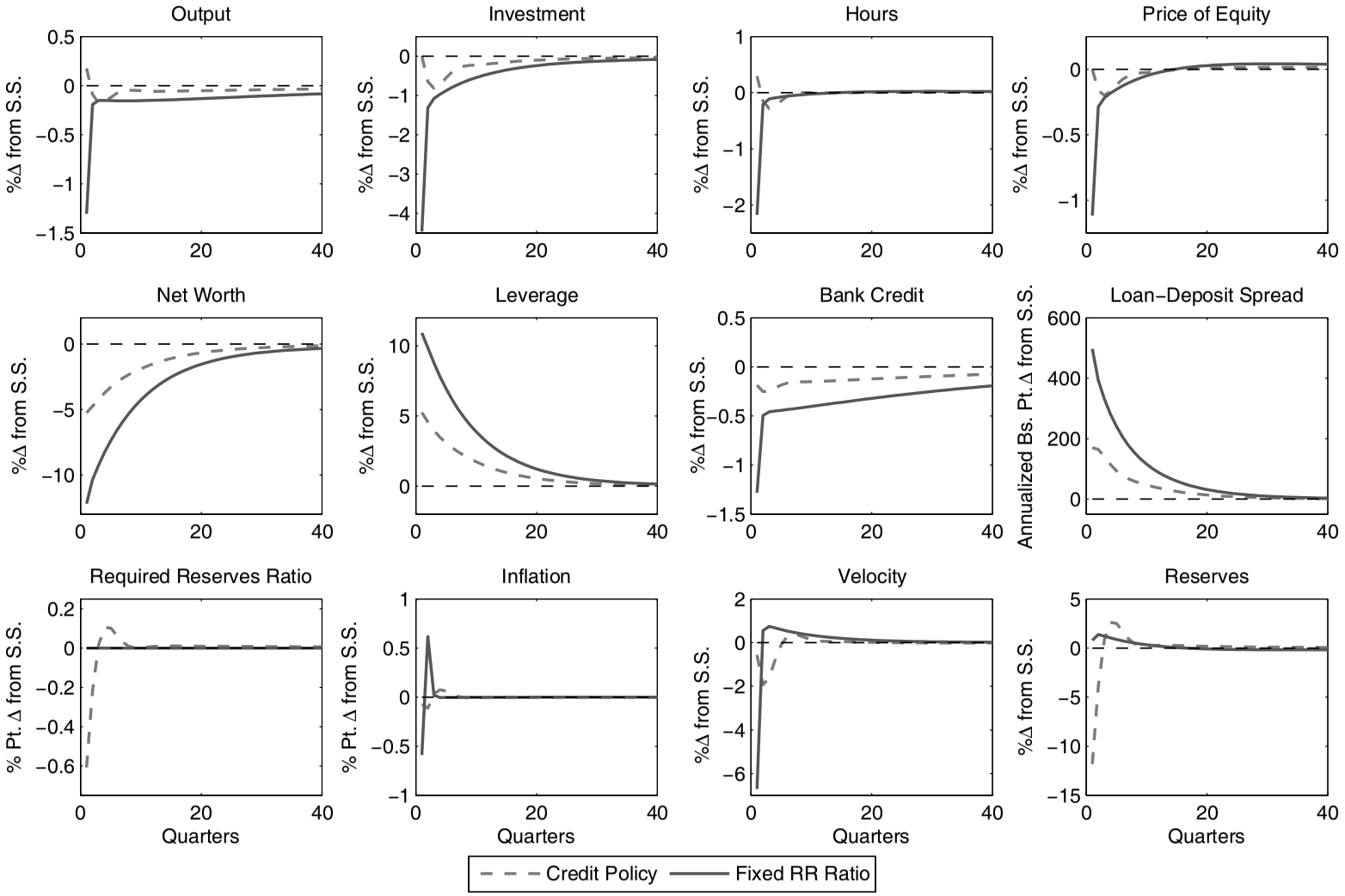


Figure 6: Loss Function for All Model Economies

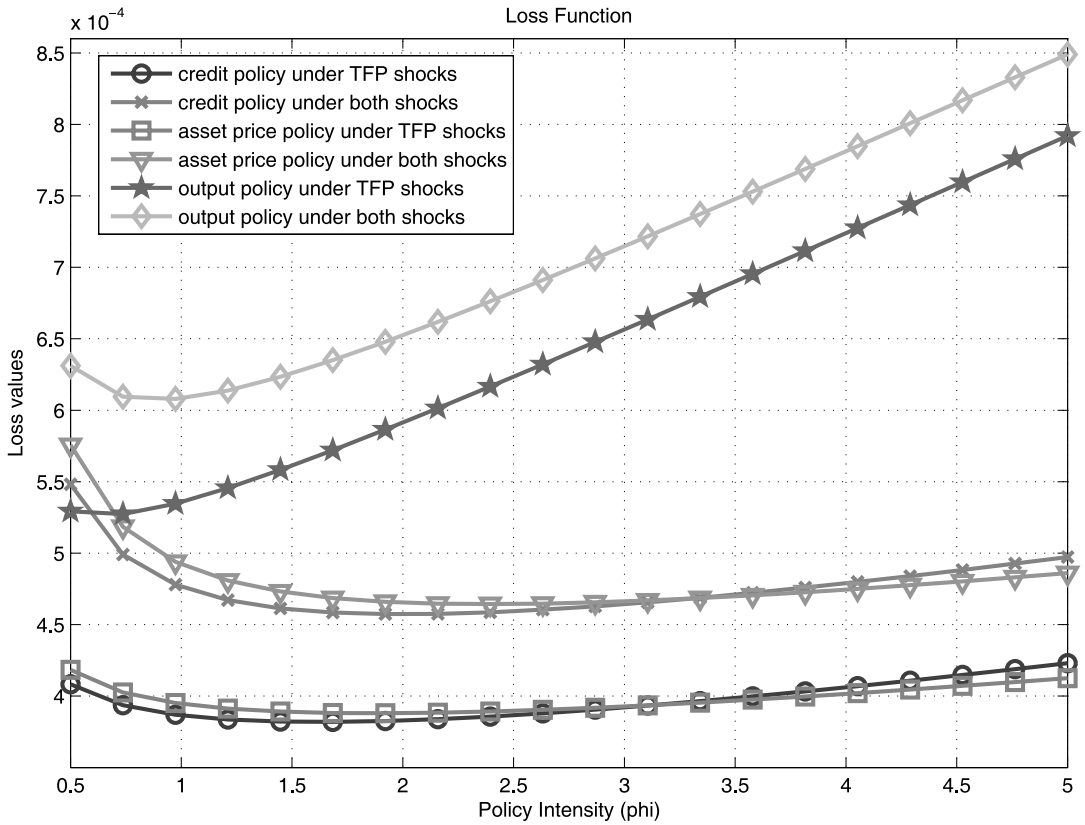


Figure 7: Loss Function under Different Policies

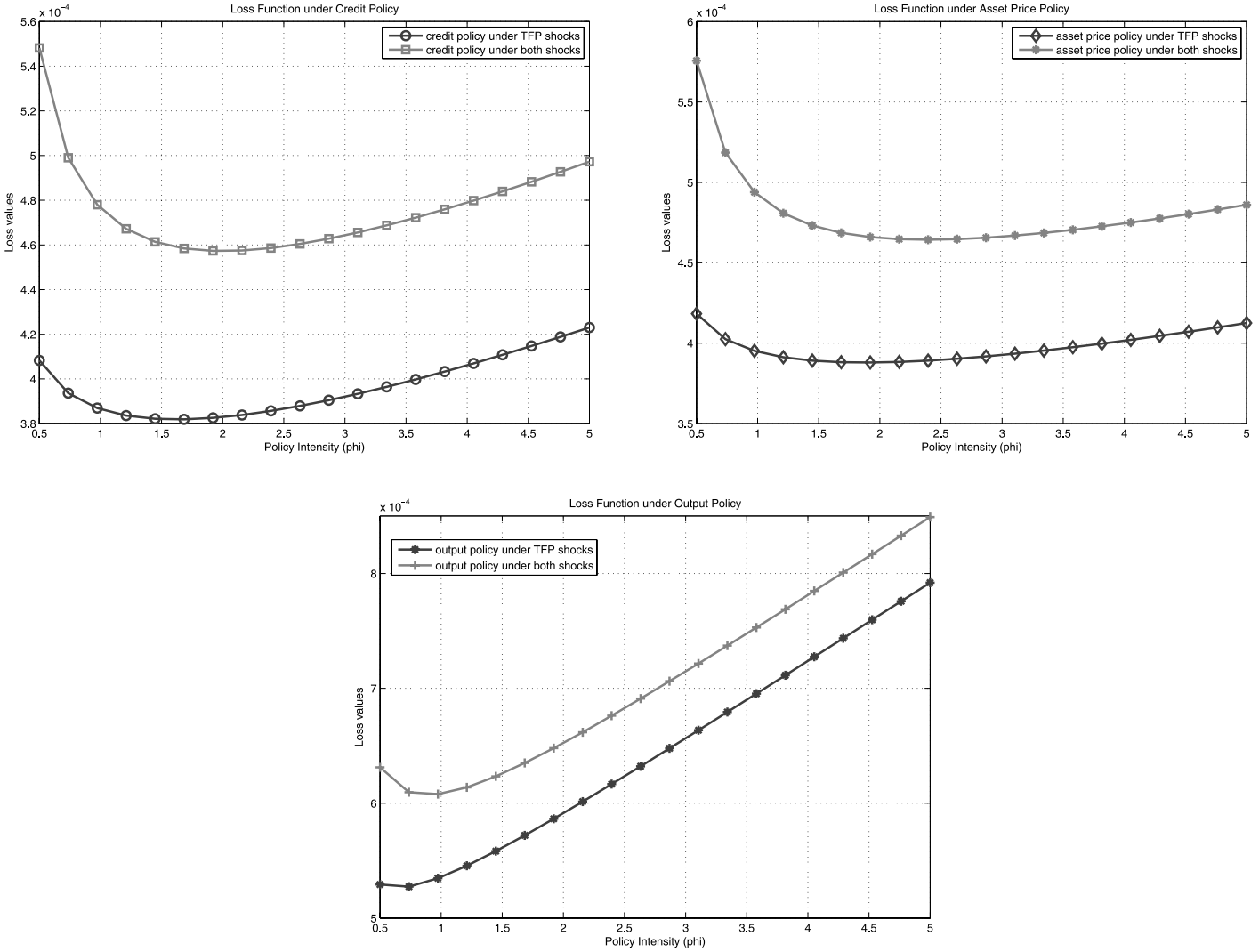
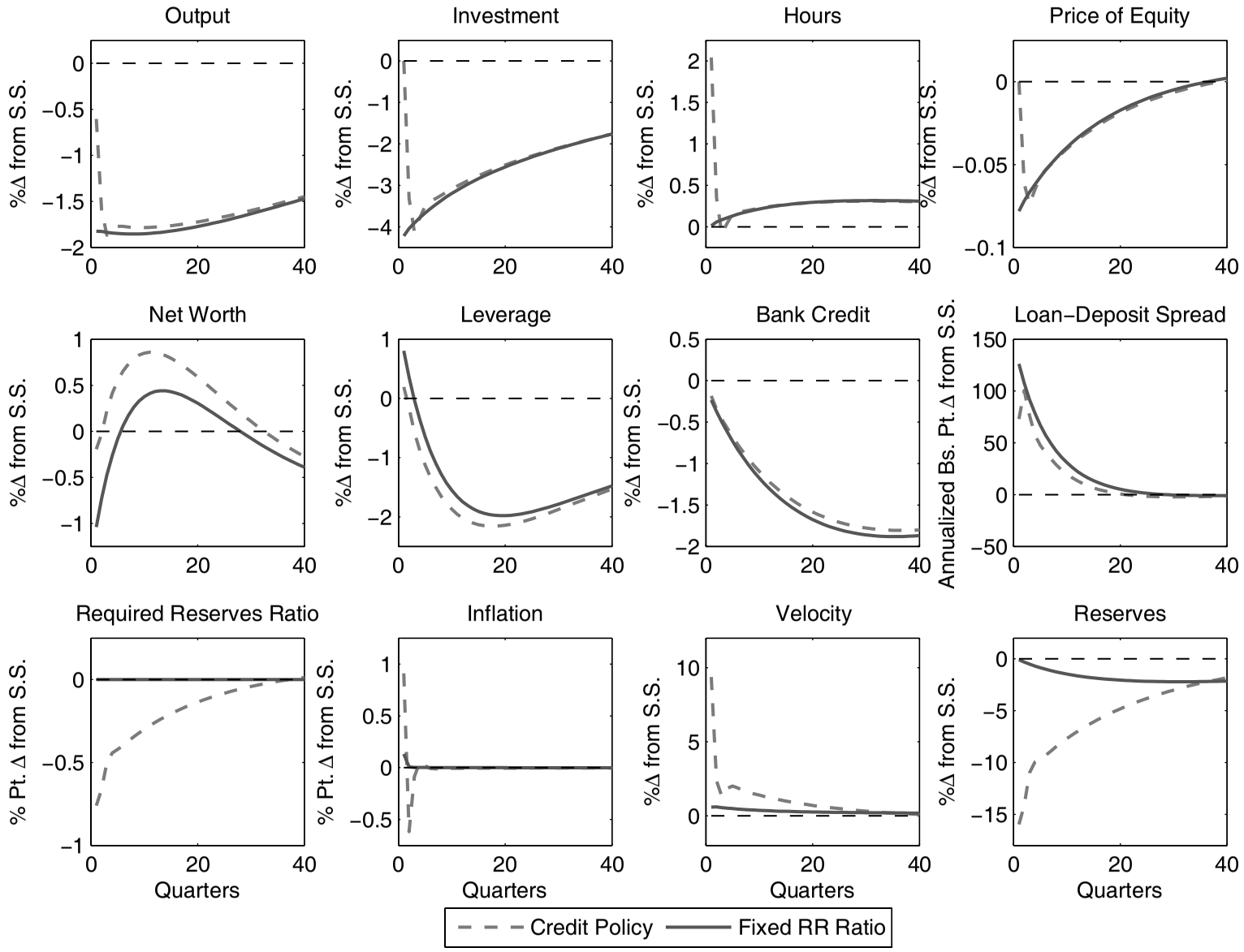


Figure 8: Impulse Responses Led by a 1-σ Adverse TFP Shock with ϕ = 0.5



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TRACKING MONETARY-FISCAL INTERACTIONS ACROSS TIME AND SPACE[1]

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Abstract

The fiscal position of many countries is worrying - and getting worse. Should formally independent central bankers be concerned about observed fiscal excesses spilling over to monetary policy and jeopardizing price stability? To provide some insights, this paper tracks the interactions between fiscal and monetary policies in the data across time and space. It makes three main contributions. The first one is methodological: we combine two recent econometric procedures - time-varying parameter vector autoregression with sign restrictions identification - and discuss the advantages of this approach. The second contribution is positive: we show how monetary-fiscal interactions and other macroeconomic variables have changed over time in six industrial countries (Australia, Canada, Japan, Switzerland, the UK, and the U.S.). The third contribution is normative: the paper highlights the role of the institutional design of each policy on the outcomes of both policies. Specifically, it first offers some evidence that an explicit long-term commitment of monetary policy (a legislated numerical target for average inflation) gives the central bank stronger grounds for not accommodating debt-financed fiscal shocks. Our second set of (albeit weaker) results then indicates that this threat of a policy tug-of- war may improve the government's incentives and fiscal outcomes - reducing the probability of both a fiscal crisis and unpleasant monetarist arithmetic.

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Keywords: Fiscal gap, monetary-fiscal interactions, sign restrictions, time-varying parameters VAR, unpleasant monetarist arithmetic.

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Nontechnical Summary

In the aftermath of the global financial crisis, several high-income countries have faced a substantial amount of fiscal stress. Most others are likely to follow in their footsteps within a decade or two, primarily due to the demographic trends of aging populations and ballooning per capita health care costs.

That such a fiscal trend is undesirable and threatens economic prosperity is uncontroversial. For example, the 2011 Global Risks Barometer by the World Economic Forum ranks 'fiscal crises' as the number 1 risk in terms of the perceived financial losses (out of 37 economic, geopolitical, societal, environmental, and technological risks), perceived as 'very likely to occur in the next ten years.'

It is, however, an open question whether such fiscal stress may affect the outcomes of monetary policy, and if so, how. The unpleasant monetarist arithmetic first warned of the possible inflationary consequences of fiscal excesses. The fiscal theory of the price level identified a slightly different channel through which fiscal stress can spill over to monetary policy and jeopardize the goal of price stability.

To contribute to the debate, this paper tracks the interactions between fiscal and monetary policies in the data across time and space, namely, from 1980 in six advanced countries: Australia, Canada, Japan, Switzerland, the UK, and the U.S. We do so using a novel empirical approach based on a combination of two recent econometric procedures - time-varying parameter vector autoregression with sign restrictions identification.

Our analysis highlights the role of the institutional design of monetary policy on the behavior of the central bank when faced with excessive fiscal policy. Specifically, we demonstrate that legislating a strong monetary commitment in the form of a numerical inflation target substantially changed the bank's interest rate responses to debt-financed government spending shocks. These shocks were no longer accommodated, and in fact they were offset by higher interest rates. Intuitively, a committed central bank engaged in a tug-of-war with the government in its pursuit of low inflation. Importantly, we show that this altered the government's incentives, as marked improvements in fiscal policy towards sustainability were observed 1-3 years after the adoption of explicit inflation targeting.

The implied policy conclusion is therefore that a strong commitment of monetary policy in the long term, reduced the threat of undesirably high inflation as well as increased the chances of the necessary fiscal reform.

1. Introduction

Many countries have been experiencing substantial fiscal stress. The responses to the global financial crisis combined with a large structural gap between government expenditures and revenues have led to rapidly growing debt-to-GDP ratios, which are forecasted to deteriorate much further due to aging populations.[3]

These cyclical and structural fiscal policy developments have given rise to a new wave of discussions on whether such fiscal stress affects the conduct of monetary policy, and if so, how. Does it (eventually) spill over and lead to sub-optimally high inflation as many observers fear? Or is formal central bank independence sufficient to shelter monetary policy from such fiscal spillovers? To provide some answers, this paper uses a novel empirical framework to track fiscal- monetary interactions over time in six major countries.

The fact that monetary and fiscal policies are inter-related is widely accepted. Both policies jointly affect a number of economic variables, including private agents' expectations, and these in turn affect the payoffs of central bankers and government officials. In addition to the obvious channels (such as the crowding-out effect or inflationary pressures arising from excessive government spending), the seminal work of Sargent and Wallace (1981) and Leeper (1991) identified two avenues through which fiscal excesses may spill over to monetary policy. When fiscal policymakers are unable or unwilling to balance their budgets, both the unpleasant monetarist arithmetic and the fiscal theory of the price level eventually imply undesirable departures from price stability.

Our game theoretic work Libich et al. (2012) analyzed such strategic monetary-fiscal interactions (the policy game of chicken) and identified two main institutional variables at play. The likelihood of inflationary fiscal spillovers into monetary policy was found to decrease with the degree of long-term monetary commitment (the explicitness of the inflation target) and to increase with the degree of fiscal rigidity (the size of the fiscal gap). These variables are graphically depicted for high-income countries in Figure A1 of Appendix A, which is accompanied by a discussion of the underlying intuition. The likelihood of unpleasant monetary arithmetic was found to diminish with the monetary commitment to fiscal rigidity ratio, i.e., it is lowest in Australia and New Zealand, and highest in the United States and Japan.

The presented paper attempts to assess these theoretic predictions using a novel econometric approach. We use vector autoregressions (VARs) with time-varying parameters (TVP) as introduced in Primiceri (2005) and Cogley and Sargent (2005).[4] The flexibility of this approach enables us to examine medium to long-term changes in policy behavior over and above the short- run stabilization issues explored in fixed-parameter VARs. Given the dire long-term fiscal projections, we believe that this broadened focus is warranted. It must, however, be acknowledged that the use of TVP-VARs requires a reduced number of endogenous variables and lags to keep the set of parameters manageable.

In comparison with standard approaches featuring structural breaks, the TVP-VAR framework allows for structural policy changes to be gradual and differ in their timing across the two policies. As such, an analysis based on TVP-VARs can be superior to an analysis based on data sub-samples.[5] We use the framework to contrast the differences in monetary policy responses to debt-financed government spending shocks in three early inflation-targeting countries (Australia, Canada, and the United Kingdom) before and after adoption of the regime, and compare them to those in countries without a legislated numerical inflation target (Japan, Switzerland, and the United States).

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[3] See, for example, IMF (2009), which reports the net present value of the impact of aging-related spending on fiscal deficits to be in the order of hundreds of percent of GDP for advanced countries (and on average over the G20 countries about ten times higher than the effect of the global financial crisis). Specifically for the United States, Batini, Callegari, and Guerreiro (2011) provide a recent estimate of the 'fiscal gap' (unfunded liabilities) arguing that: 'a full elimination of the fiscal and generational imbalances would require all taxes to go up and all transfers to be cut immediately and permanently by 35 percent' (italics in the original).

[4] TVP-VARs have been used by many studies, mainly to analyze monetary policy transmission (e.g. Canova et al., 2007; Benati and Surico, 2008). But there have also been applications to fiscal policy (Kirchner et al., 2010; Pereira and Lopes, 2010), financial issues (Eickmeier et al., 2011), exchange rate dynamics (Mumtaz and Sunder-Plassmann, 2010), oil price shock transmission (e.g. Baumeister and Peersman, 2008), and yield curve dynamics (Bianchi et al., 2009).

[5] It is well established that many advanced countries have experienced structural breaks in monetary and fiscal policy, with their policy regimes changing over time - see, for example, Davig and Leeper (2010) and Clarida, Gali, and Gertler (1998). Fiscal policy analyses based on sub-samples can be found in Pappa (2010), Perotti (2007), and Blanchard and Perotti (2002).

The methodological contribution of this paper, discussed in detail in the next section, is an extension of the TVP-VAR framework using an identification of fiscal shocks based on a combination of sign, magnitude, and contemporaneous restrictions.

So far, only Kirchner et al. (2010) and Pereira and Lopes (2010) have employed the TVP-VAR framework to assess the effect of fiscal policy shocks. Kirchner et al. (2010) focus on the euro area using the traditional recursive assumption (e.g. as in Fatás and Mihov, 2001) to identify government spending shocks. Pereira and Lopes (2010) examine the United States and identify the tax-net-of-transfers shock and the spending shock along the lines of Blanchard and Perotti (2002), who exploit institutional information on taxes and transfers to separate automatic movements of fiscal variables from fiscal shocks.

While the identification approach in Kirchner et al. (2010) and Pereira and Lopes (2010) based on the assumption of lagged reactions among endogenous variables is suitable in some contexts, it may be too restrictive for the analysis of monetary-fiscal interactions. This is because it implies that either the monetary authority does not react contemporaneously to fiscal shocks, or the fiscal authority neglects contemporary movements in monetary policy. Intuitively, such specification may implicitly impose unrealistic timing assumptions about the interaction between the monetary and fiscal authorities. As the game theoretic examination of monetary-fiscal interactions dating back to Sargent and Wallace (1981) suggests, the exact timing of policy moves is a crucial determinant of the outcomes of both policies. Similarly, Caldara and Kamps (2008) show that different identification approaches can lead to qualitatively different results in terms of monetary policy responses to government spending shocks.

Therefore, an additional advantage of using the sign restrictions framework in the policy context is that no timing assumptions on the monetary-fiscal interaction need to be imposed. On the other hand, sign restrictions are a weak identification approach in terms of there being many structural models that correspond to the estimated reduced-form model and satisfy the signs imposed on the impulse responses (Fry and Pagan, 2011). We mitigate this potential problem by adding a set of contemporaneous and magnitude restrictions.

Our analysis offers several insights regarding the monetary-fiscal interaction: how it changed over time, how it differed across countries, and how the institutional design of the policies may explain the changes and differences. In particular, it is shown that in the inflation-targeting countries considered, the degree of monetary policy accommodation of debt-financed fiscal shocks indeed decreased after the adoption of a numerical inflation target. In contrast, in the 'non-targeters' the degree of accommodation over the same period did not change much, or, most notably in the United States, increased.

Importantly, the inflation-targeting countries have not only improved their monetary outcomes. With a delay of 1-3 years after the adoption of the regime, their fiscal outcomes started improving as well, and remained in good shape until at least the recent crisis. These findings are consistent with the game theoretic predictions of Libich et al. (2012) that a long-term monetary commitment may help the central bank discipline governments (induce fiscal reforms) through a credible threat of a policy tug-of-war. This may explain the negative correlation in Figure A1: institutional reforms increasing long-term monetary commitment (moving a country to the right) may also induce a reduction in fiscal rigidity (a movement down). However, one needs to be careful in drawing conclusions about causality between stronger monetary commitment and improved fiscal outcomes - our evidence is limited to correlation.

The tentative policy recommendation is therefore as follows: to get an upper hand in the policy game of chicken, central banks should try to commit as explicitly as possible to their long-term inflation objective.[6] The fact that the Federal Open Market Committee has subscribed more explicitly to the 2% long-term inflation target is consistent with our recommendation. The committee's justification also seems to point to the channels examined in our paper: 'Communicating this inflation goal clearly to the public helps keep longer-term inflation expectations firmly anchored.'

[6] It should be stressed, however, that since the target is specified as a long-term objective achievable on average over the business cycle, it does not seem to reduce short-run policy stabilization flexibility: for recent evidence see e.g. Kuttner and Posen (2011) and for theoretic modeling see Libich (2011).

Our analysis offers additional results, most importantly regarding the size of output and private consumption multipliers and how these evolved over time. Due to space constraints we will cover these results in detail in a separate paper.

2. Identification

Three approaches to the identification of fiscal policy shocks have been established in the literature. First, the event-study approach (Ramey and Shapiro, 1998) focuses on describing the effects of an unexpected increase in government defense spending. Second, the structural VAR approach (Blanchard and Perotti, 2002) draws on the assumption of a lagged reaction of fiscal variables to changes in economic conditions. Third, the identification scheme based on sign restrictions, developed originally for the analysis of monetary policy shocks, has been applied to fiscal policy (Mountford and Uhlig, 2009; Pappa, 2009; Canova and Pappa, 2007). Recently, the sign restrictions identification approach has been enriched by additional identifying assumptions based on, for example, cointegration (Dungey and Fry, 2009) and magnitude restrictions (Hur, 2011).

Our identification procedure complements sign restrictions with magnitude and contemporaneous restrictions, building on Franta (2011). Our focus is on the identification of a debt-financed government spending shock. Government spending is defined as government consumption and investment, i.e., total expenditures excluding government transfers.

Similarly to Canova and Pappa (2007), Pappa (2009), and Dungey and Fry (2009) we assume that a positive debt-financed government spending shock increases: (i) government spending for four quarters, (ii) government debt for four quarters, and (iii) output for two quarters. The length of the imposed sign restrictions is related to some aspects of the data, which we discuss in Section 4. As shown in Pappa (2009) such restrictions, at least on impact, are consistent with standard structural models of both the real business cycle and the New Keynesian tradition, and they do not result from productivity, labor supply or monetary shocks.[7]

A rise in output and government debt can, however, also be brought about by a tax cut and/or an increase in transfers. Therefore, to filter out the effects of government transfer and tax shocks, we impose a magnitude restriction that an identified debt-financed spending shock does not increase government debt by more than the amount of government spending.[8] The situation where tax cuts imply an increase of tax revenues cannot be distinguished from a government spending shock within our identification framework, but such a scenario is arguably unlikely.

Next, to capture the fact that government purchases do not react much to the business cycle, we impose a zero contemporaneous restriction on the effect of a business cycle shock on government spending. This is reminiscent of the recursive identification of shocks when government spending is ordered before GDP. Nevertheless, we do not restrict the contemporaneous feedback between government debt and output to allow for the effect of automatic stabilizers on the fiscal variables (taxes/debt). The contemporaneous restriction on the relationship between output and government spending enables us to distinguish between a generic business cycle shock (Mountford and Uhlig, 2009) and fiscal shocks. As shown by Wouters (2005) a higher number of shocks identified implies greater reliability of the sign identification procedure.

Finally, let us stress that we do not impose any restriction on the interest rate because it is our main variable of interest, summarizing the responses of monetary policy to debt-financed spending shocks. Furthermore, no restriction on private consumption is imposed because of the opposite predictions of the

[7] Leeper et al. (2010) show within a neoclassical growth model fit to U.S. postwar data that government investment implementation delays can even lead to a slight decline of output in the short run. We discuss the anticipation effects of fiscal shocks in Section 6.

[8] In focusing on monetary-fiscal interactions we need to distinguish a debt-financed government spending shock from a tax-cut shock and government transfers shock. This is because the real economy behaves differently after different types of fiscal shocks (e.g. private investment is usually crowded out in the case of excessive government spending, but not in the case of a tax cut), which would warrant a different response from the central bank. To distinguish between spending and tax-cut shocks, Pappa (2010) assumes a zero or small correlation of the identified shock and tax revenues. The difference of our identification approach is driven by our set of endogenous variables, which includes government debt instead of tax revenues.

traditional Keynesian and real business cycle models: the former predicts an increase whereas the latter predicts a decrease in private consumption following a debt-financed government spending shock.

3. The Econometric Model

The reduced-form TVP-VAR follows Cogley and Sargent (2005) and Primiceri (2005):

$$y_t = X_t\beta_t + A_t^{-1}\Sigma_t\varepsilon_t \qquad t = p+1,...,T\,, \tag{1}$$

where y_t is an $M \times 1$ vector of endogenous variables, $X_t = I_M \otimes \left(1, y'_{t-1},...,y'_{t-p}\right)$ is a Kronecker product of the identity matrix with a constant and lagged vectors of endogenous variables, p denotes the number of lags, and ε_t denotes the vector of i.i.d. structural shocks. An $M(Mp+1)\times 1$ vector β_t stacks reduced-form coefficients, the matrix A_t is a lower triangular matrix capturing contemporaneous relations:

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{21,t} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{M1,t} & \cdots & \alpha_{M,M-1,t} & 1 \end{bmatrix},$$

and the matrix of standard deviations of structural shocks, Σ_t, is diagonal:

$$\Sigma_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{M,t} \end{bmatrix}.$$

The TVPs follow random walks and a geometric random walk:

$$\beta_{i,t} = \beta_{i,t-1} + u_t^i \qquad i = 1,...,M^2p + M\,, \tag{2}$$

$$\alpha_{i,t} = \alpha_{i,t-1} + v_t^i \qquad i = 1,...,\left(M^2 - M\right)/2\,, \tag{3}$$

$$\log(\sigma_{i,t}) = \log(\sigma_{i,t-1}) + w_t^i \qquad i = 1,...,M\,. \tag{4}$$

Model innovations are assumed to be jointly normally distributed:

$$\begin{bmatrix} \varepsilon_t \\ u_t \\ v_t \\ w_t \end{bmatrix} \sim N\left(0, \begin{bmatrix} I_M & 0 & 0 & 0 \\ 0 & U & 0 & 0 \\ 0 & 0 & V & 0 \\ 0 & 0 & 0 & W \end{bmatrix}\right), \tag{5}$$

where the vectors u_t, v_t and w_t consist of innovations as introduced in (2)-(4). The matrices U, V, and W are positive definite. Moreover, V is assumed to be a block diagonal matrix, with blocks constituted by the coefficient innovations from a particular equation, i.e., we assume that innovations to contemporaneous effects are uncorrelated across equations. Finally, we follow Cogley and Sargent (2005) and assume the matrix W to be diagonal. As noted in Kirchner et al. (2010) the reason is that fiscal TVP-VARs usually consist of more variables than VARs for monetary policy analysis and thus we need to reduce the number of parameters.

The simulation of the system (2)-(5) employs a Gibbs sampler. A sample from the joint posterior distribution of the parameter set is obtained from blocks that provide samples from conditional distributions. Thus, draws from the VAR coefficients $\beta_{i,t}$, contemporaneous relations $\alpha_{i,t}$, volatility states $\sigma_{i,t}$, and the

hyperparameters U, V, and W are produced by the sampler in turn. A detailed description of the sampler and priors used can be found in Appendix B. The Gibbs sampler generates 20,000 draws after a burn-in period of 20,000. Only every fifth draw is kept to avoid autocorrelation of draws. Convergence diagnostics are presented in Appendix C.

The identification of structural shocks boils down to finding a linear combination of structural shocks ε_t that yields the reduced-form residuals z_t . The relationship between the two is modeled in (1) as follows:

$$z_t = A_t^{-1}\Sigma_t\varepsilon_t \, .$$

The sign restrictions identification approach draws on the fact that for any orthonormal matrix Q, i.e., the matrix such that $Q'Q = I_M$, it holds that:

$$z_t = A_t^{-1}\Sigma_t Q'Q\varepsilon_t \, .$$

In such way the new set of uncorrelated structural shocks, $\tilde{\varepsilon}_{tt} = Q\varepsilon$, is produced and the new linear combination, $z_t = A_t^{-1}\Sigma_t Q'\tilde{\varepsilon}_t$, no longer determines the system of structural shocks recursively. However, the covariance matrix of the reduced-form residuals does not change.[9] The implementation of the identification restrictions is based on Givens rotations, i.e., orthonormal matrices of the form:

$$Q_{ij}(\theta) = \begin{pmatrix} 1 & \cdots & 0 & \cdots & 0 & \cdots & 0 \\ \vdots & \ddots & \vdots & & \vdots & & \vdots \\ 0 & \cdots & \cos(\theta) & \cdots & -\sin(\theta) & \cdots & 0 \\ \vdots & & \vdots & \ddots & \vdots & & \vdots \\ 0 & \cdots & \sin(\theta) & \cdots & \cos(\theta) & \cdots & 0 \\ \vdots & & \vdots & & \vdots & \ddots & \vdots \\ 0 & \cdots & 0 & \cdots & 0 & \cdots & 1 \end{pmatrix},$$

where the rotation angle and $\theta \in [0, \pi]$ respective goniometric functions occupy the i-th and j-th columns and the i-th and j-th rows of the matrix. For 5x5 matrices, any rotation can be constructed as a product of 10 possible Givens rotations:

$$Q(\theta) = \prod_{\substack{i,j=1 \\ i<j}}^{5} Q_{ij}(\theta) \, .$$

In order to impose no impact of output on government spending in a given period, we use only nine Givens rotations to guarantee zero at the respective position (the first row and the second column) in the matrix Q. Hence we have:

$$Q(\Theta) = Q_{24}(\theta_1)Q_{23}(\theta_2)Q_{14}(\theta_3)Q_{35}(\theta_4)Q_{34}(\theta_5)Q_{25}(\theta_6)Q_{45}(\theta_7)Q_{15}(\theta_8)Q_{13}(\theta_9) \, .$$

For each rotation we check the sign and magnitude restrictions. The sign restrictions are described in the first row of Table 1. Pappa (2009) shows that a crucial feature of the spending shock identification - distinguishing it from other types of shocks - is that unexpected spending raises output and the government deficit on impact. In terms of our framework this means that a government debt-financed spending shock increases output and government debt. In addition, the second and third rows of Table 1 present the reactions of endogenous variables to a generic business cycle shock (e.g. a technology or labor supply shock) and a monetary policy shock. The important feature of the shocks is that either they do not affect government spending contemporaneously, or they affect output and government debt in opposite directions.

[9] In contrast to Kirchner et al. (2010) and Pereira and Lopes (2010), the identification is not an integral part of the estimation procedure. In their case, the estimated matrices of the contemporaneous effects already embed the identification scheme.

Table 1. Sign Restrictions

	Output		Private consumption		Interest rate		Government spending		Government debt	
	impact	2 lags	impact	lag	impact	lag	impact	4 lags	impact	4 lags
Debt-financed gov. spending shock	+	+	none	none	none	none	+	+	+	+
Monetary policy shock	0	-	0	-	+	+	0	+/-	+	+
Generic business cycle shock	+/-	+/-	+/-	+/-	+/-	+/-	0	+/-	-	-

In addition, magnitude restrictions are imposed such that the effect of a shock on government spending is not lower than the effect of the shock on government debt in the next four quarters. If it is lower it means that other components of the government budget constraint must have been affected by the shock (e.g. lower tax revenues). Note that the magnitude restrictions are applied on a particular draw of the rotation matrix, i.e., on a particular structural model. For a given draw of the model parameters, at most forty rotations are tested to find the ones that satisfy the sign and magnitude restrictions.

4. Data

An analysis of this type is constrained by the unavailability of fiscal data affecting decisions on the variables and countries included. Our set of endogenous variables yt consists of five variables, namely, output, private consumption, the short-term interest rate, government spending (consumption and investment), and government debt.[10] All variables except the interest rate are in logs of real per capita terms. The data are quarterly, except for government debt, which is yearly. Using a simple univariate interpolation (Boot-Fiebes-Lisman) method we disaggregated the yearly debt data into quarters.[11] The data enter our analysis in levels like in Kirchner et al. (2010) - but unlike in Pereira and Lopes (2010), who detrend the data. This is for three reasons. First, trends can reveal valuable information about monetary-fiscal interactions and how these have changed over time. Second, this approach avoids the possibility of incorrectly imposing cointegration relationships; see Sims et al. (1990). Third, within the Bayesian estimation strategy it is not necessary to stationarize time series, as the presence of unit root does not affect the likelihood function. The lag length is set equal to two.[12] The data sources are described in Appendix G.

[10] This adds government debt to the four endogenous variable analyses of Kirchner et al. (2010) and Pereira and Lopes (2010) (the latter paper uses taxes net of transfers instead of private consumption). This choice is very close to the set of endogenous variables usually employed in VAR studies dealing with fiscal policy issues. VARs for monetary policy analysis use mainly output, inflation, the interest rate, and the exchange rate. It would be our preferred choice to also include the latter two variables in our estimation and thus better capture the monetary policy rule and open economy features, but this is not computationally feasible due to the large number of estimated parameters in the TVP-VAR framework.

[11] This is one of the reasons for imposing sign restrictions on the response of debt to four quarters: a change in government debt that occurs anytime during the year is reflected by the debt data in all four quarters. Similarly, this is true for the magnitude restrictions.

[12] The choice of the lag length is driven by both the number of parameters to estimate and an attempt to best capture the dynamics of endogenous variables. Two lags imply more than 10,000 parameters to estimate, and three lags almost 20,000. Exact determination of the lag length based on the marginal likelihood is beyond the scope of this paper. Nevertheless, some guidance can be taken from the sample autocorrelations presented in the following table for two and three lags. Even for two lags, the table does not indicate any problems with residual autocorrelation.

Autocorrelation of Reduced-Form Residuals

	lags		p=2					p=3		
	t-1	t-2	t-3	t-4	t-5	t-1	t-2	t-3	t-4	t-5
var1	0,15	0,03	0,20	0,08	0,05	0,10	0,02	0,11	0,01	0,03
var2	0,07	0,15	0,06	0,01	-0,02	0,10	0,07	0,08	0,04	0,01
var3	0,07	0,03	0,16	-0,08	0,04	0,11	0,06	0,11	-0,06	0,04
var4	0,13	0,10	0,20	-0,04	0,10	0,17	0,09	0,10	0,02	0,04
var5	0,12	-0,05	0,08	0,07	0,06	0,09	-0,03	0,09	0,07	0,07

We estimate the model for Australia, Canada, Japan, Switzerland, the UK, and the U.S. The country choice is driven by our interest in comparing countries with and without a legislated inflation target. As there are only three advanced countries in the latter category (Japan, Switzerland, and the U.S.), we pick an equal number of early targeters. Their choice follows the justification of Dotsey (2006), most importantly the fact that 'their inflation rates were fairly well contained before they adopted inflation targeting.'

The data set covers the period 1980Q1-2008Q2 (the UK data set begins in 1981Q1). We do not include data on the recent financial crisis in our benchmark analysis for three main reasons. First, it is well documented that this period reflected an environment of increased risk following the collapse of Lehman Brothers and the subsequent credit crunch. As we are interested in monetary- fiscal interactions, we would like the interest rate to represent the behavior of monetary policy alone, rather than risk. Second, during the crisis central banks affected the economy through additional channels, e.g. by directly subsidizing commercial banks. Third, our priors are based on OLS estimates of the model on the whole sample, so extreme observations can alter the estimates in a way unrepresentative of the medium to long-term developments.[13] Nevertheless, as a demonstration we report the estimates on the dataset ending with 2010Q4 for the U.S. in Appendix F. It shows that while our benchmark results are robust, including the recent crisis leads to some loss of insight.

Two points in relation to data choices are worth emphasizing. First, to analyze monetary-fiscal interactions an appropriate short-term interest rate must be chosen, one that reflects the monetary policy stance for the whole period. This means that we do not automatically use the currently announced instrument of the central bank, as it may not be informative of monetary policy behavior under older style money growth targeting performed at the start of our sample. Therefore, for robustness we mainly use the Treasury bill rate. Second, government spending data are usually available for the general level of government (except the UK). However, the government debt data relate to central government only. Assuming that the change in general government debt is no smaller than the change in central government debt, the magnitude restrictions imposed imply that the change in general government spending does not exceed the change in general government debt.

5. Two Conjectures

Our game theoretic work Libich et al. (2012) implies two conjectures regarding monetary-fiscal interactions (Appendix A sketches the theory and intuition behind them):

Conjecture 1: A central bank with a numerical target for average inflation is less prone to accommodate a debt-financed government spending shock than a central bank without such an explicit long-term monetary commitment.

Conjecture 2: Legislating a long-term monetary commitment (and the subsequent change in monetary policy responses described in Conjecture 1) alters the incentives of governments by reducing their payoff from debt-financed spending, and therefore leads to an improvement in the fiscal balance.

[13] As Canova (2007) suggested, in the case of short samples it is preferable not to use a training sample that would be discarded.

In summary, we are interested in both directions of the policy interactions: from fiscal to monetary, and from monetary to fiscal. Tracking how these have changed over time can provide some clues about the possible outcomes of both policies in the future. Specifically, it is of high importance to anticipate to what extent the observed and predicted structural fiscal shortfalls can threaten the outcomes of monetary policy, and whether any institutional arrangements can play a positive role in this respect.

Such interest drives our empirical analysis. We estimate the impulse response functions (IRFs) of the endogenous variables to a positive debt-financed government spending shock. As shown by Fry and Pagan (2011) sign restrictions can recover correct impulse responses to an *unknown* one standard deviation shock, i.e., one cannot distinguish between the shock itself and the contemporaneous effect of the shock on a variable.[14] Therefore, the impulse responses are normalized with respect to the impact of the shock on government spending. Since the sign of the impact is driven by the sign of the contemporaneous effect, the signs of the IRFs provide accurate information. It should be acknowledged that the same cannot be claimed with certainty about the magnitudes of the IRFs, which are of interest for comparison between periods. However, assuming that the variance in the impacts is driven mainly by shocks - that is basically our prior belief on hyperparameters implying variation of coefficients in comparison with the prior on the variation of volatility - conclusions can be also made with respect to changes in magnitude.

Finally, in order to get the interpretation of impulse responses as multipliers, the size of the shock equals one percent of GDP and all endogenous variables except the interest rate are also expressed as a percentage of GDP. The interest rate, which is the main variable of interest, is considered in percentage points. To maintain the focus on monetary-fiscal interactions, in the main text we will only report the impulse responses of the interest rate to the debt-financed fiscal shock. For an illustration of the rest of the results, the responses on impact and in the 3rd quarter are available in Appendix D for all variables and countries.

6. Results Regarding Conjecture 1

If Conjecture 1 is correct, we should see no monetary accommodation of fiscal shocks (lowering of interest rates) after a numerical inflation target is legislated, or even observe the central bank offsetting such shocks by raising interest rates. In contrast, Conjecture 1 predicts no change or possibly more monetary accommodation in countries without a legislated inflation objective.

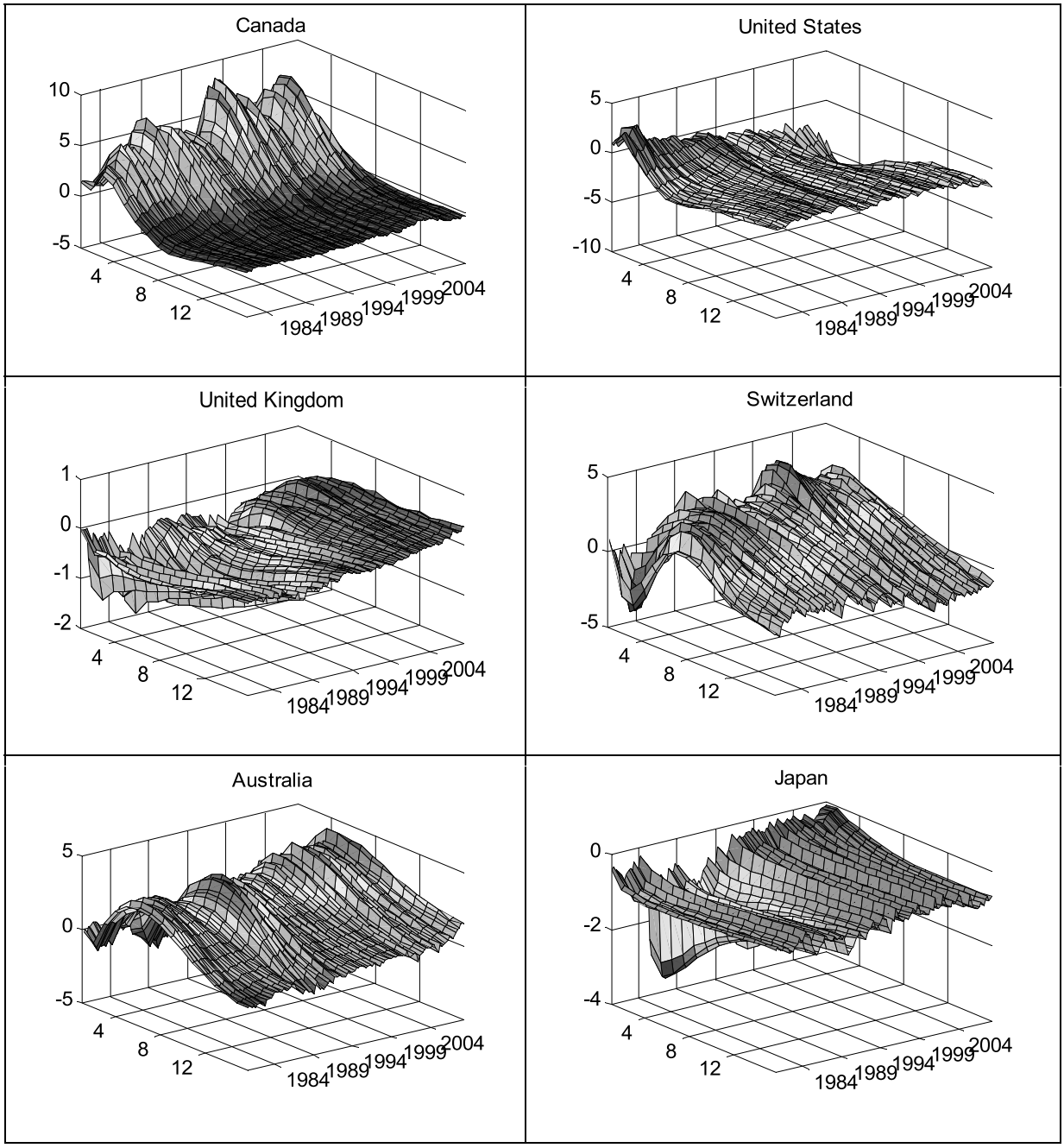
6.1. Estimated Impulse Responses

Figure 1 reports the estimated responses of the interest rate to the fiscal shock for all the countries considered. It plots the medians of the posterior distributions. Figure 2 presents the *average* responses for two sub-samples in order to better contrast monetary policy behavior before and after the introduction of an explicit numerical inflation target.[15]

[14] Primiceri (2005) avoids this problem by assuming recursive identification and estimating the matrix of standard deviations Σ_t and the matrix of contemporaneous effects A_t separately. We adjust the matrices with the rotations and hence lose the possibility of distinguishing them.

[15] Note that for countries without a legislated inflation target the switch period for the computation of the average responses is set to 1992/1993 following Dotsey (2006).

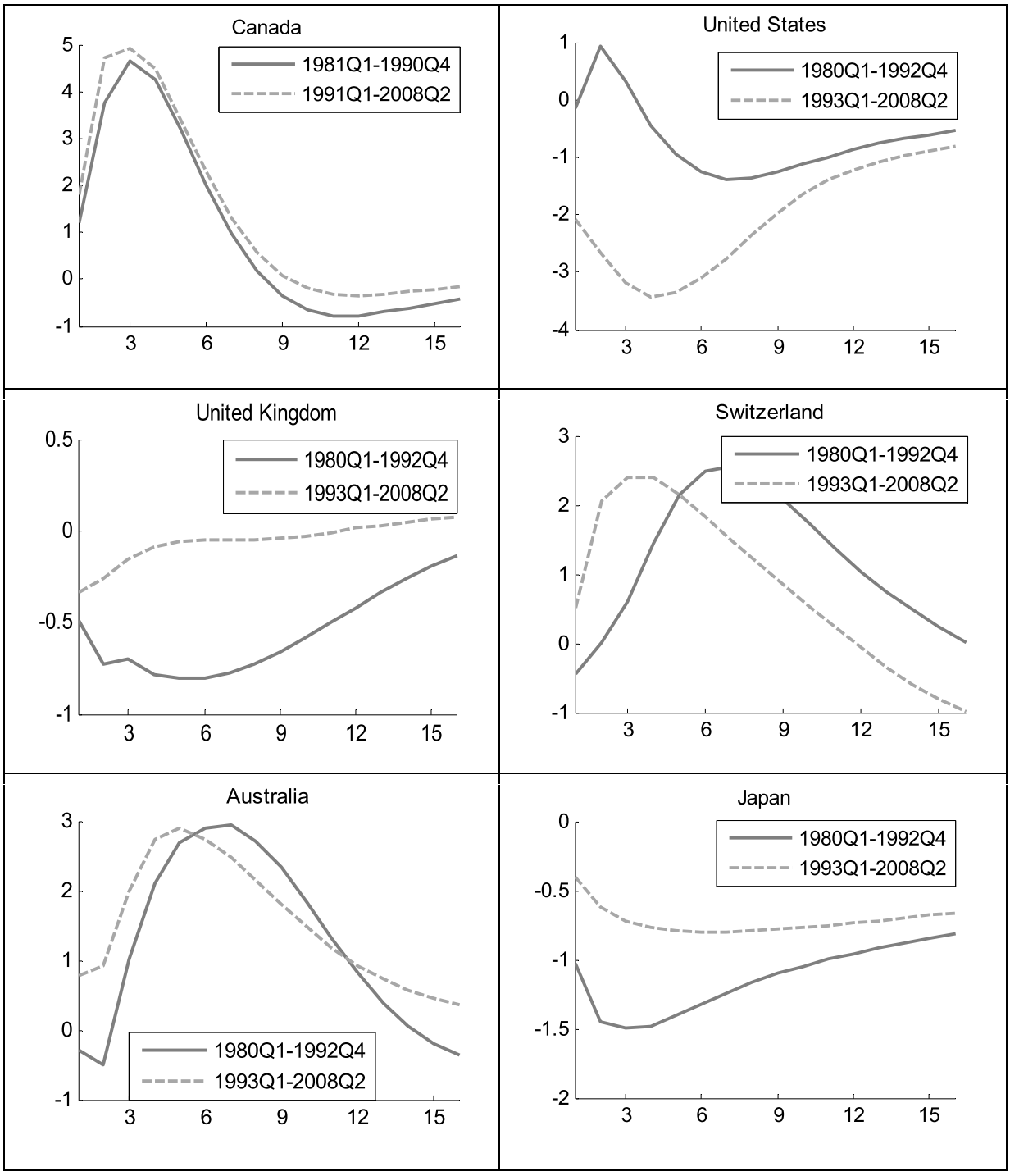
Figure 1: IRF of the Interest Rate for Explicit Inflation Targeters (the Left Column) and Non- targeters (the Right Column)



The results in Figures 1-2 are largely consistent with Conjecture 1. The estimates suggest that after legislating a numerical inflation target the central banks' response to unexpected debt- financed government spending has changed in all three countries considered in the predicted direction of less accommodation or more offsetting.[16]

[16] This is in line with the results of Kirchner et al. (2010) and Cimadomo (2010) for the euro area.

Figure 2: Average IRFs of the Interest Rate for a Horizon of 16 Quarters



6.2. Discussion of Explicit Inflation Targeters

The left columns of Figures 1 and 2 show the following changes after the formal adoption of the inflation-targeting regime. The Bank of Canada now tends to offset fiscal shocks slightly more aggressively on impact as well as over longer horizons (where it seems to have switched from accommodating to no reaction). Specifically, after an episode of M1 growth targeting (ending in November 1982) and a short period without a specific anchor for monetary policy, in 1988 the Bank of Canada announced price stability to be its new monetary policy goal. This announcement corresponds to the first peak of monetary offsetting of fiscal shocks in Figure 1. Such offsetting further increased in the 1990s after the formal adoption of inflation targeting. This is especially visible around 1998 (the horizon of the second inflation target announced in 1993).

As for the UK, the degree of fiscal shock accommodation by the Bank of England has decreased substantially over time, as Figure 2 shows. Figure 1 then reveals a more nuanced view of what happened. The monetary accommodation of debt-financed government spending shocks observed in the 1980s largely disappeared around the introduction of an explicit inflation target in 1992. Interestingly, this arrangement was not sufficient and accommodation resurfaced until the Bank of England was granted formal independence from the government in 1997. This seems to confirm what many have argued: formal central bank independence is a pre-requisite for an inflation- targeting regime to function effectively (see e.g. Masson et al., 1997).

Turning to Australia, in the 1980s the Reserve Bank of Australia tended to accommodate fiscal shocks on impact and then, after about one year (arguably when the inflationary effects became apparent), the bank would reverse this accommodation by tightening monetary policy. Such (non- forward-looking) responses led to a much greater volatility of the interest rate instrument and were inconsistent with the notion of interest rate smoothing (Woodford, 1999). Figures 1 and 2 show that after the adoption of a numerical inflation target in 1993 there is no more monetary accommodation of debt-financed fiscal shocks on impact. The bank raises rates immediately and keeps increasing them further for another four quarters to offset the effect of such shocks.

6.3. Discussion of Non-targeters

In contrast to full-fledged inflation targeters, the central banks in the three considered countries without a legislated inflation commitment (the right column of Figure 1) accommodated on impact both before and after 1992. Since 1992 they have either not changed their responses to debt-financed spending shocks in a major way (Japan and Switzerland), or their policy response has become more accommodative (the United States).

In the U.S., Figure 1 shows that the degree of monetary accommodation of debt-financed fiscal shocks has been increasing through time over all horizons. It is interesting to note the strong monetary offsetting of such shocks in the early 1980s. This reflects the tug-of-war between Chairman Volcker's disinflation efforts and the expansionary fiscal policies of the Reagan administration. This finding is in line with the estimates of Davig and Leeper (2011), who identify this period as an active fiscal and active monetary regime in which debt is on an explosive path. Our estimated U.S. monetary policy responses for other periods also match Davig and Leeper (2011). For example, the period from the early 2000s on can be characterized as passive monetary policy accommodating active fiscal policy.

In the case of Japan, we see monetary accommodation over all horizons throughout the sample. Naturally, its magnitude since the early 1990s has been constrained by the zero lower bound on interest rates, which is reflected in our results even though we did not explicitly account for this bound.

As regards Switzerland, the Swiss National Bank is arguably closer to being an explicit inflation targeter, with an upper bound on medium-term inflation (similar to that of the European Central Bank). This can be seen in our estimates, in that monetary accommodation on impact is smaller (or non-existent) in the second part of the sample, largely due to strong monetary offsetting of fiscal shocks in the period since 1999, in which the bank re-iterated price stability as being an important part of its monetary policy framework. Nevertheless, the impulse responses reveal that the bank has started accommodating shocks in the medium run, suggesting its monetary commitment may be insufficiently explicit.

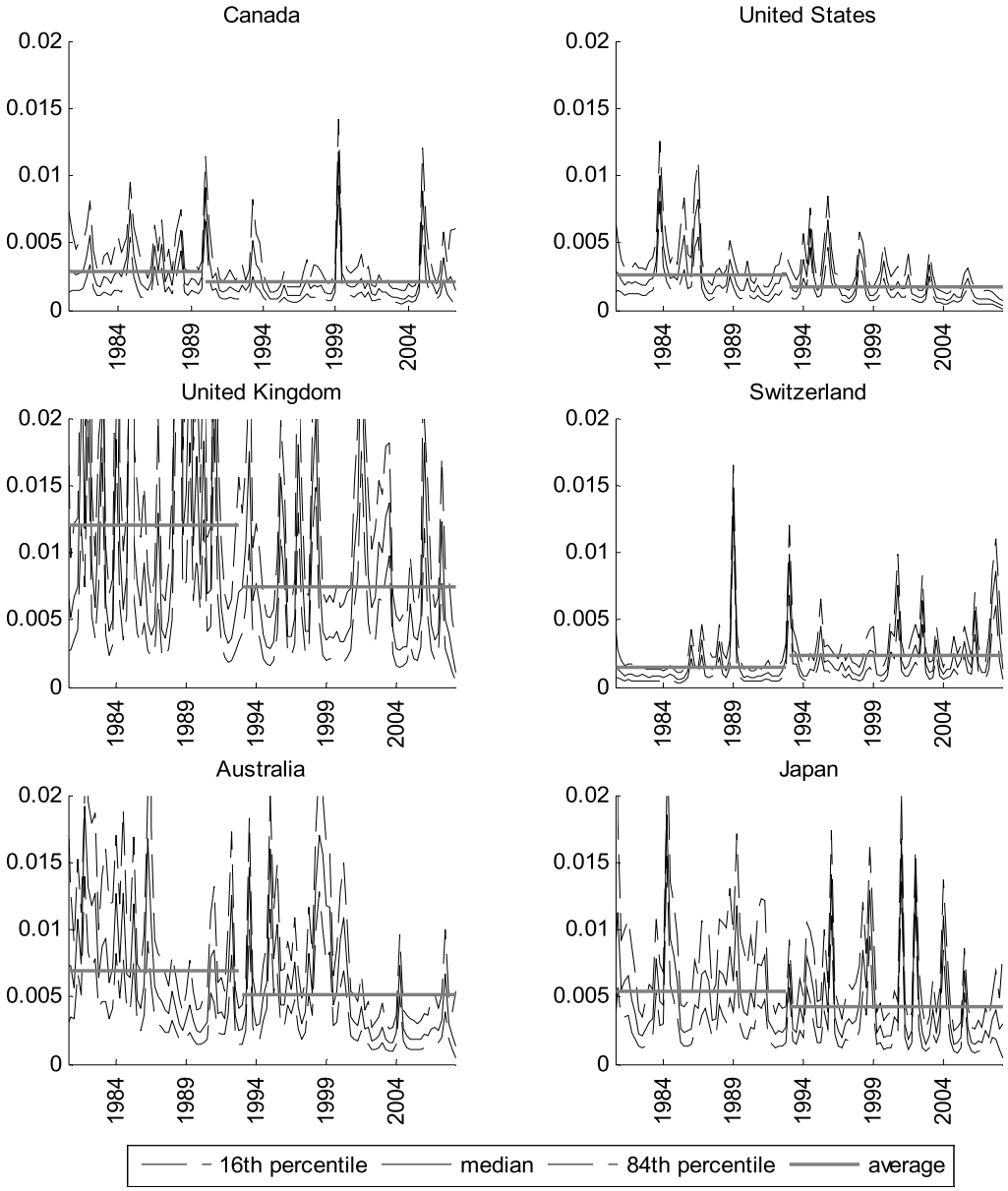
Let us stress that the presented results should be taken as only indicative, not conclusive. As already discussed, the TVP-VARs contain a large number of parameters, and an additional piece of information in the form of priors will not necessarily lead to a substantial decrease in uncertainty. Moreover, the identification based on sign restrictions adds uncertainty related to the structural model underlying the reduced-form VAR. For illustration, Figures E1 and E2 in Appendix E present the effects of a debt-financed spending shock on impact together with the centered 68 percent of the posterior distribution of the response. In general, the posterior distributions for the two periods overlap to a large extent. Nevertheless, for some countries and horizons, the centered 68 percent of the posterior distribution lies above/below the horizontal axis, which suggests changes in the responses. Figure E3 shows credible intervals for the posterior distribution of all IRFs for a given sub-period.

7. Results Regarding Conjecture 2

Conjecture 2 implies that the estimated standard deviations of debt-financed government spending shocks should decrease after a numerical inflation target is legislated. The fact that government spending does not react contemporaneously to the business cycle shocks in our identification approach is an advantage, as it means that the reduced-form residuals in the equation for government spending do not capture immediate reactions of government spending to the state of the real economy. Nevertheless, they can represent both an unexpected fiscal shock and an immediate reaction to an unexpected monetary policy shock. Therefore, a decrease in the standard deviation of the reduced-form residuals could be caused not only by a reduction in the frequency/size of debt-financed government spending shocks, but also by a reduction in the response of the fiscal authority to monetary policy actions.

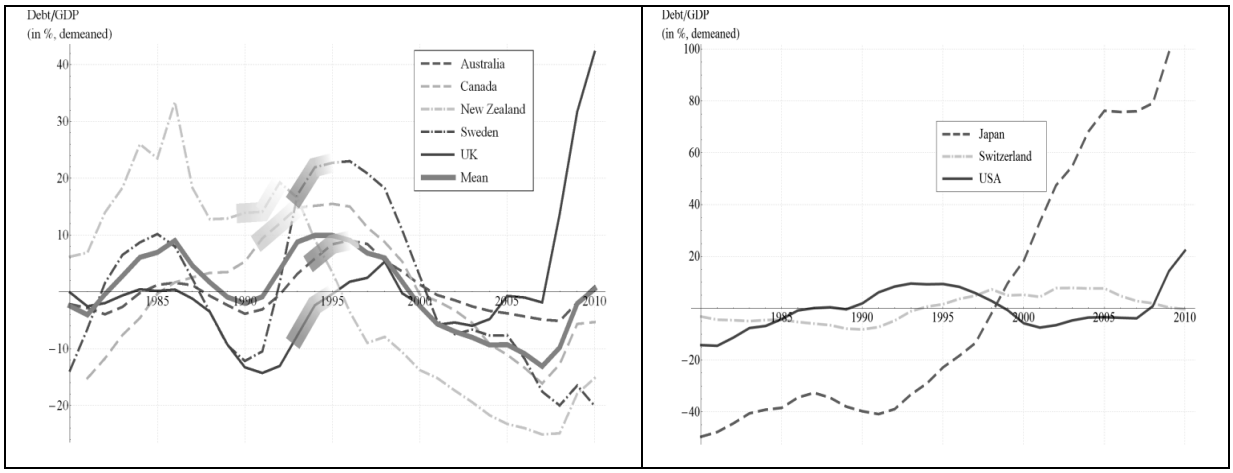
Figure 3 shows the standard deviation of the reduced-form residuals for spending, with the red line indicating the average of the standard deviations median for the two sub-periods. The figure shows - in line with Conjecture 2 - that the standard deviation decreased after the adoption of formal inflation targeting. Nevertheless, reductions in the volatility of spending are present for some of the non-targeters as well, so no clear-cut conclusions can be drawn. Figure E4 in Appendix E captures credible intervals for the posterior distribution of the reduced-form residuals in the equation for government spending over a given sub-period.

Figure 3: Estimated Standard Deviations of the Reduced-form Residuals for Government Spending



Therefore, in order to get an indication of whether the reductions in the volatility of fiscal shocks are linked to the commitment effect of an explicit inflation target, Figure 4 plots the central government debt to GDP ratio separately for five early inflation targeters and non-targeters (to better see the trends the series are de-meaned). In all five early targeters, we can see a decrease in government debt starting about 1-3 years after the formal adoption of an explicit inflation target (in the case of the UK after the subsequent granting of central bank instrument independence discussed above). These improvements are sustained at least until the global financial crisis. In contrast, such improvements in the fiscal balance are not present for the non-targeters. A similar picture emerges if we plot the (primary) deficit to GDP ratio.

Figure 4: Central Government Debt (De-meaned) to GDP for Explicit Inflation Targeters (the Left Panel, where the Start of the Regime Is Indicated by the Shaded Region) and Non-targeters (the Right Panel)



It should be emphasized, however, that this and the negative correlation of monetary commitment and fiscal rigidity reported in Figure A1 do not constitute evidence of causality. It is plausible that both the introduction of inflation targeting and the improvement of fiscal policy were driven by a common factor. Narrative evidence shows this to be the case for Canada, where fiscal sustainability became the number one policy issue for the public at the time see Mauro (2011). But the New Zealand experience tells a different story. As the former governor of the Reserve Bank of New Zealand Don Brash (2011) argues: 'I have not the slightest doubt that having legislation which requires government and central bank to formally agree, and disclose to the public, the inflation rate which the central bank must target has a most useful role in creating strong incentives for good fiscal policy.'[17]

Importantly, the fact that fiscal outcomes *continued* to be well behaved in the inflation-targeting countries considered long after the original fiscally responsible governments left office provides some anecdotal evidence for the 'disciplining effect' of an explicit monetary commitment over fiscal policy.

8. Notes on Anticipation Effects and Some Robustness Issues

In this section we briefly discuss the anticipation effects of fiscal policy shocks in relation to our modeling approach and then touch on several robustness issues of the estimation. Government spending shocks are often anticipated by agents because of implementation and legislative lags.

Anticipation effects can be related to the timing of a spending shock (Ramey, 2011), or the way future fiscal adjustment will be carried out (Leeper et al., 2010).

The identification approach used in this paper can deal with the first type of anticipation effects similarly to Mountford and Uhlig (2009), who account for 'announcement effects' by imposing a positive sign on a fiscal variable after four quarters. For the first four quarters, the fiscal variable is assumed to be inert and the prescribed signs of other responses do not change. Using U.S. data, Martens and Ravn (2010) demonstrate that the anticipation effects of spending shocks do not affect

[17] For additional real world examples see the discussion in Brash (2011b).

the sign of the output reaction. Therefore, our identification approach is not affected by the presence of such anticipation effects.

The latter type of anticipation effects - agents' expectations of the way current fiscal shortfalls are reversed by the future fiscal-monetary mix - could possibly be an issue for our identification strategy. This would be the case if different expected ways of fiscal adjustment affected the real economy differently and satisfied the same set of identification restrictions. Nevertheless, in our analysis the problem is partially mitigated by the fact that our focus is strictly on debt-financed spending. An additional insight in this regard can be taken from the robustness exercise on the length of the imposed magnitude restrictions. For the U.S., a change in the number of quarters for which the magnitude restriction is imposed affects the magnitude and profile of the impulse responses only marginally.

Another robustness exercise suggests that the length of the sign restrictions to some extent affects the magnitudes of the responses. Similarly to Primiceri (2005) we find the results to be robust to the choice of priors for the variance of initial states. We also find that our prior belief for the parameter U, which drives how much coefficients can differ between adjacent periods, significantly influences the posterior variation of the coefficients and thus the resulting impulse responses. Nevertheless, our prior belief reflected by the parameter is that changes in the economy/coefficients are gradual.

9. Summary and Conclusions

It is uncontroversial that monetary and fiscal policies are inter-related even if the central bank is formally independent of the government. This is because the actions of each policy affect many important economic variables (including private expectations of the future), and these variables in turn affect the actions of both policies. That the institutional design of each policy affects the incentives and outcomes of that policy is also uncontroversial. But could it be that the design affects the behavior and outcomes of the *other* policy in a major way? If so, how?

This paper attempts to track monetary-fiscal interactions over time and across several advanced countries in order to contribute to our understanding of the inter-relation of the two policies and offer some tentative answers to these questions. It does so using a novel empirical framework that combines time-varying parameter vector autoregression with the sign restrictions identification procedure.

Having first discussed the advantages of this framework vis-à-vis the standard fixed parameter VARs and/or the recursive identification method, we then report how monetary policy responses to debt-financed government spending shocks have changed in countries that legislated a commitment to a numerical target for average inflation. Specifically, inflation-targeting central banks generally stopped accommodative monetary policy and started offsetting debt-financed fiscal shocks by raising interest rates. No comparable change can be found in the non-targeters.

Interestingly, we find some (albeit weak and indirect) evidence that the disciplining effects of a legislated monetary commitment may have spilled over to fiscal policy too. The adoption of inflation targeting was associated with a decrease in the variability of fiscal shocks, and, with a 1- 3 year lag, is followed by a general improvement in the fiscal position (sustained debt reductions). This could be because the threat of a tug-of-war with a committed central bank reduced the government's incentives to pursue excessive fiscal policy and avoid necessary fiscal reforms.

While our empirical results should be taken as only suggestive rather than conclusive, they indicate that an institutional reform of *each* policy may perhaps have positive effects on the outcomes of *both* policies. More research is required to shed light on the robustness of our findings and the many specific channels through which monetary and fiscal policies affect each other. This is of particular importance in the current situation of high economic uncertainty following the Great Recession and of a large fiscal gap facing advanced countries.

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Appendix A: The Theory Behind Strategic Monetary-Fiscal Interactions

The seminal analyses of Sargent and Wallace (1981) and Leeper (1991) point in the direction of *strategic* interactions between monetary and fiscal policy. Using game theoretic methods, their gist can be presented in the payoff matrix below. Let us stress that this represents a structural (i.e., cycle-free) situation: the economy is performing at potential, it is *not* at a cyclical swing requiring specific (stimulatory) actions.

		Fiscal policymaker	
		Debt-financed Spending (active)	Tax-financed Spending (passive)
Monetary policymaker	Not Accommodate (active)	a, w	b, x
	Accommodate (passive)	c, y	d, z

The variables $\{a, b, c, d, w, x, y, z\}$ denote the policymakers' payoffs, which are functions of the structure of the economy, policy preferences, the behavior of expectations, etc. Roughly speaking, Leeper's (1991) passive policies adjust to balance the intertemporal budget constraint of the government. Specifically, an increase in government spending is accompanied by an increase in (current or future) taxes under passive fiscal policy, and higher (current or future) inflation - via lower interest rates and debt monetization - under passive monetary policy. In contrast, active policies largely ignore the budget constraint to focus on other policy goals. Spending is financed by debt creation under active fiscal policy, whereas active monetary policy focuses on achieving low inflation.

The payoff matrix makes it transparent that, unless $a=c$, the central bank's (intended/actual) responses affect the payoffs of the government and hence potentially its decision regarding the medium-run fiscal stance. A number of papers, starting with Sargent and Wallace (1981), imply that in the presence of a fiscal gap the policy interaction can best be modeled as a game of chicken where the payoffs satisfy: $a>d>max\{b,c\}$ *and* $z>w>max\{x,y\}$.[18] In such case the game has two pure strategy Nash equilibria: (active monetary, passive fiscal) and (passive monetary, active fiscal), alternatively called the Ricardian and non-Ricardian regimes. The fact that the former is preferred by the central bank and the latter by the government implies that there is a policy conflict. In addition, the fact that both pure Nash equilibria are Pareto superior to the mixed Nash equilibrium implies a coordination problem between the policies.

Given that neither standard nor evolutionary game theory can select between pure Nash equilibria, researchers have commonly applied Stackelberg leadership to the game. The leader in the game (the dominant policy) ensures its preferred pure Nash by being able to force the follower to coordinate. Libich et al. (2012) generalize the timing of the policy moves to allow for arbitrary (stochastic or deterministic) policy revisions that can capture institutional features such as monetary commitment and fiscal rigidity. Effectively, their framework converts the standard

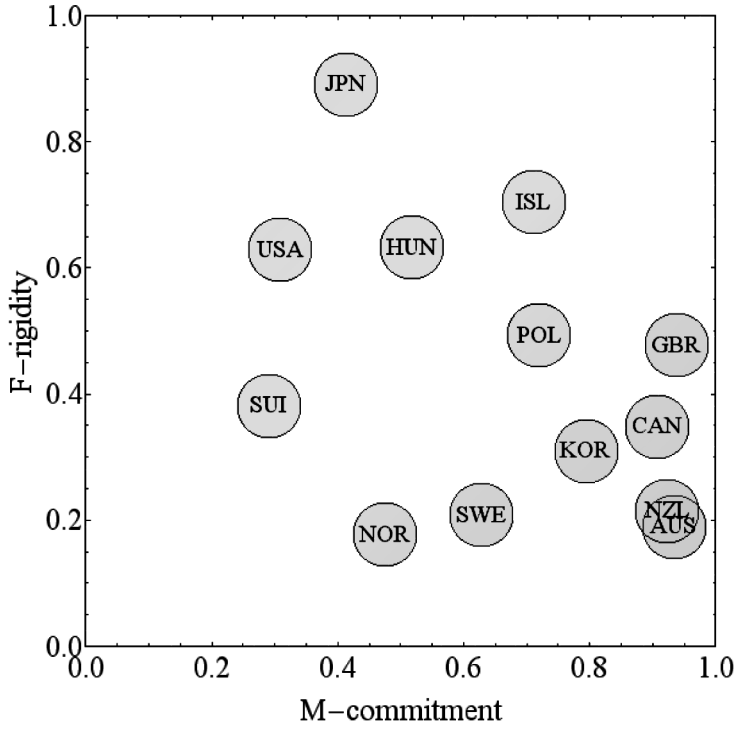
Stackelberg leadership concept from static to dynamic. Their analysis refines the standard conclusion that the leader in the game always ensures its preferred Nash equilibrium by showing that this depends on a number of economic and policy variables. Nevertheless, the result that under reasonable circumstances the central bank's commitment reduces monetary accommodation of fiscal shocks and the government's incentive to accumulate debt and avoid fiscal reforms still obtains.

The paper then uses twelve existing measures in the literature to quantify indices of long-term monetary commitment and fiscal rigidity for high-income countries, see Figure A1.[19]

[18] Let us stress again that the payoff relationships, and hence the class of game, would be different in a cyclical downturn such as the global financial crisis, in which stimulatory actions (passive monetary and or active fiscal policy) are likely to be required.

[19] The paper does not provide monetary commitment values for the euro area countries as they do not have autonomous monetary policy.

Figure A1: Long-term Monetary Commitment Versus Fiscal Rigidity Indices from Libich et al. (2012)



The probability of inflationary fiscal spillovers decreases as countries move from the top left corner to the bottom right corner of Figure A1.

Appendix B: Gibbs Sampler

The specification of the sampling algorithm and the parameters of the prior distributions mostly follows Primiceri (2005), Cogley and Sargent (2005), Kirchner et al. (2010), and Pereira and Lopes (2010).

B1. Priors

The prior distribution of the initial states $(\alpha_{i,0}\ ,\ \beta_{i,0}\ ,\ log(\sigma_{i,0}))$ is normal with means given by corresponding OLS estimates on the whole data sample. The assumed prior variances are proportional to the estimated OLS variances for the coefficients and to the identity matrix for the volatility states:

$$\beta_{i,0} \sim N\left(\beta_{i,0}^{OLS}, 4Var\left(\beta_i^{OLS}\right)\right),$$

$$\alpha_{i,0} \sim N\left(\alpha_{i,0}^{OLS}, 4Var\left(\alpha_i^{OLS}\right)\right),$$

$$\log\left(\sigma_{i,0}\right) \sim N\left(\log\left(\sigma_i^{OLS}\right), 10I_5\right).$$

The hyperparameter U and blocks of V are distributed as an inverse-Wishart distribution:

$$U \sim IW\left(k_Q^2 \tau Var\left(\beta^{OLS}\right), \tau\right),$$

$$V_{bl} \sim IW\left(k_V^2\left(1+\dim\left(V_{bl}\right)\right)Var\left(A_{bl}^{OLS}\right), 1+\dim\left(V_{bl}\right)\right), \qquad bl = 1,...,4,$$

where $k_Q = 0.01$ and $k_V = 0.1$. These parameters represent our prior belief on the proportion of uncertainty of the OLS estimate attributed to time-variation of the VAR coefficients and elements of the matrix A. The degrees of freedom parameter τ is 50. The diagonal elements of W are distributed as inverse-Gamma (Kirchner et al., 2010):

$$W_i = IG\left(\frac{k_w^2}{2}, \frac{1}{2}\right), \qquad \text{where } k_W = 0.01.$$

B2. Estimation Procedure

The Gibbs sampler exploits the fact that draws from the conditional distributions of subsets of the model parameters (given the rest of the parameter set) represent a sample from the joint posterior distribution. So, the sampler can be described in several steps:

The vector of coefficient states β is estimated using the Carter and Kohn (1994) algorithm. For the given data and history of the covariance and volatility states, equation (1) and (2) represent a linear Gaussian system with a known covariance matrix.

The covariance states stacked in matrix A_t are also estimated employing the algorithm of Carter and Kohn (1994). Equation (1) implies that

$$\hat{y}_t = A_t\left(y_t - X_t\beta_t\right) = \Sigma_t \varepsilon_t, \qquad \text{(A1)}$$

i.e., given the data and the history of the coefficient and volatility states we again obtain a linear Gaussian system. The algorithm is applied equation by equation i.e., it yields draws of the covariance states stacked below the diagonal of A_t in turns.

To draw the volatility states we follow Cogley and Sargent (2005). Given the data and the history of the coefficient and covariance states, the RHS of (A1) is observable. Assuming diagonality of the hyperparameter W, the volatility states can be drawn as in Jacquier et al. (1994), i.e., a univariate algorithm is applied on the orthogonalized residuals element by element. Jacquier et al. (1994) describe a Metropolis step that produces a draw (if accepted) from the conditional posterior distribution for a volatility state.

Finally, given the data, coefficient states, and covariance and volatility states, innovations in (2)- (4) are observable. The priors on the hyperparameters are distributed as inverse-Wishart (inverse- Gamma), thus posterior distributions take the same type of distribution and drawing of the hyperparameters is straightforward.

Appendix C: Convergence Diagnostics

The convergence of the sequence of draws to a posterior distribution is assessed by two measures based on the autocorrelation of draws and by the diagnostics suggested by Raftery and Lewis (1992).[20] The first measure is a simple autocorrelation of draws from conditional posterior distributions at a lag equal to 10. Low autocorrelation suggests efficiency of the sampling algorithm. A more sophisticated

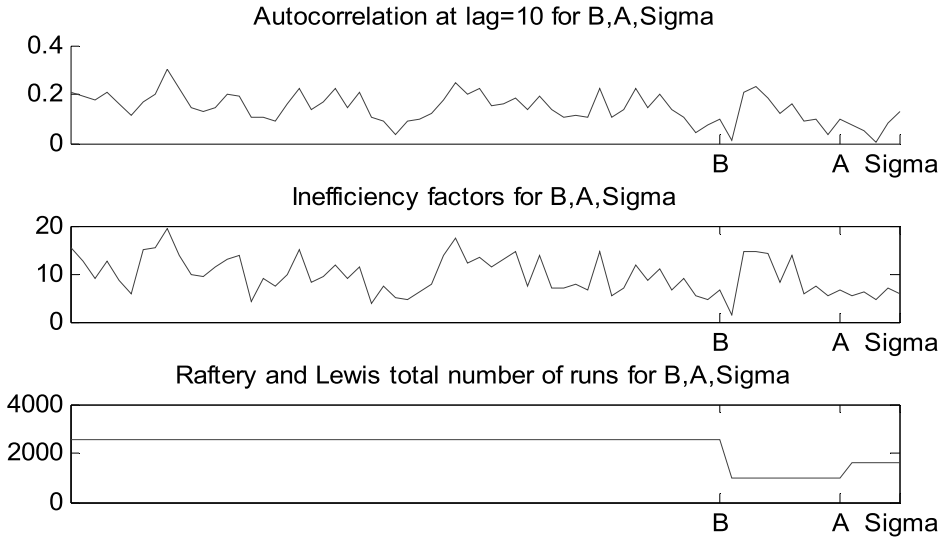
[20] The same convergence diagnostics as in Primiceri (2005) are presented. The implementation in Matlab draws on Econometric Toolbox discussed in LeSage (1999).

measure based on sample autocorrelations takes into account autocorrelations at all possible lags. It is defined as

$$1 + 2\sum_{k=1}^{\infty} \rho_k \ ,$$

with ρ_k denoting the k-th autocorrelation of the chain of draws and denoted as an inefficiency factor. Primiceri (2005) suggests that values of the inefficiency factor below 20 can be viewed as satisfactory. Finally, Raftery and Lewis (1992) introduced a statistic that provides the number of draws ensuring a certain level of precision.[21]

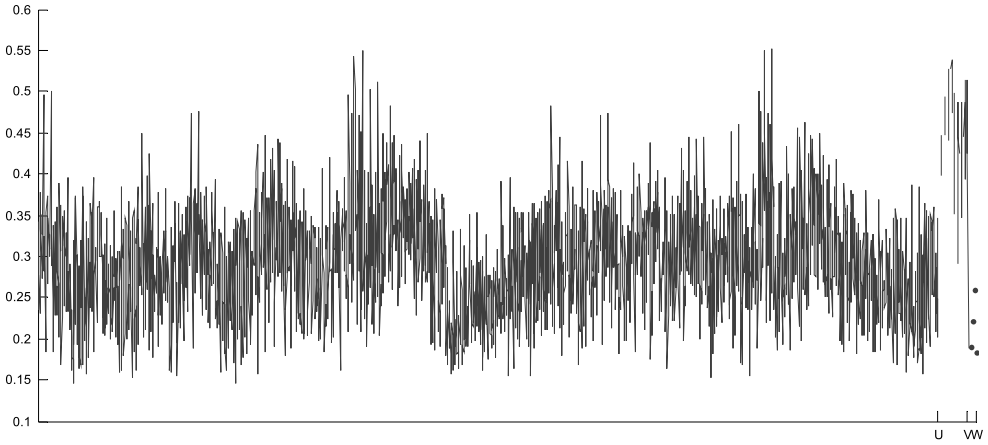
Figure C1: Autocorrelation, Inefficiency Factors, and the Raftery and Lewis Statistic for the Model Parameters in the Period 1985Q1



Due to a high number of parameters we present in Figure C1 the convergence diagnostics only for Australia, and only for coefficients related to an arbitrarily chosen period 1985Q1. The statistics presented in Figure C1 suggest sufficient convergence of the Markov chain Monte Carlo algorithm for the parameters: the autocorrelation of the chain is low, the inefficiency factors take values below 20, and the suggested number of runs is lower than 4,000. For other countries the convergence statistics look very similar.

The hyperparameters are reported in Figures C2-C4. The diagnostics for some elements of the hyperparameter vector suggest possible convergence problems. Our primary interest, however, lies in the parameters and thus we do not elaborate on these convergence diagnostics.

Figure C2: Autocorrelation of the Chain for the Hyperparameters U, V, W Autocorrelation at lag=10 for U,V,W



[21] Here, for the 0.025 and 0.975 quantiles of the marginal posterior distributions, the desired accuracy of 0.025 is required to be achieved with probability 0.95.

Figure C3: Inefficiency factors for the hyperparameters U, V, W

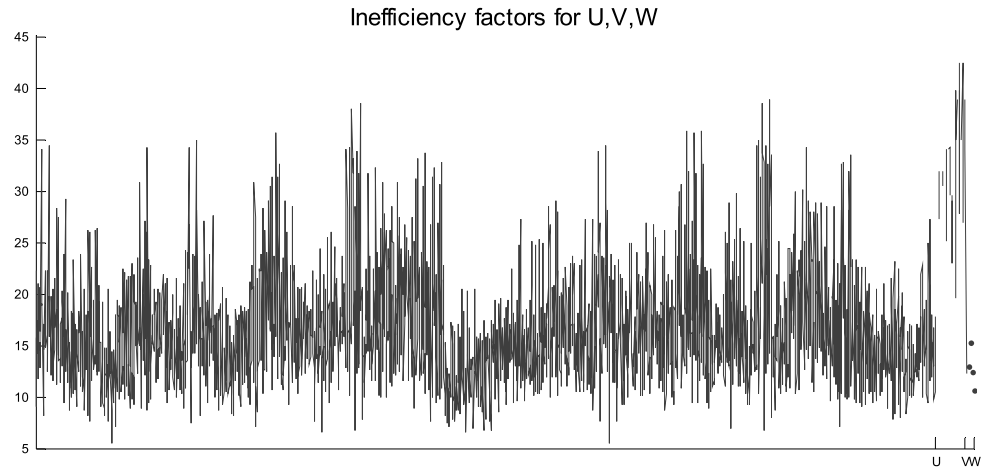
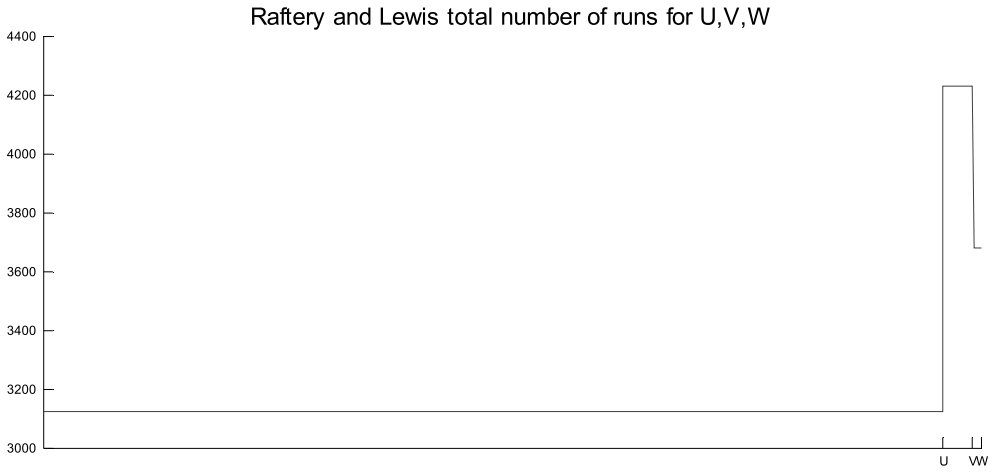


Figure C4: Raftery and Lewis Statistics for the Hyperparameters U, V, W



Appendix D: IRFs for a Debt-financed Government Spending Shock for All Countries and Variables at Two Horizons

As explained above we will leave an in-depth discussion of results not relating to monetary-fiscal policy interactions, primarily the estimated fiscal multipliers, to a separate paper. A selection of the results - namely the impulse responses on impact and in the 3rd quarter - appears in Figures D1-D6.

Let us just mention in passing that our output and private consumption multipliers are high compared to the literature (for a survey see e.g. Hall, 2009). This is because existing studies examine the effects of shocks to general government purchases, while we focus on a subset of such shocks: those financed by debt. It is well established that government spending financed by higher taxes can affect output and private consumption in a different way than spending financed by debt, depending on whether the assumptions underlying Ricardian equivalence hold. In particular, if economic agents are myopic and/or credit constrained, debt-financed spending tends to have a larger stimulatory effect than tax-financed spending.

Figure D1: Canada: IRF on Impact and in the 3rd Quarter

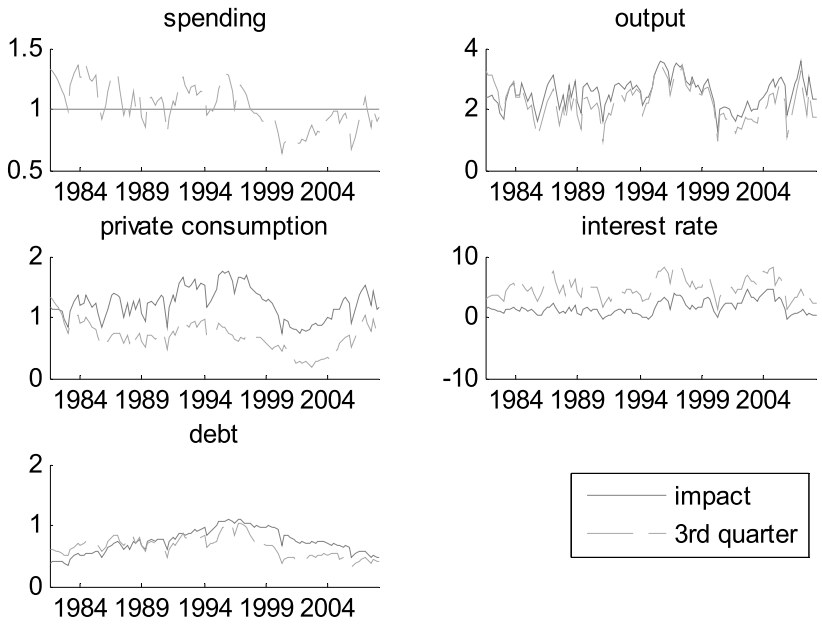


Figure D2: The UK: IRF on Impact and in the 3rd Quarter

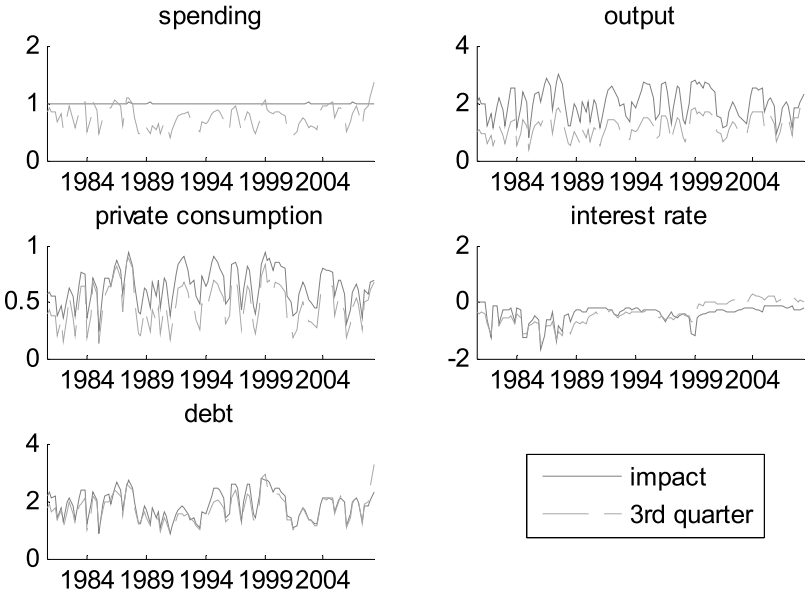


Figure D3: Australia: IRF on Impact and in the 3rd Quarter

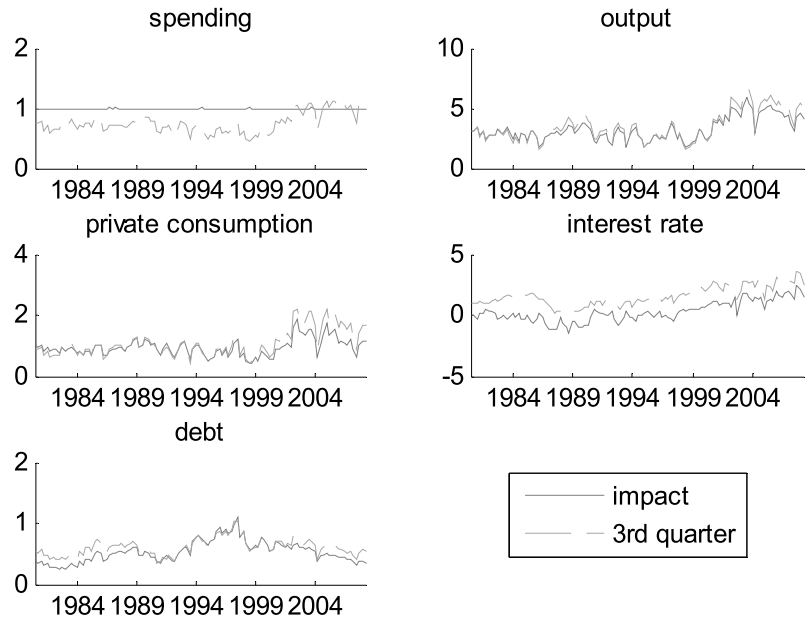


Figure D4: The U.S.: IRF on Impact and in the 3rd Quarter

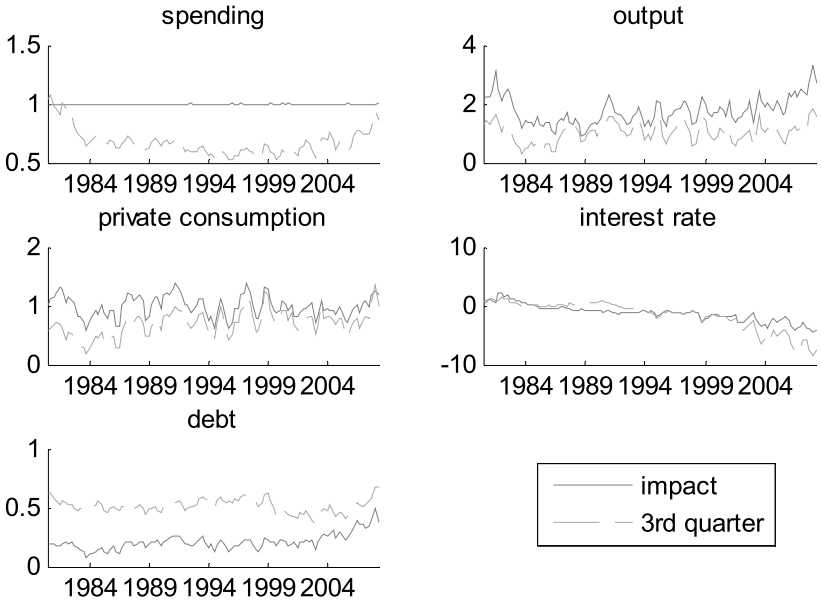


Figure D5: Switzerland: IRF on Impact and in the 3rd Quarter

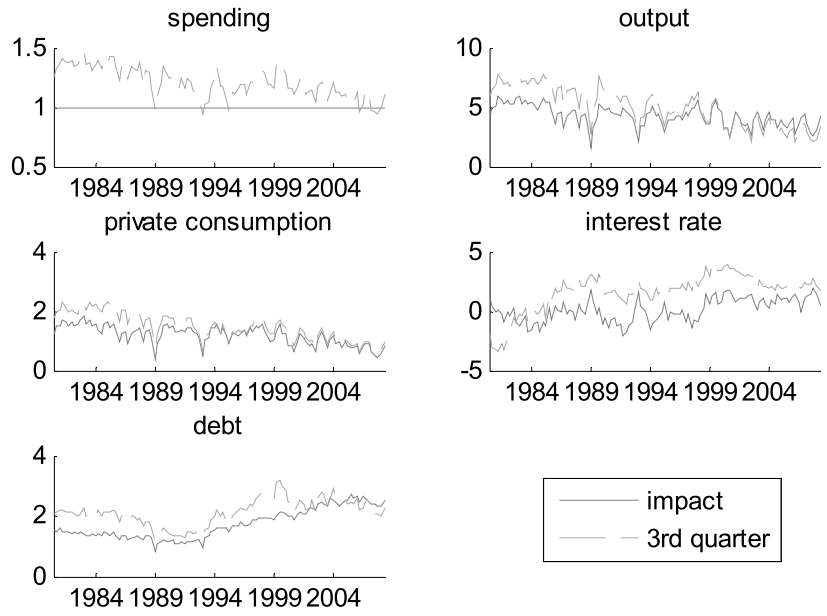
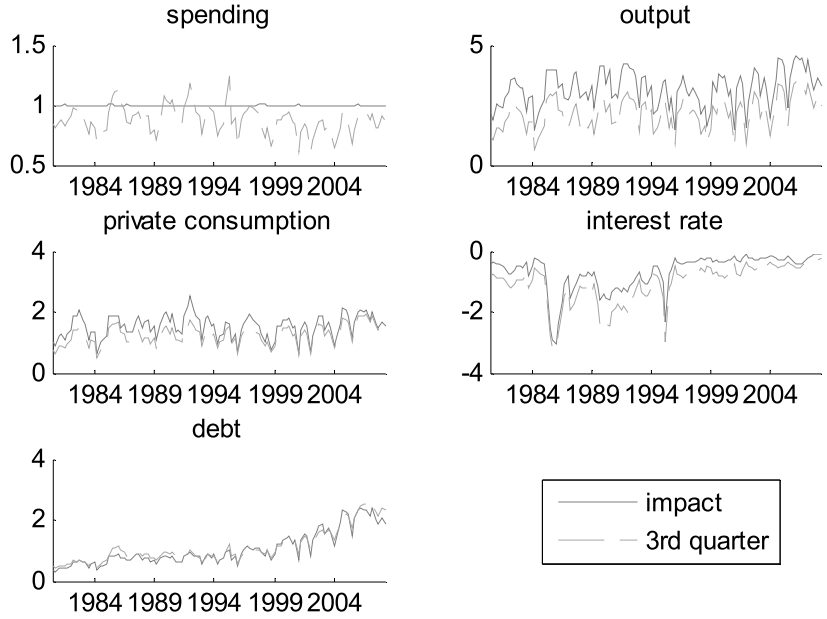


Figure D6: Japan: IRF on Impact and in the 3rd Quarter



Appendix E: Illustration of the Estimates' 'Uncertainty'

Figure E1: Canada: IRF on Impact with the Centered 68 Percent of the Posterior Distribution

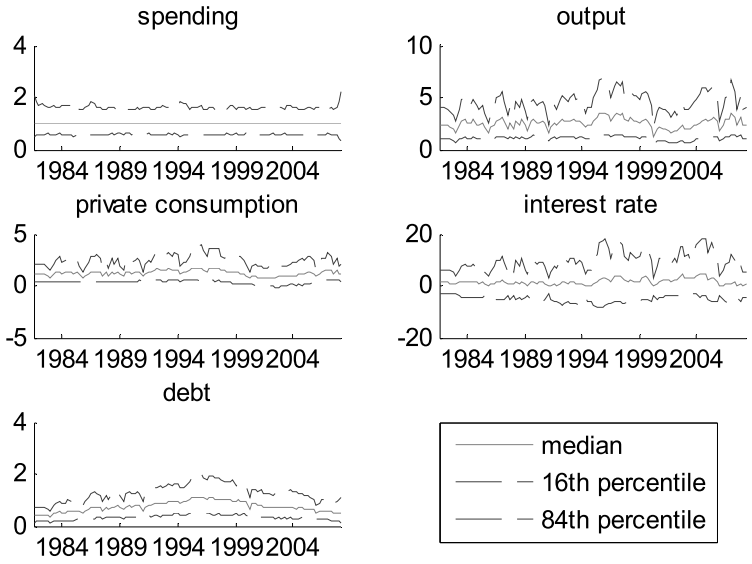


Figure E2: The U.S.: IRF on Impact with the Centered 68 Percent of the Posterior Distribution

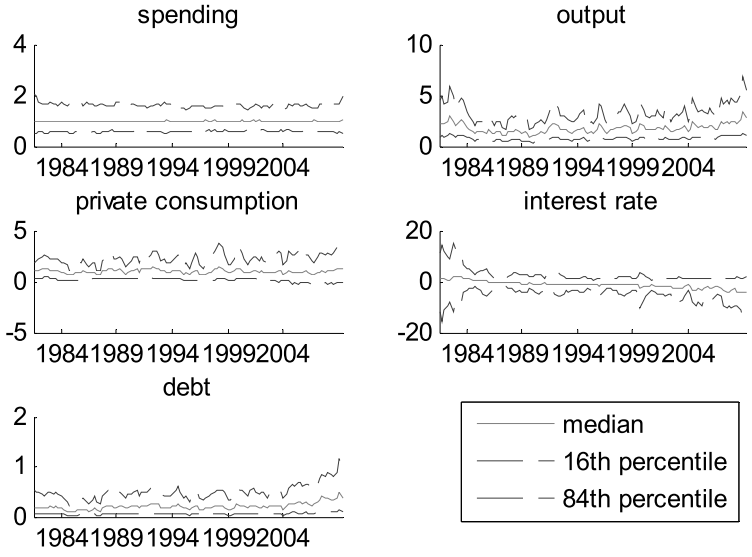


Figure E3: Median IRFs of the Interest Rate over a Horizon of 16 Quarters with the Centered 68 Percent of the Posterior Distribution of All IRFs in a Given Sub-period

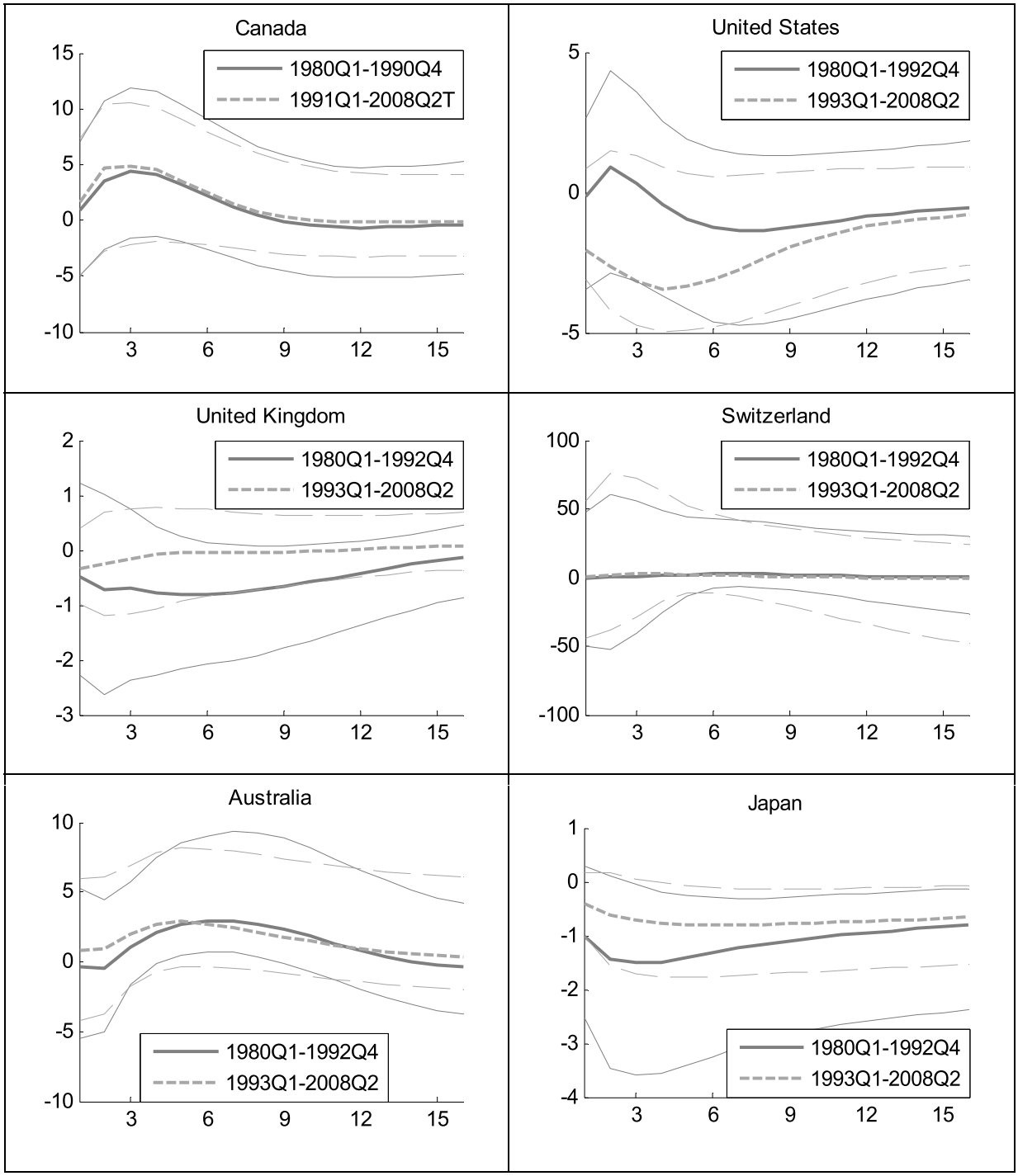
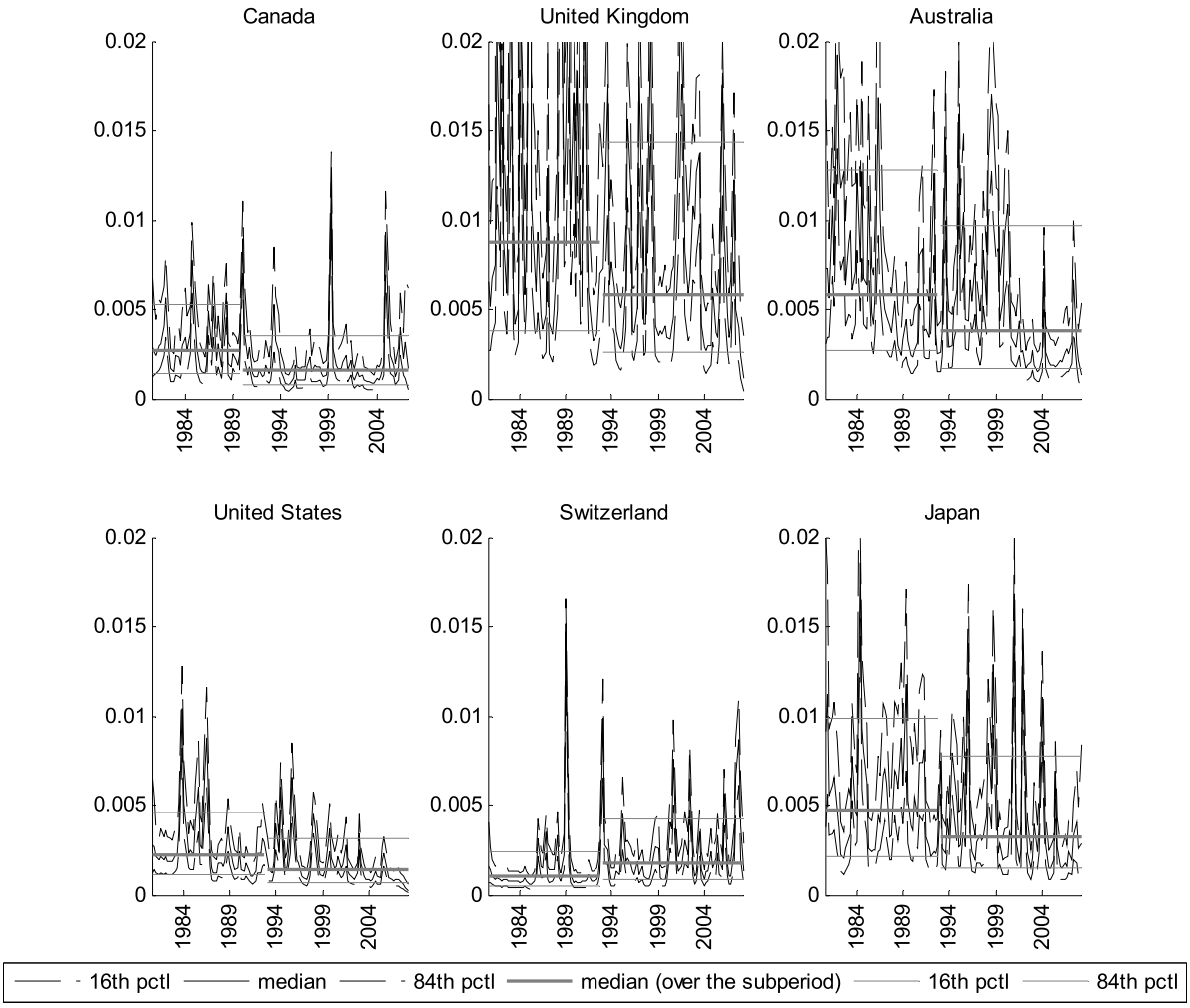


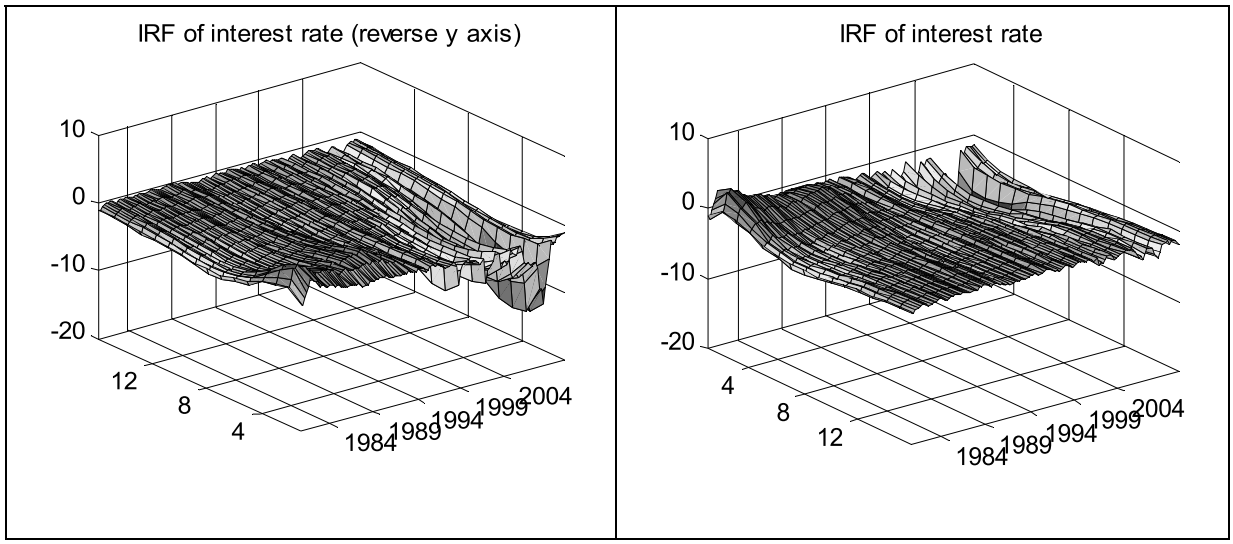
Figure E4: Estimated Standard Deviations of the Reduced-form Residuals for Government Spending



Appendix F: Inclusion of the Global Financial Crisis

Figure F1 presents estimation results for the U.S. based on an extended dataset (1980Q1-2010Q4) for reasons discussed in the main text. Comparing it with the benchmark results in Figure 1, especially the scale on the vertical axis, makes clear that the inclusion of the recent financial crisis is costly in terms of loss of insight. Nevertheless, while this large shock overshadows some of the phenomena discussed in the main text, the fact that U.S. monetary policy has become more accommodative of debt-financed fiscal shocks over time is still apparent.

Figure F1: Selected Impulse Responses for the U.S. Estimated on the Full Sample (1980Q1- 2010Q4)



Appendix G - Data Sources

	Government spending	Output	Private consumption	Interest rate
AUS	General government; Final consumption expenditure; PLUS General government; Gross fixed capital formation; Australian Bureau of Statistics	Gross Domestic Product Australian Bureau of Statistics	Households; Final consumption expenditure Australian Bureau of Statistics	13-WEEK TREASURY BILLS IMF IFS
CAN	Government final consumption expenditure PLUS Gross Fixed Capital Formation: General government OECD QNA	Gross Domestic Product IMF IFS	Household Consumption Expenditure incl NPISHs IMF IFS	TREASURY BILL RATE IMF IFS
CH	Government Consumption Expend. Sa PLUS Government gross fixed capital formation (yearly) IMF IFS and OEO: Economic Outlook (OECD)	Gross Domestic Product Sa IMF IFS	Househ.cons.expend.,incl.npishs IMF IFS	TREASURY BILL RATE IMF IFS
JAP	Government Consumption Expend. Sa PLUS Gross fixed capital formation: General government IMF IFS and OECD QNA	Gross Domestic Product Sa IMF IFS	Househ.cons.expend.,incl.npishs IMF IFS	Call rate (Bank of Japan) adjusted before 1985 as in Miyao (2005).
UK	Central Gov: Current expenditure: Total payable MINUS Central Gov: Current expenditure: Net Social Benefits payable Office for National Statistics	Gross Domestic Product at market prices: Current price: sa Office for National Statistics	Household final consumption expenditure: National concept CP SA Office for National Statistics	TREASURY BILL RATE IMF IFS
US	Government consumption expenditures and gross investment NIPA Table Bureau of Economic Analysis	Gross domestic product NIPA Table Bureau of Economic Analysis	Personal consumption expenditures NIPA Table Bureau of Economic Analysis	Federal Funds Rate IMF IFS

General: Population and CPI are taken from IMF IFS. Total central government debt is taken from OECD Statistics.

UDK 338.23:336.74]:336.02(497.11)

EFFICIENCY OF THE FISCAL AND MONETARY STIMULI: THE CASE OF SERBIA

Branko Hinić[1], Mirjana Miletić[2]

Abstract[3]

This paper aims to examine the effectiveness of countercyclical fiscal policy and its impact on monetary policy during the on-going global economic crisis on the example of Serbia by assessing the fiscal multiplier.

The fiscal multiplier is expected to be low in the case of Serbia bearing in mind the impact of factors that, according to empirical studies, determine its value: the level of capacity utilisation, degree of openness of the economy and the exchange rate regime, the initial level of public debt, composition of fiscal stimuli, its coordination with the monetary policy, etc.

In order to assuage the negative ramifications of the first wave of the crisis, Serbia pursued an even more expansive fiscal policy as soon as the first effects of the crisis became evident. Nevertheless, considering the sluggish economic recovery over the past two to three years, it seems at first glance that the majority of the fiscal stimuli were insufficiently effective. Further, as public debt accumulated, nearly doubling since the outbreak of the crisis, a question emerged as to its sustainability and macroeconomic stability as a whole. When the scope for a countercyclical effect of the fiscal policy is narrow, monetary policy should provide impetus to economic activity. The extent of its countercyclical effect, however, depends on the nature and intensity of inflationary pressures. The efficiency of monetary policy in Serbia is further constrained by the high euroisation of the domestic economy.

The effectiveness of fiscal stimuli on the revenue and expenditure side and of their effect on monetary policy, and vice versa, was estimated using the structural VAR model for the period 2003q1: 2012q4. The results of the analysis suggest that an increase in public consumption of 1 pp of GDP pushes the non-agricultural economic activity up by 0.14 pp after one quarter or by 0.77 pp after four quarters, in accumulated terms. The effect stabilises at around 1 pp of GDP, but loses statistical significance after two years. In contrast to the above, a positive net tax shock leads to a statistically insignificant increase in non-agricultural economic activity, but also to a statistically significant increase in interest rates. The estimated effect of fiscal policy on interest rates, through increased public consumption or net taxes, basically suggests accommodative monetary policy. On the other hand, fiscal policy responds to a positive interest rate shock by cutting expenditure since economic activity and fiscal revenue decrease on the same grounds. This indicates that access to finance plays a major role in determining the character of fiscal policy in Serbia, which confirms the procyclicality of fiscal policy in the prior period.

Key words: countercyclical fiscal and monetary policies, fiscal multiplier, structural VAR model

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[3] The views expressed in the paper are those of the author, and do not necessarily represent the official view of the National Bank of Serbia.

1. Introduction

In response to the crisis, and as one of the pillars of defence against it, a number of countries implemented packages of fiscal stimuli to encourage domestic demand and pull the economy out of the recession. However, the resulting high fiscal deficits soon raised the question of public debt sustainability in many countries. Among the expert public, a question arose concerning the justifiability of a countercyclical fiscal policy, and the strength of fiscal multipliers became one of the key topics. At the same time, theoretical views and results of numerous empirical studies showed that the fiscal multipliers' strength and direction depend on the country's macroeconomic characteristics, applied methods of estimation, the period under analysis, the degree of coordination between the monetary and fiscal policies, etc.

For quite some time, the **Keynesian** view was dominant in macroeconomic theory. According to it, expansionary fiscal policy is an adequate reaction of economic policy holders to recession tendencies, as it boosts the increase in aggregate demand and the consequent economic recovery against the background of price rigidity and unused capacity. According to this view, the fiscal multiplier is higher than one, and is higher if instead of reduced taxes there is increased government spending. The positive effect of an expansive fiscal policy on economic growth can be weakened through its influence on the growth of interest rates and appreciation of the domestic currency. This is to say that additional government borrowing leads to higher interest rates, which has an adverse effect on domestic private investment. At the same time, higher interest rates in the domestic market lead to an increase in capital inflow from abroad, resulting in appreciation of the domestic currency which negatively affects net exports. All of the above suggests that the effect of an expansive fiscal policy on economic activity depends on a series of factors. Thus, for instance, if investments are more sensitive to interest rates, the effects of the fiscal stimuli on economic activity will be lesser. Moreover, the effects will be lesser if the demand for money is less sensitive to interest rates, and more to income. On the other hand, the upward pressure on interest rates can be assuaged or neutralised by an expansive monetary policy or by borrowing abroad. In the case of open economies in the flexible exchange rate regime, the effect of the fiscal stimuli diminishes any major inflow of foreign capital because it results in appreciation of the domestic currency. In open economies with a fixed exchange rate regime, fiscal stimuli are relatively more efficient given that the rise in the money supply under conditions of greater capital mobility relieves pressure on interest rate growth.

According to certain theoretical views, an expansive fiscal policy is not efficient during a recession. A viewpoint, commonly referred to in literature as **Ricardian equivalence**, states that lower taxes do not lead to higher consumption because economic entities anticipate that the financing of a deficit accumulated in this way would demand additional government borrowing and result in tax increases in the future (*Barro*, 1974). In the case of perfect Ricardian equivalence, increased government consumption will be completely neutralised by private sector net savings, which will result in unchanged aggregate demand, i.e. the value of the fiscal multiplier will be zero.

The existence of rational expectations is another possible explanation for a lower or, at worst, a negative fiscal multiplier. According to this view, long-term fiscal expansion leads to a neutralisation of the effects of fiscal stimuli because economic entities expect the heightened fiscal expansion to result in a longer-lasting increase in interest rates and appreciation of the foreign exchange rate (*Krugman* and *Obstfeld*, 1997).

Low or even negative fiscal multipliers could also be explained by the **risk premium growth,** which, due to the accumulation of public debt in conditions of fiscal expansion, can lead to an increase in interest rates and neutralise the positive effects of fiscal stimuli on economic growth (*Miller*, *Skidelsky* and *Weller*, 1990). In such situations, short-term expansion is a better solution than long-term as it poses a lower risk to public debt sustainability. In addition, if increased expansiveness of the fiscal policy is accompanied by **growing uncertainty**, households and corporates may start saving more and investing less out of precaution, rendering the effects of fiscal stimuli ineffective (*Caballero* and *Pyndick*, 1996).

A majority of economists agree that in periods of expansion it is immensely important to have a responsible and credible fiscal policy, which enables more savings, in order to create more manoeuvring space for its countercyclical activity during periods of crisis and recession.

Another prevailing opinion among the expert public is that fiscal consolidation has a negative effect on economic growth in the short run, while from a long-term perspective it contributes to macroeconomic stability and sustainable economic growth. In the short-term, a decrease in government consumption and an increase in tax dampen domestic demand and economic activity. However, in countries where continuing fiscal expansion would soon lead to a public debt crisis, even short-term fiscal consolidation would indirectly affect the economy in a positive manner as it would help improve the credit rating and reduce the borrowing costs. The strength of the positive effects of fiscal consolidation on long-term economic growth depends on the manner of implementing fiscal consolidation, as well as on whether it is accompanied by adequate structural reforms. As a rule, the positive effects of fiscal consolidation are stronger if fiscal consolidation is implemented on the expenditure side, as well as if it is accompanied by adequate structural reforms.

Although a generally acceptable conclusion about the effects of the countercyclical fiscal and monetary policies on economic growth can hardly be drawn from the results of numerous empirical studies,[4] most of them point to the following conclusions:

- As a rule, the value of the fiscal multiplier should be higher if there are unused capacities and if unemployment is of cyclical nature. If, on the other hand, unemployment is of structural character, fiscal and monetary stimuli can only have inflationary consequences.
- The level of openness of the economy and the foreign exchange rate regime are also the factors determining the size of the fiscal multiplier. Expansive fiscal policy should be more efficient in closed economies. It is more efficient in open economies if the fixed exchange rate regime is applied.
- The size of the fiscal multiplier is also determined by the initial level of public debt. If this level is low, expansive fiscal policy should be more efficient, but not so if the initial fiscal deficit is also low.
- The value of fiscal multipliers depends also on the composition of fiscal stimuli. Fiscal policy is usually more efficient if fiscal stimuli are implemented on the expenditure side, rather than if taxes are reduced.
- Expansive fiscal policy should be more efficient if accompanied by an expansive monetary policy, in order to ensure that fiscal stimuli are not neutralised by the growth in interest rates and appreciation of the national currency.

In the case of Serbia, most of these factors work toward reducing the fiscal multiplier. Firstly, the unused factors of production are not prone to cyclical movement, hence domestic production cannot meet the conditions for initial increase in demand, caused by fiscal expansion, within an adequate time frame and by offering an appropriate range of products. Secondly, Serbia is a small and an open economy running a flexible exchange rate regime which, combined with the above, indicates that fiscal stimuli will have a stronger impact on import growth than on demand for domestic products. Thirdly, Serbia's high public debt to GDP ratio reflects the high risk premium and borrowing costs, which can have a dampening effect on investments. Even in the pre-crisis period, the fiscal position of Serbia was inadequate, being either expansive or insufficiently restrictive in periods of high privatisation revenues, which prevented fiscal stimuli from being more effective during the crisis. Fourthly, Serbia has scope for increasing government spending, particularly through investment in underdeveloped infrastructure, which in the long run could have a favourable impact on business and investment environment. Fifthly, the relatively strong inflationary pressures, even under recession conditions, prevent monetary policy from exerting a countercyclical effect, i.e. from having the required expansionary character.

The majority of fiscal stimuli applied in the case of Serbia during the ongoing recession appear to be rather ineffective. Under conditions of a high degree of euroisation, the monetary policy's standard incentive mechanisms, in the form of policy rate and reserve requirement cuts, often prove insufficiently effective as the generated liquidity is not used for lending purposes, but rather for buying foreign exchange. In such circumstances, the increase in the degree of monetary policy expansiveness most often results in depreciation of the domestic currency and a rise in inflation, instead of growth in lending and economic activity. Nevertheless, in order to obtain a precise estimation of the strength and direction of fiscal stimuli, an empirical analysis must be conducted.

[4] A detailed list of references is enclosed at the end of the paper.

This paper is structured in five chapters. The following chapter gives a more detailed overview of empirical literature. The third chapter discusses the character and measures of fiscal and monetary policy in Serbia during the global economic crisis. The results of the fiscal multipliers estimation, obtained by applying a structural VAR model, are presented in the fourth chapter. Our closing observations are presented in the final part of the paper.

2. Overview of empirical literature

The interest of economic policy holders, the expert public and analysts in terms of the countercyclical fiscal policy's effect on economic growth was particularly intense during and after the Asian crisis. There is a large number of available empirical studies on the role of the fiscal and monetary policies in securing conditions for economic recovery during recession relating to developed market economies, mostly for OECD countries, while studies on the emerging economies are much fewer. Essentially, we can distinguish three groups of studies concerning this issue. One group of empirical studies focuses on the estimation of fiscal multipliers for individual countries, mostly derived from macroeconomic models, models of general economic equilibrium and econometric models [*Bryant, Hooper* and *Mann* (1993); *McKibbin* (1996); *Saito* (1997); *Richardson* (2001); *Baxter* and *King* (1993); *Ramey* and *Shapiro* (1998); *Ardagna* (2001), *Baksa, Benk* and *Jakab (2010); Freedman, Kumhof, Laxton* and *Lee* (2009) et al]. The second group of studies is concerned with episodes of recession, the character of the fiscal policy and its influence on the economy, with a particular emphasis on the expansive effect of fiscal consolidation programmes [*Gavazzi* and *Pagano* (1990); *Alesina* and *Perotti* (1997); *Giavazzi, Jappelli* and *Pagano* (2000); *Hemming, Mahfouz* and *Schimmelpfennig* (2002); *Christiansen* (2008) et al]. The third group of studies analyses the influence of factors that reduce the effectiveness of fiscal stimuli and tests Ricardian equivalence [*Barro* (1989); *Seater* (1993); *Giavazzi, Japelli* and *Pagano* (1997); *Callen* and *Thimann* (1997) et al.].[5]

The results of individual empirical analyses of short-term fiscal multiplier estimates based on macroeconomic models and models of general equilibrium differ to a great extent. Nevertheless, most of these studies relating to developed market economies point to a conclusion that the fiscal multiplier is positive, though lower if fiscal policy expansiveness is achieved through tax cuts, instead of through an increase in consumption. Fiscal multiplier estimates for countries such as the United States, Japan and some European countries range between 0.1 and 3.1 percentage points; in terms of expenditures, their range is 0.6–1.4 percentage points, and 0.3–0.8 percentage points for taxes. Thus, for instance, *Freedman, Kumhof, Laxton* and *Lee* (2009) demonstrated that if applied throughout the world together with an accommodative monetary policy, an expansive fiscal policy has a considerable positive effect on the global economy, around 2–3% in accumulated terms after several years.

For most of the empirical studies based on econometric models, the estimation was conducted by applying the VAR model [*Blanchard* and *Perroti* (2002); *Perroti* (2002); *Edelberg, Eichenbaum* and *Fisher* (1999); *Mountford* and *Mihov* (2002); *Fatas* and *Mihov* (2001); *Romer* and *Romer* (2007); *Caldara* and *Kamps* (2008) et al.]. According to the results of these studies, the short-term influence of expenditure-side shocks on GDP is positive and ranges from 0.1 to 0.9 percentage points. It then grows during the next several quarters, although the number of periods after which the reaction abates can vary. For example, the results of a study conducted by *Blanchard* and *Perotti* (2002) showed that in the case of the United States, a fiscal stimulus of 1% GDP leads to a GDP rise of around 1 percentage point in the long run when it comes to expenditure-side fiscal stimuli, while in the case of reduced taxes, it stands at around 0.2 percentage points. This study yielded an interesting result, namely that the long-term effect of the fiscal stimulus on the expenditure side is lower than the one stemming from tax cuts. *Perroti* (2002) conducted estimations of the fiscal multiplier for the United States, Germany, Canada and Australia. The highest fiscal multiplier value was obtained for Germany when the fiscal stimuli arose from the expenditure side, whereas for other countries it very much resembled the estimate obtained for the United States.

The results of an analysis carried out by *Ilzetzki, Mendoza* and *Vegh* (2011) by applying the structural VAR model in the panel indicate that the value of fiscal multipliers is to a great extent influenced by the characteristics of analysed economies. The main conclusion of this analysis is that the effect of fiscal

[5] For a more detailed overview of results of the said groups, please see Hemming, Kell and Mahfouz (2002).

spending on economic activity is small and not evident in the short term, which raises questions as to the justifiability of increasing discretionary expenses to stabilise the economy in the short run. In closed economies with a fixed foreign exchange rate regime, the effect of fiscal stimuli is of greater scope and longer-lasting, while it is negligible in open economies with a flexible foreign exchange rate regime. As for countries with a high share of public debt in GDP, fiscal multipliers are negative. While rising public consumption negatively affects GDP in less developed countries, the impact of public investment is positive.

A relatively large group of empirical studies, starting from *Gavazzi* and *Pagano* (1990), monitored the effect of fiscal consolidation on economic growth. Although these studies differ in terms of the methods of analysis they used and the period observed, essentially, they all start by identifying episodes in which fiscal consolidation exerted a positive effect on economic activity in the short run, over a period of 10–35 years. Thus, for instance, *Gavazzi* and *Pagano* (1990) reached a conclusion that Denmark and Ireland, in respective periods of 1983–86 and 1987–89, are the most obvious examples of fiscal consolidation which had a positive effect on GDP in the short term. *Giavazzi, Jappelli* and *Pagano* (2000) concluded that large fiscal consolidation programmes were the most effective, and *Alesina* and *Perotti* (1997) that the structure of fiscal consolidation also matters, along with its scope. *Hemming, Mahfouz* and *Schimmelpfennig* (2002) identified 61 episodes of recession in the case of 27 out of 29 developed market economies during the period 1971–98. They established that these were cases of deep recession with an average negative output gap of around 4.5%, but also that these recessions were of relatively short breath (a little under 1.5 years, on average). In 80% of cases, fiscal authorities reacted to recession by increasing the fiscal deficit – with the rise averaging around 2.5% GDP. On the other hand, if the fiscal authorities chose to respond with fiscal consolidation, then the fiscal result, on average, improved by around 0.75% of GDP. While the results of a descriptive analysis indicate that an expansive fiscal policy has a certain positive effect on a recession-hit economy, the results of a regression analysis are less indicative. On these grounds, the authors concluded that the fiscal multiplier value is higher in the case of closed economies, but that nonetheless the multiplier is still low, as well as that it is close to zero in the case of countries with a flexible foreign exchange rate. However, they do not discard the possibility that expansive fiscal policy can be effective in recession under certain conditions, such as a surplus of unused production capacity, provided it is also accompanied by an expansive monetary policy.

The majority of papers analysing the impact of specific factors on the level of the fiscal multiplier failed to confirm that rising interest rates and the appreciation of the domestic currency lessen the fiscal stimuli significantly, and rejected the Ricardian equivalence [see, for instance, *Giavazzi, Japelli* and *Pagano* (1997); *Bernheim* (1989)].

The studies attempting to estimate fiscal multipliers in emerging market economies such as Central and East European countries are not that frequent. *Baksa, Benk* and *Jakab* (2010) have estimated the fiscal multiplier for Hungary based on the DSGE model for different categories of revenue (value added tax, personal income tax and employers' social security contributions), as well as for some categories of expenditure (social transfers and purchase of goods and services).

Following the model used by *Baksa, Benk* and *Jakab* (2010), *Serbanoiu* (2012) made an estimate of the fiscal multiplier for Romania in the period 2000–2011. According to *Serbaniou*, fiscal policy is procyclical and automatic fiscal stabilisers weak, which is consistent with the results of *Baksa, Benk* and *Jakab* (2010). Based on the impulse response function, a VAT shock has a negative effect on total consumption, primarily because of the falling consumption of liquidity-strapped households. Surprisingly, the increase in personal income tax leads to growth in wages, which can be explained by the stronger pressure to change employment contracts. The shock in employers' social security contributions has certain implications in terms of economic activity. A positive shock in social security contributions causes a decrease in wages and employment. Besides, to earn the same profits in such a scenario, enterprises will tend to raise the prices of their products and services, pushing the interest rates also higher. The increase in transfers leads to a significant rise in consumption and a fall in investment. The results of this analysis suggest that fiscal stimuli do not give a positive contribution to economic activity.

Applying the DSGE model, *Cariani* (2010) analysed the effects of fiscal policy on economic activity in some Central and East European countries (the Czech Republic, Poland, Hungary and Romania) during

the ongoing global economic crisis. The results of the analysis indicate that expansionary fiscal policy can neutralise not only the negative shocks in the domestic economy, but also those stemming from the fall in external demand (notably, the euro area), as well as that such fiscal policy has helped GDP recover during the crisis. The only exception in this respect is Poland, whose economy recorded positive growth rates even during this period.

Applying the structural VAR model, *Cuaresma, Eller* and *Mehrotra* (2011) observed the impact of the fiscal variable shocks on other key macroeconomic variables in the case of the Czech Republic, Hungary, Poland, Slovakia and Slovenia, as well as the impact of the fiscal shock in Germany from 1995 to 2009. The results of the analysis showed that domestic fiscal policy in the countries observed responds to the loosening of fiscal policy in Germany, their main foreign trade partner, by increasing the degree of fiscal expansion through an increase in expenditure rather than through a decrease in revenue. Greater fiscal expansion in Germany leads to economic growth in Poland and Hungary, whereas in other countries the value of the fiscal multiplier is negative. By contrast to other countries observed, in Hungary and Slovakia increased expansiveness of the domestic fiscal policy serves as a fillip to economic activity.

3. Fiscal and monetary policy in Serbia during the global economic crisis

To ease the negative effects of the first wave of the crisis, most countries, Serbia included, loosened their fiscal policy stance. When the first effects of the crisis emerged in late 2008, the Serbian authorities adopted measures to bolster domestic savings (increase of the insured deposit amount from 3 thousand to 50 thousand euros and abolishment of the interest tax) whereby the outflow of deposits from the banking sector was halted. The taxes on capital gains and transfer of absolute rights were abolished so as to encourage trading in the stock exchange. In early 2009, the authorities adopted the Programme of Measures to Mitigate the Negative Effects of the Global Economic Crisis with a view to supporting production, exports and employment. The main requirement for companies to use the facilities under this programme was to maintain the existing level of employment. Incentives for exporters included loans under favourable terms, shortening of the timeframe for VAT refund from 45 to 15 days, removing tariff and non-tariff barriers, etc. To support lending activity, the authorities launched a subsidised loan programme for households and corporates (loans for maintaining liquidity, loans for financing current assets, investment and consumer loans). In addition to incentives, the Programme of Measures to Mitigate the Negative Effects of the Global Economic Crisis included measures aimed at increasing budget revenue (higher fuel excise duties, temporary tax on mobile telephony impluses, higher luxury goods tax, etc.) and cutting expenditure (cutting the expenses of all budget beneficiaries, temporary freeze on pensions and public sector wages, to name a few).

Increased fiscal policy expansiveness, attributable to the government's decision to react to the fallout from the global economic crisis by increased spending, resulted in the widening of the share of the general government deficit in GDP from 2.6% at end-2008 to 5.0% at end-2011. During the same period, the share of structural deficit jumped from 3.3% to 4.9%. Increased government spending, most notably discretionary spending, in the pre-election period, i.e. the first half of 2012, pushed the deficit further up so that it ended the half-year at around 7% of GDP.

Still, it seems that accommodative fiscal policy failed to produce the expected results in terms of economic activity as most of the fiscal stimuli ended up in imports. Besides, fiscal expansion produced limited effects because of the gradual, but cumulatively significant deepening of external imbalances, which opened up the issue of public debt sustainability and led to a deterioration of the country's credit rating and a rise in its risk premium.

Chart 1 Actual and cyclically-adjusted fiscal result (% of GDP)

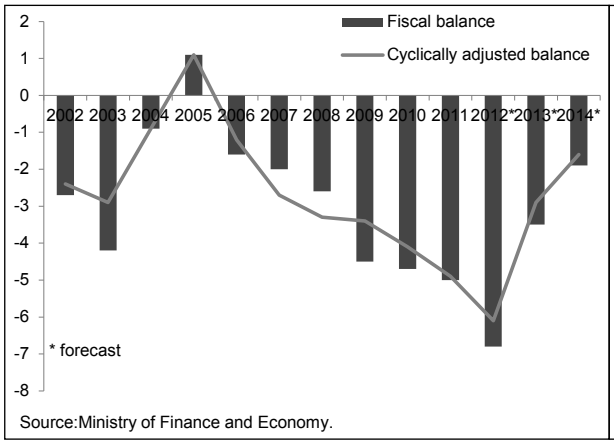
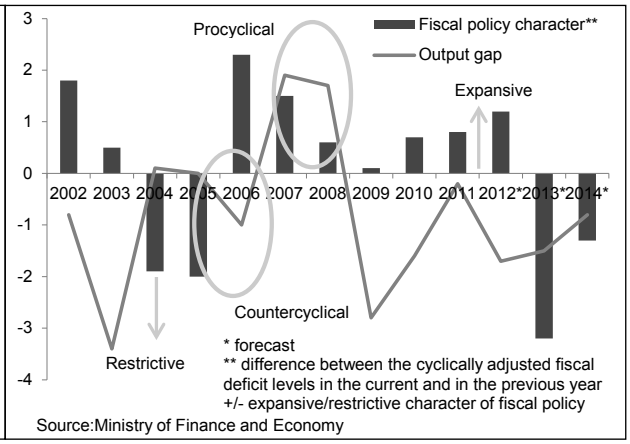


Chart 2 Character of fiscal policy



Serbia suffers from chronic procyclicality of fiscal policy. Ever since 2001, fiscal policy in Serbia has been markedly procyclical in periods of stronger economic growth. This was accompanied by a rise in domestic consumption financed by external capital. Due to this, appropriate countercyclicality could not be achieved in times of recession as access to external financing became strained. Insufficiently tight fiscal policy in the run-up to the crisis, when privatisation receipts were used for financing consumption rather than for repaying debts and for saving, limited the efficiency of automatic (fiscal) stabilisers and narrowed the scope for the countercyclical effect during the crisis.

The deficit building up and the government borrowing heavily in order to finance it, the situation with regard to public debt sustainability changed dramatically from 2009 onwards. Public debt grew at an accelerated pace and its share in GDP swelled from 29.2% at end-2008 to 44.6% in mid-2011. By the end of 2011, public debt reached 48.7% of GDP, exceeding the upper bound of the ceiling defined by the fiscal rule (45% of GDP) established by the Serbian government in 2010 with a view to ensuring fiscal sustainability. In addition to putting a ceiling on public debt, the government limited the target general government deficit to around 1% of GDP p.a. in the medium term, with the possibility of short-term deviations, depending on the phase of the economic cycle. Public debt continued to rise in 2012, measuring around 60% of GDP at year-end.

By contrast to other countries in the region which started fiscal consolidation earlier, Serbia had to postpone this process because of the election cycle. The government announced fiscal consolidation in September 2012 and two months later adopted a fiscal strategy aimed at bringing public debt back to sustainable levels and creating scope for additional investments. According to this strategy, fiscal adjustment will be implemented through changes in tax policy and measures on the side of expenditures, with a contribution from structural reforms geared towards reducing public consumption. The changes in tax policy relate to increasing the VAT rate, personal income tax, profit tax and excise duties on tobacco and petroleum products. On the expenditure side, a lid was put on pensions and public sector wages, discretionary expenses were slashed, and so were subsidies (save for agriculture) and budget loans to the corporate sector. The government announced austerity measures at all levels, as well as improving the efficiency of the public procurement procedure, redefining economic support measures and setting priorities in public investments so that limited resources would give maximum results in terms of economic growth and employment. In line with the fiscal consolidation measures, the share of public debt in GDP is projected to go down beginning from 2014. Planned is the sale of a part of state holdings in enterprises exposed to competition and not falling in the category of the so-called state monopolies, as well as the sale of minority packages in some enterprises and of some inactive state resources (buildings, agricultural land, etc.). A part of the funds thus obtained would be used for debt repayment in order to alleviate interest burden in the coming budget years.

When the scope for a countercyclical effect of fiscal policy is narrow, monetary policy is the one to provide impetus to economic activity. The extent of its countercyclical effect in Serbia, however, was largely constrained by the almost invariably present inflationary pressures. Serbia met the crisis as an

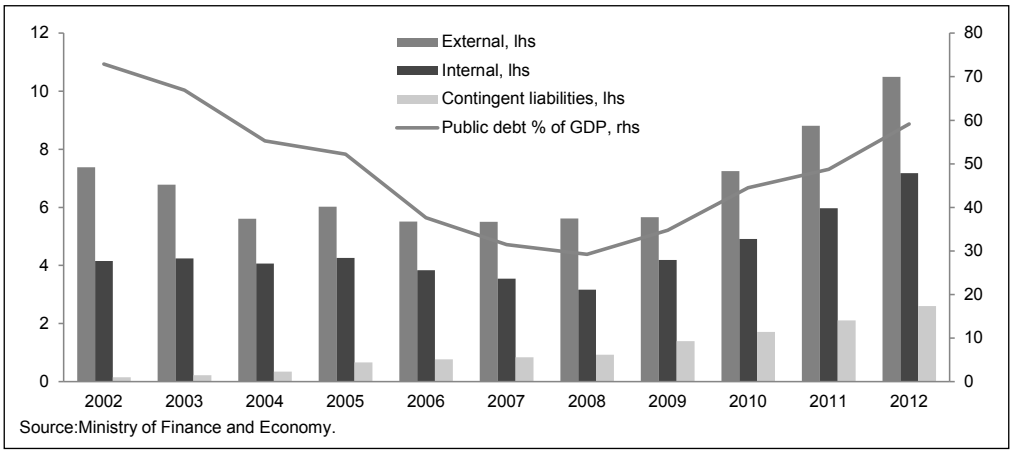
inflation targeter with a flexible exchange rate, high reserve requirement and capital adequacy ratios. When the first effects of the crisis unfolded in the form of reduced capital inflow and withdrawal of foreign exchange deposits from the banking system, the dinar weakened despite significant interventions in the FX market. As this had only fuelled the already high inflation expectations, in contrast to other central banks which lowered their policy rates as part of the overall anti-crisis effort, the National Bank of Serbia (NBS) had to raise its key policy rate to the record highs – 17.75% in November 2008. The first downward revision took place in January 2009. As inflation expectations and inflation itself subsided in the course of the year, the rate was lowered steadily to 9.5%.

As early as in 2009, the NBS amended its regulations to boost lending activity and to provide for more favourable credit repayment terms. Banks were encouraged to convert foreign exchange-indexed into dinar loans and to allow early loan repayment without additional charges. The restriction which required banks to maintain a specific household lending-to-core capital ratio was abolished. To facilitate cross-border borrowing for banks, the NBS also abolished the reserve requirement for loans and deposits received from abroad in the course of the year. With a view to supporting the government programme of measures to ease the negative effects of the financial crisis, the NBS subtracted the amount of loans granted under that programme from the reserve requirement base. Banks were also offered new sources of liquidity – dinar loans with maturity up to one year and short-term foreign exchange swap transactions.

Downward revisions of the key policy rate continued in 2010. The rate was gradually lowered to 8.0%. The monetary grip was relaxed through the new reserve requirement decision, which unified and lowered the reserve requirement ratios, changed the reserve bases and cancelled the largest number of exemptions, in order to encourage bank activity on both the liability (accumulation of deposits and cross-border borrowing) and asset side (lending). As the new decision was to bring about significant changes in the balance sheet structure of banks, the new model was phased in over a one-year period.

Chart 3 Public debt

(EUR bln)



Source:Ministry of Finance and Economy.

Another cycle of policy rate hikes began in August 2010, when bad agricultural season and surging international prices of food took their toll on food prices in Serbia, sparking inflation growth in the second half of the year. In a bid to counter depreciation pressures, which were present for most of 2010 due above all to the rise in the country risk premium, the NBS intervened heavily in the FX market. Monetary tightening proceeded until April 2011, when the key policy rate was raised to 12.5% in order to prevent the spillover of the food price growth to other prices through the inflation expectations channel. In January 2011, the NBS adopted a new decision on reserve requirements. The aim was not to withdraw, but to release less liquidity than envisaged by the earlier decision. The ratios on the dinar and foreign exchange reserve bases were differentiated according to maturity, a more favourable treatment being granted to dinar-denominated and longer-maturity liabilities. The decision also stipulated the obligation to allocate in dinars a part of the reserve requirements calculated in euros.

As inflationary pressures receded, in mid-2011 the NBS embarked on the process of gradual monetary policy easing, intervening in the FX market only occasionally. In this cycle of easing, the key policy rate was last lowered in January 2012 to 9.5%.

The 2012 budget deviated significantly from the framework planned, which sent the risk premium up and gave rise to depreciation pressures. An additional challenge for monetary policy in 2012 was the agricultural shock (drought-induced food price growth) and the increase in excise duties and VAT. For this reason, the key policy rate was raised from 9.5% in May to 11.75% in February 2013.

4. Empirical estimate of the fiscal and monetary stimuli in Serbia

4.1. Definition of the fiscal multiplier

The fiscal multiplier is usually defined as the change in real GDP or some other measure of economic activity, caused by a unity change in any fiscal variable. Depending on the period for which the fiscal multiplier is calculated, there are several ways to quantify the fiscal multiplier. The current multiplier (*Fm*) shows the effect of a unit increase in fiscal variable (Δf_0) on economic activity (Δy_0) at the moment of shock occurrence. It is calculated as follows:

$$Fm = \frac{\Delta y_{t0}}{\Delta f_{t0}}.$$

The accumulated multiplier up to period T represents accumulated change in the economic activity indicator caused by the unit change in fiscal variable also up to period T. It is calculated as follows:

$$KFm = \frac{\sum_{t=0}^{T} \Delta y_t}{\sum_{t=0}^{T} \Delta f_t}.$$

The maximum multiplier is the largest change in the economic activity indicator for a time period up to period T caused by the unit change in fiscal variable during period t_0. It is calculated as follows:

$$MFm = \frac{\max \Delta y(t_0 + T)}{\Delta f_{t0}}.$$

4.2. Description of variables used in the analysis

To estimate the fiscal multiplier, we have used a structural VAR model with five variables: gross value added excluding agriculture (*VANA*), real net taxes (*NT*), real public consumption (*G*), Consumer Price Index (*CPI*) and nominal money market interest rate (*R*). The estimation was made based on quarterly data series for the period 2003q1–2012q4. All of the observed data series, except for interest rates, are logarithmed, while the series for gross value added excluding agriculture, real public consumption and real net taxes have been also seasonally-adjusted. As an exogenous variable in the model, we have also used a dummy variable which takes nonzero value in the last quarter of 2005 because of a break in the real public consumption series.

In addition to expenditure for the purchase of goods and services, public sector wages and capital investments, the impact of other expenditure-side fiscal variables on economic activity was observed. These variables include total fiscal expenditure (*TG*) and total fiscal expenditure less foreign debt repayments (*PTG*).

Table 1 Description of model variables

Variable	Description of series	Unit of measure	Treatment of series	Data source
G	Public consumption = purchase of goods and services + expenditure for public sector wages + capital investment	logarithm, in RSD million	seasonally-adjusted and CPI-deflated series	Ministry of Finance and Economy
NT	Net taxes = revenues – subsidies – transfers	logarithm, in RSD million	seasonally-adjusted and CPI-deflated series	Ministry of Finance and Economy
VANA	Gross value added excl. agriculture in previous year's prices	logarithm, in RSD million	seasonally-adjusted series	Statistical Office
CPI	Consumer Price Index	logarithm, index (2010=100)		Statistical Office
R	Nominal money market interest rate – two-week BELIBOR	% p.a.		National Bank of Serbia

4.3. Estimation results

In order to estimate the size and direction of impact of fiscal multipliers, we started from the structural model recommended by *Blanchard* and *Perotti* (2002):

$$A_0 X_t = A(L) X_{t-1} + B\varepsilon_t ,$$

where X_t is the vector of the following endogenous variables, $X_t = (G_t, NT_t, VANA_t, CPI_t, R_t)$, while for structural shocks we assume $\varepsilon_t \sim \left(0, \sum_{\varepsilon} diag\left(\sigma_i^2\right)\right)$. The appropriate reduced form of the model is given with

$$X_t = C(L) X_{t-1} + U_t$$

where $C(L) = A_0^{-1} A(L)$ and $U_t = A_0^{-1} B\varepsilon_t$. Using the link between the reduced form of the residual and structural shocks, we have obtained the residual estimate model as follows:

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & -0.9 & -0.5 & 0 \\ -\alpha_{g} & -\alpha_{y\tau} & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ -\alpha_{g} & -\alpha_{r\tau} & 0 & -\alpha_{r\pi} & 1 \end{pmatrix} \begin{pmatrix} u_t^g \\ u_t^\tau \\ u_t^y \\ u_t^\pi \\ u_t^r \end{pmatrix} = \begin{pmatrix} \beta_{g} & 0 & 0 & 0 & 0 \\ 0 & \beta_{\tau} & 0 & 0 & 0 \\ 0 & 0 & \beta_{y} & 0 & 0 \\ 0 & 0 & 0 & \beta_{\pi} & 0 \\ 0 & 0 & 0 & 0 & \beta_{r} \end{pmatrix} \begin{pmatrix} \varepsilon_t^g \\ \varepsilon_t^\tau \\ \varepsilon_t^y \\ \varepsilon_t^\pi \\ \varepsilon_t^r \end{pmatrix}$$

Matrix A shows contemporaneous responses of variable i to the shock in variable j, so that α_{ij} represents the coefficient of elasticity of variable i on variable j, while matrix B shows responses of variable i to exogenous shocks in variable j.

For elasticity coefficients shown in matrix A we used similar assumptions, as it was done by *Cuaresma, Eller and Mehrotra* (2011) and *Perotti* (2002). It is assumed that the coefficient of elasticity of public consumption relative to GDP is equal to zero, which is in line with our earlier analyses, i.e. $\alpha_{g} = 0$. On the other hand, the results of our earlier empirical analyses indicate that the coefficient of elasticity of fiscal revenue varies between 0.8 and 1, depending on the revenue category, which is why we assumed $\alpha_{ty} = 0.9$. It is also assumed that the coefficient of elasticity of fiscal variables relative to interest rates is equal to zero.

The application of multi-dimensional information criteria of the estimated model suggests the incorporation of 2 lags in the VAR model (Table 2).

Table 2 Selection of the optimum number of lags in the VAR model by applying multidimensional information criteria

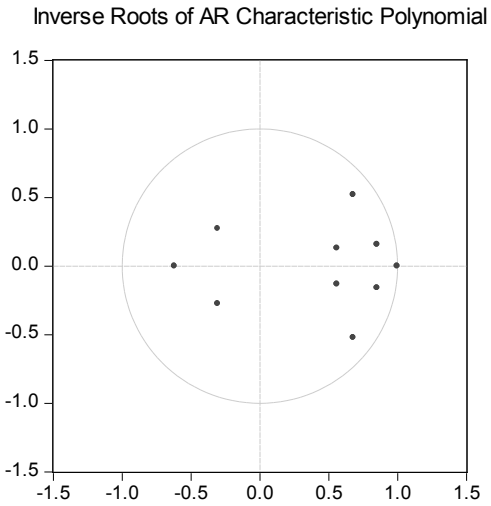
Number of lags	LogL	LR	FPE	AIC	SC	HQ
0	-634.5427	NA	68214517	32.22714	32.64936	32.37980
1	-387.8113	407.1068	1063.564	21.14057	22.61834	21.67488
2	-336.8349	71.36694*	313.4240*	19.84175*	22.37507*	20.75771*
3	-317.3514	22.40610	500.6804	20.11757	23.70644	21.41519

Results of the *Doornik-Hansen* normality test show that the random error of the estimated VAR model is normally distributed (Table 3), while the graphic presentation of characteristic roots which are by module smaller than unity and are found within the unity circle indicates that the estimated VAR model meets the stationarity condition.

Table 3 Doornik-Hansen normality test

Equation	Jarque-Bera statistics	Degrees of freedom	p value
G	0.832015	2	0.6597
NT	0.586075	2	0.7460
VANA	1.770639	2	0.4126
CPI	3.139394	2	0.2081
R	1.246171	2	0.5363
Accumulated test	7.574295	10	0.6703

Chart 4 Characteristic roots of estimated VAR model



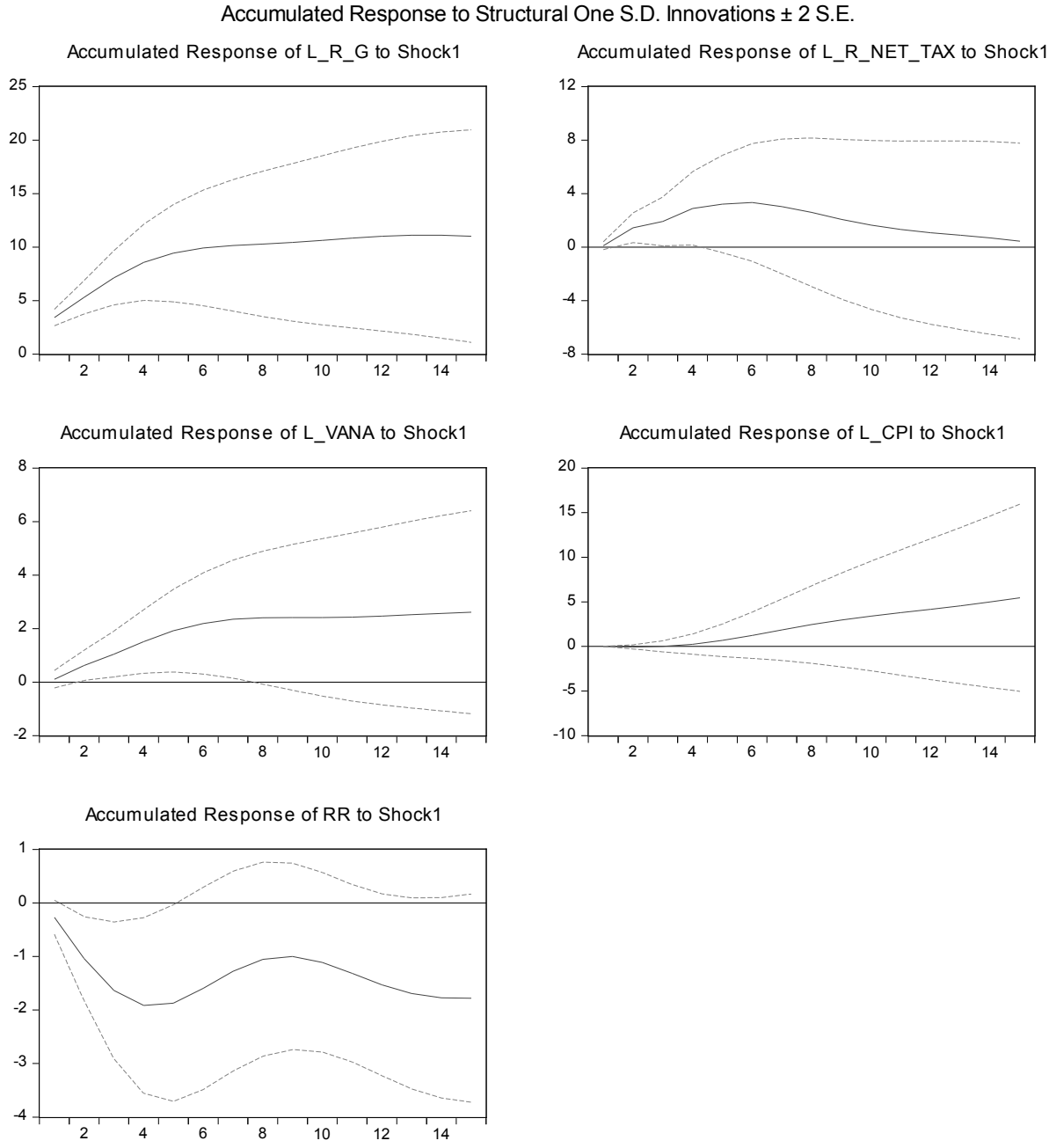
The fiscal multiplier estimate is obtained based on the impulse response function of gross value added excluding agriculture to shocks in real public consumption and real net taxes as follows:

$$kfm_t^G = \frac{ir_t^{VANA/G}}{ir_t^{G/G}} * \frac{Y}{G}, \quad kfm_t^{NT} = \frac{ir_t^{VANA/NT}}{ir_t^{NT/NT}} * \frac{Y}{NT},$$

where $ir_{t+1}^{VANA/G}$ is the value of the accumulated impulse response function of gross value added excluding agriculture in the period t to the initial shock in public consumption; $ir_t^{G/G}$ value of the impulse response function of public consumption in the period t to the initial shock in public consumption; $ir_{t+1}^{VANA/NT}$ value of the accumulated impulse response function of gross value added excluding agriculture in the period t to the initial shock in net taxes; and $ir_t^{NT/NT}$ the value of impulse response function in the period t of net taxes to the initial shock in net taxes. In order to determine the impact of fiscal variables on economic activity expressed in percentage of GDP, fiscal variables are multiplied by their average share in GDP.

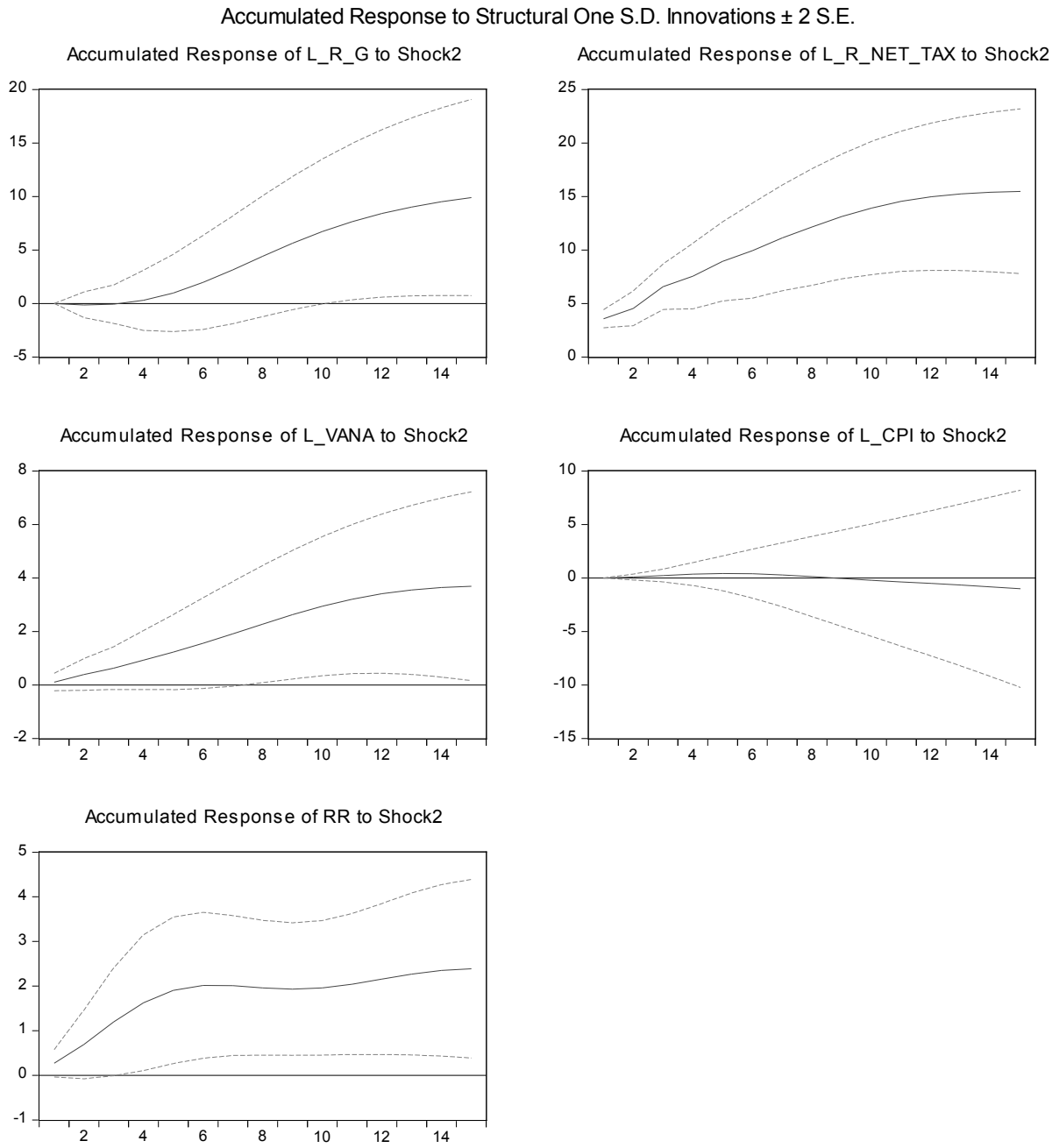
Results of the accumulated function of responses to impulses to the shock in public consumption and net taxes in the amount of structural unity, based on which we obtained the estimates of fiscal multipliers, are shown in the following charts (Charts 5 and 6).

Chart 5 Accumulated responses to the initial structural shock in public consumption



Results of the impulse response function indicate that the positive shock in public consumption (*Shock 1*) leads to economic growth which becomes statistically significant from the second quarter and stops being statistically significant after two years. Owing to the positive impact of public consumption on economic activity, net taxes are rising. A rise in public consumption is followed by a reduction in money market interest rates, which suggests accommodative monetary conditions, i.e. a rise in public consumption does not lead to a rise in the interest rate and the crowding-out of domestic investment and domestic consumption. A rise in public consumption results in a moderate increase in inflation, but this impact has not proven statistically significant.

Chart 6 Accumulated responses to the initial structural unity shock in net taxes



By contrast to public consumption, a positive shock in net taxes (*Shock 2*), i.e. their increase, leads to higher non-agricultural economic activity, contrary to expectations, but this impact has not proven statistically significant. Perotti (2002) arrived at similar results for Germany, Australia and Great Britain. He explains such result by the value of the tax elasticity coefficient on economic activity which is lower than one, which is also our case. However, by varying the degree of elasticity of net taxes on economic activity, from 0.9 to 1, the fiscal multiplier estimates which monitor the effect of net taxes on economic activity have not changed significantly in case of Serbia. The positive effect of the increase in net taxes on non-agricultural economic activity could be linked to a more regular servicing of government obligations thanks to revenue growth, which improves the liquidity position of the private sector.

The estimated impact of fiscal policy, both through rising public consumption and rising net taxes on interest rates, generally suggests accommodative monetary policy. Thus, a rise in net taxes is followed by rising money market rates. This is valid both for nominal and real rates in the money market. Perotti (2002) arrived at similar results, in terms of the simultaneous tightening of fiscal and monetary policies.

A rise in net taxes has a positive impact on inflation which is however very close to zero and is not statistically significant. This is also in line with the results obtained by Perotti (2002) for Germany and the USA. It is also interesting to note that in case of Serbia the shock in net taxes proved more persistent compared to the shock in public consumption.

Based on estimated accumulated impulse response functions, we calculated the values of fiscal multipliers from the revenue and expenditure side, as shown in Table 4.

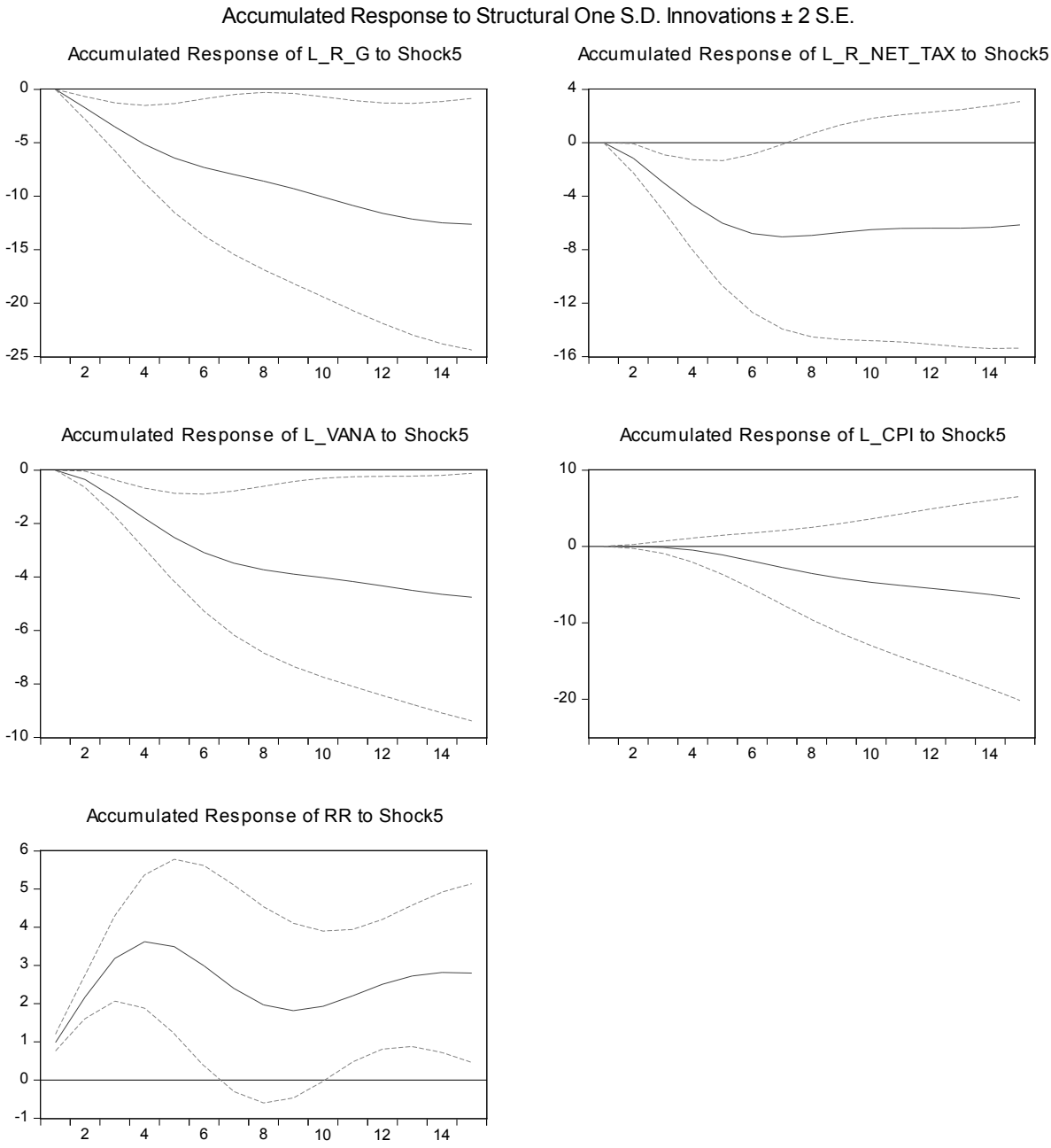
The shock in public consumption of 1% after one quarter leads to a rise in non-agricultural economic activity of 0.03%, or cumulatively of around 0.18% after one year. It stabilises at the level of around 0.23%, but stops being statically important after two years. In terms of percentage of GDP, a rise in public consumption of 1 percentage point of GDP leads to 0.14 percentage point rise in non-agricultural economic activity after one quarter, and a 0.77 percentage point increase cumulatively after four quarters (Table 4). The maximum multiplier of public consumption is achieved in the second quarter after the initial shock and equals 0.66 percentage points (see Chart D1 in Appendix).

Table 4 Estimated values of accumulated fiscal multiplier based on public consumption and net taxes

Period	$\frac{ir_t^{VANA/G}}{ir_t^{G/G}}$	$\frac{ir_t^{VANA/G}}{ir_t^{G/G}} * \frac{Y}{G}$	$\frac{ir_t^{VANA/NT}}{ir_t^{NT/NT}}$	$\frac{ir_t^{VANA/NT}}{ir_t^{NT/NT}} * \frac{Y}{NT}$
1	0.0315	0.1368	0.0298	0.1863
2	0.1174	0.5105	0.0855	0.5347
3	0.1466	0.6376	0.0953	0.5957
4	0.1770	0.7696	0.1231	0.7695
5	0.2037	0.8856	0.1373	0.8581
6	0.2209	0.9603	0.1570	0.9810
7	0.2313	1.0056	0.1716	1.0725
8	0.2339	1.0168	0.1873	1.1706
9	0.2314	1.0062	0.1999	1.2493
10	0.2272	0.9877	0.2114	1.3215
11	0.2242	0.9746	0.2204	1.3777
12	0.2239	0.9735	0.2277	1.4232

Results of the impulse response function show that fiscal policy responds to the positive shock in the interest rate (*Shock 5*) by lowering expenditure as economic activity and fiscal revenue contract on the same grounds. This is indicative of the conclusion that funding possibilities determine significantly the character of fiscal policy in Serbia, which confirms its procyclicality in the past period.

Chart 7 Accumulated responses to the initial structural shock in the money market interest rate



In order to verify the robustness of the estimates obtained, we have also made the analysis of the impact of other fiscal variables such as total fiscal expenditure (TG) and this expenditure less external debt repayment (PTG) on economic activity. The results obtained suggest that the shock in total fiscal expenditure of 1% after one quarter leads to a 0.03% rise in non-agricultural economic activity, or to a rise of around 0.15% cumulatively after one year. It stabilises at this level and gradually declines after two years. In terms of percentage of GDP, a rise in total public expenditure by 1 percentage point of GDP after one quarter leads to a 0.06 percentage point rise in non-agricultural economic activity, and to a 0.34 percentage point rise after one year (Table 4a). The value of the fiscal multiplier obtained based on total fiscal expenditure less external debt repayment is slightly higher than this estimate, but is smaller than the estimate obtained for the public consumption indicator.

Table 4a Estimated values of the fiscal multiplier based on total expenditure

Period	$\frac{ir_t^{VANA/TG}}{ir_t^{TG/TG}}$	$\frac{ir_t^{VANA/TG}}{ir_t^{TG/TG}} * \frac{Y}{TG}$	$\frac{ir_t^{VANA/NT}}{ir_t^{NT/NT}}$	$\frac{ir_t^{VANA/NT}}{ir_t^{NT/NT}} * \frac{Y}{NT}$
1	0.0258	0.0599	0.0357	0.2230
2	0.1112	0.2586	0.0991	0.6194
3	0.1302	0.3028	0.1149	0.7180
4	0.1455	0.3384	0.1430	0.8937
5	0.1554	0.3615	0.1568	0.9798
6	0.1625	0.3780	0.1763	1.1021
7	0.1648	0.3833	0.1885	1.1779
8	0.1660	0.3860	0.2027	1.2667
9	0.1648	0.3832	0.2127	1.3292
10	0.1630	0.3791	0.2229	1.3928
11	0.1604	0.3729	0.2304	1.4400
12	0.1577	0.3667	0.2374	1.4840

5. Conclusion

Given that a great number of countries, including Serbia, tightened their fiscal policies during the crisis and that the accumulated deficits opened the issue of public finance sustainability, the estimate of fiscal multipliers becomes one of the key topics of the economic analysis. To the best of our knowledge, this is the first paper which presents the estimate of fiscal multipliers for Serbia.

In estimating the fiscal multiplier we used the structural VAR model with the following five variables: gross value added excluding agriculture, real net taxes, real public consumption, the consumer price index and the money market interest rate for the 2003–2012 period on a quarterly basis.

Results of the analysis show that a rise in public consumption of 1 percentage point of GDP leads to a 0.14 percentage point rise in non-agricultural economic activity after one quarter, and 0.77 percentage points cumulatively after four quarters. It stabilises at the level of around 1 percentage point of GDP after six quarters, but loses statistical significance after two years. Unlike the fiscal stimulus on the expenditure side, it has not been confirmed that a reduction in net taxes on the revenue side would contribute to economic growth, but on the contrary. In case of Serbia, as also shown by numerous studies for other countries, this suggests that fiscal stimuli originating from the expenditure side are essentially more effective. Also, the estimated impact of fiscal policy on interest rates generally suggests accommodative monetary policy conditions.

Results of the impulse response function indicate that fiscal policy responds to the positive shock in the interest rate by lowering expenditure as economic activity and fiscal revenue contract on the same grounds. This leads to the conclusion that funding possibilities determine significantly the character of fiscal policy in Serbia, which confirms its procyclicality in the past period.

In order to verify the robustness of estimates obtained, we modified the model on several grounds. For instance, we varied the degrees of elasticity of net taxes on economic activity, from 0.9 to 1, but the estimates of the fiscal multiplier used to monitor the effect of net taxes on economic activity have not changed significantly. In addition, instead of nominal, we also used the real interest rate in making the estimate, but the direction of impact of fiscal policy on interest rates has not changed. The estimates of impact of public consumption on inflation remained largely unchanged when we set the limitation of 0.5 on public consumption price elasticity. Finally, we also observed the impact of other fiscal variables such as total fiscal expenditure and this expenditure less external debt repayment on economic activity, but these estimates have not changed significantly either.

The estimated value of the fiscal multiplier in Serbia is relatively high taking into account the macroeconomic characteristics of the Serbian economy (small and open economy with flexible exchange rate, high levels of public debt and fiscal deficit, etc.), and the fact that the fiscal expansion, which culminated in 2012, would have led to a public debt crisis if the fiscal consolidation program had not been adopted. The results of empirical analyses (for instance *Gavazzi and Pagano* (1990)) showed that in some countries fiscal consolidation had an expansionary effect, even in the short term.

The relatively high estimated value of the fiscal multiplier for Serbia could be related to the fact that the sample was dominated by the period of recession which is typically characterized by higher positive effects of the fiscal stimulus compared to the period of expansion.

In this regard, the limitation of this analysis lies in the fact that the estimated sample is relatively small and it is not possible to make estimates by sub-periods. i.e. segregate the impact for periods of expansion and recession, in order to verify the reliability of obtained estimates and analyse more clearly the effect of fiscal stimuli on economic activity. One of the ways to solve this problem is to use the STVAR model, which will be the subject of our future analysis.

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Appendix

Chart D1 Responses to the initial structural unity increase in public consumption

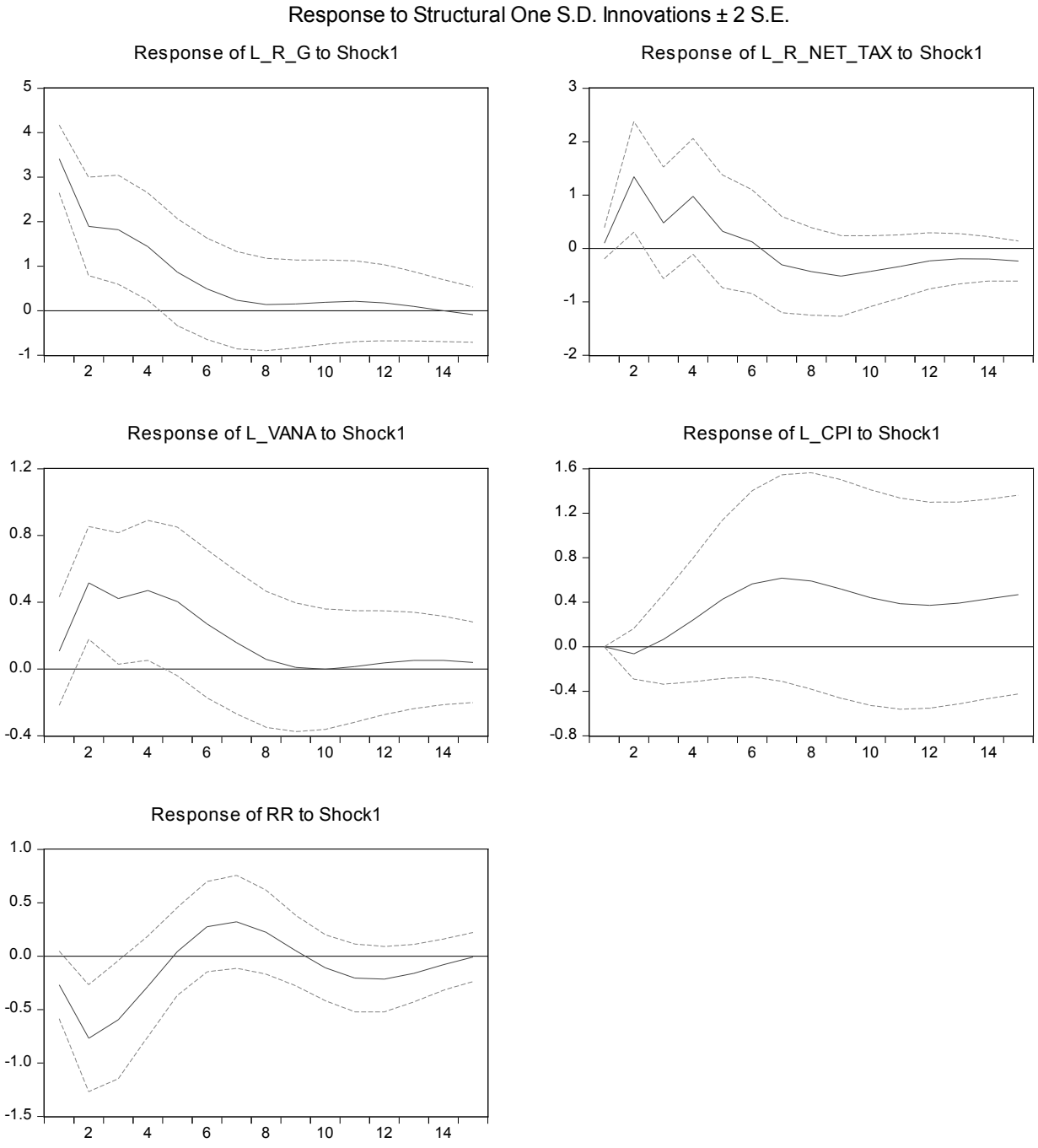
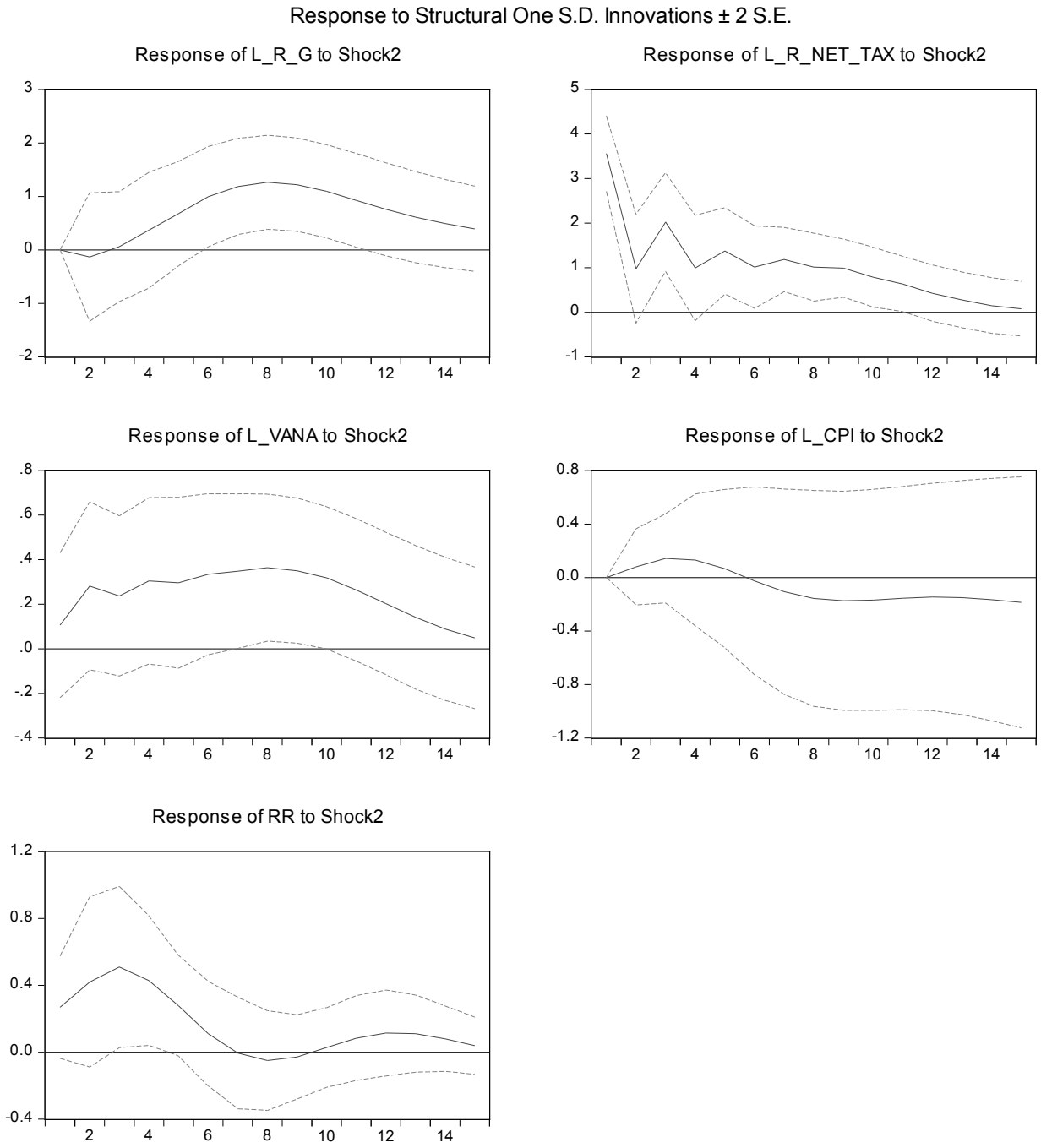


Chart D2 Responses to the initial structural unity increase in net taxes



UDK 330.354:336.02(497.2)

FISCAL POLICY AND ECONOMIC GROWTH IN BULGARIA

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(Preliminary version)[2]

Abstract

This paper analyses the impact of fiscal policy on real economic activity in Bulgaria and provides a range of estimates for the tax and spending multipliers. We compare the results of linear VAR models with the output from time-varying parameters Bayesian VAR with stochastic volatility. In all model specifications, first-year spending multipliers do not exceed 0.4, implying that there is not much to gain in terms of economic output from demand stimulating fiscal policy in Bulgaria. There is a lot of uncertainty in regards to the size of the tax multipliers, given contrasting results from VARs with different identification techniques, but the overall output effect of tax measures appears to be small and short-lived. The results from the linear models are largely consistent with the output from the time-varying parameters VAR model, which indicates that the size of first-year spending multiplier has doubled during the recent global crisis, but remains no larger than 0.3. These findings support the general view in the literature that fiscal multipliers are higher during periods of economic recession, but they are typically small in small open economies.

JEL Codes: C11, C32, E62

Keywords: Fiscal policy, Structural VAR models, Fiscal multipliers, Bayesian estimation, Time-varying parameters

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[2] Please do not quote.

1. Introduction

The strand of literature researching the effect of fiscal policy on the real economy has gained momentum after the 2007/2008 global financial turmoil. While initially the main question for the policy makers was what should be the size and appropriate mix of fiscal stimuli to counteract the severe economic downturn, sovereign debt sustainability issues soon moved the focus of the discussion on fiscal consolidation strategies and the quantification of the expected negative effects on output.

In both cases, however, the output effects of fiscal policy, as measured by the fiscal multiplier, is in the center of the discussion.

In 2012 the debate on the size of the fiscal multipliers has become even more relevant, as economic recovery turned weaker than expected in most European countries and the eurozone fell into recession for a second time.

Despite its critical importance and the large number of research papers, published in recent years, the discussion regarding the macroeconomic effects of fiscal policy remains a highly controversial one. In fact, there is no theoretical consensus on the size and even the sign of the fiscal multipliers, with neoclassical and new Keynesian macroeconomic models predicting different responses of private consumption, employment and real wages, following a fiscal shock. The numerous studies published since the onset of the global crisis did not manage to provide firm support for either of the theoretical models. On the contrary, the estimates on the size of the fiscal multipliers are now dispersed over an even broader range largely due to the lack of consensus on the most appropriate way of their assessment.

What became clear in the recent years is that fiscal multipliers are found in many different forms in the academic literature and their size might range considerably even when the analysis is focused on a specific economy and time span. Therefore, some definitions would be useful.

Commonly, the fiscal multiplier is measured by the ratio of the change in real GDP, or other measure of output, to the exogenous change in real fiscal variable that has caused the effect on output.[3] For example, the spending multiplier represents the change of GDP due to an increase of government spending.

Depending on the fiscal variable that is chosen for the assessment the ratio could be defined as government consumption multiplier, government investment multiplier, tax multiplier (which can be further broken down to direct or indirect tax multiplier, net tax multiplier etc.), lump-sum transfers multiplier, etc.[4] In several studies the percentage change of output following a 1% change in the fiscal variable is reported. This definition is closer to output elasticity rather than fiscal multiplier, making comparison of results from different studies difficult.

The definition of the fiscal multipliers differs according to the period of time, which is considered in the assessment. For instance, the impact multiplier refers to the estimated ratio in the first period (e.g. first quarter) after the fiscal shock has taken place, while the cumulative multiplier refers to the ratio of the cumulative changes in the output and the fiscal variable over a specified time horizon (Spilimbergo et al., 2009). Short-, medium- and long-term multipliers are also frequently used notations in the literature. Short-term multipliers usually provide a measure for the output effects up to one year after the fiscal shock has taken place, while the medium-term multipliers are typically calculated for a period between 1 and 3 years.

Nonetheless, there is a broad consensus in the academic literature about the main factors that affect the size of the fiscal multipliers. Spilimbergo et al. (2009) have grouped some of the most relevant of them.

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[3] Therefore, if the fiscal multiplier is higher or smaller than one, fiscal expansion would respectively crowd-in or crowd-out some component of aggregate demand and consequently output.

[4] Different types of fiscal interventions affect aggregate demand through different channels. For instance, government investment and government consumption impact directly on aggregate demand, while an increase in transfers or reduction in taxes operate mainly through their effects on personal disposable incomes.

First, fiscal multipliers are considered to be larger when only small part of the additional income, generated by the fiscal stimulus, is saved by the private sector or used for imported goods and services (thus limiting the negative effect on output resulting from lower consumption or higher imports). These conditions are particularly valid when: the economy is large or relatively closed (i.e. the marginal propensity to import is relatively small); the structure of the stimulus is such that it does not affect imports and it is mostly based on an increase in government expenditure, rather than a decrease in taxes[5]; the marginal propensity to consume is high and the stimulus is targeted towards credit or liquidity constrained consumers (i.e. hand-to-mouth consumers); economic agents do not expect future compensatory measures due to short planning horizon or poorly formulated expectations for the future (i.e. non-Ricardian households[6]); the automatic stabilizers are small[7] and the efficiency of public spending is high.

Second, the size of the fiscal multiplier, at least theoretically, depends on the monetary policy response to the fiscal shock (expansion). The traditional argument in the literature follows the Mundell-Fleming proposition, which implies that fiscal multipliers are lower in economies with floating exchange rates regimes.[8]

The sustainability of the fiscal stance after the stimulus is another important determinant of the multiplier's size. For instance, debt sustainability issues may be considered as a signal for an inevitable fiscal tightening in the near future. In turn, the anticipation of consolidation measures (increase in public savings or taxes) might lead to lower private consumption due to precautionary saving reasons (Ricardian equivalence proposition).

More recent studies have found that the degree of financial market development of the country could also affect the size of the fiscal multipliers. Limited credit availability would result in higher share of liquidity-constrained households and companies, which would spend the addition income, associated with the fiscal stimulus, in order to smooth their consumption or investment needs.

What complicates the assessment of the fiscal multipliers even further, especially in the current economic environment, is the variation in the size (and possibly the sign) of the fiscal multipliers over time. During the recent financial and economic crisis, many governments around the globe implemented sizable fiscal stimulus measures with the aim to counter the economic downturn. However, the theoretical and empirical literature on the output effects of fiscal stimulus remains rather inconclusive, especially as regards to the EU economies, which are typically characterized by a high degree of openness. The issue is particularly relevant for the less developed EU Member States, which have experienced a number of structural changes over the last 15 years that have undoubtedly influenced the output effects of fiscal policy over this period.

For instance, the process of integration of Bulgaria into the EU single market has significantly increased the openness of the economy, which has certainly widened the imports related fiscal stimuli leakage. In addition, other factors, such as the gradual decrease of the share of liquidity and credit constrained households during the years of economic expansion; the reforms in the tax system, the changes in the efficiency and the structure of public spending might have also significantly impacted the size of fiscal multipliers in Bulgaria over the last 15 years. On the one hand, small open economies, such as Bulgaria, with relatively recent episodes of severe economic distress and debt sustainability issues are characterized by limited effectiveness of policy measures and under certain circumstances fiscal contractions can often lead to economic expansion (Expansionary Fiscal Contraction hypothesis).

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[5] The increase in government expenditure usually has a more direct effect on aggregate demand (increase in public sector wages, social transfers in kind, government purchases of goods and services etc.), while the additional income from a tax decrease might be saved by the consumers, thus limiting the second round effects on aggregate demand.

[6] E.g. economic agents do not expect an increase in taxes in the future as a result of fiscal stimulus today. Therefore, the agents would rather spend the additional income, resulting from the stimulus, than increase precautionary savings in anticipation of higher taxation in the future. In case the Ricardian equivalence is valid, private saving would offset the effects from the expansionary fiscal policy, especially if the fiscal shock is permanent.

[7] Smaller automatic stabilizers are associated with relatively small output elasticity of government revenue and spending is relatively small. Therefore, the automatic offset effect, resulting from the fiscal stimulus, would be more limited.

[8] See Born et al. (2012) for a discussion on the relevance of the Mundell-Fleming proposition in explaining the size of fiscal multipliers and its empirical validity. The authors conclude that the difference between the size of the spending multipliers in economies under fixed and floating exchange rate are smaller than what the traditional Mundell-Flaming analysis would suggest.

On the other hand, the relatively large share of liquidity constrained households and the Currency Board Arrangement in Bulgaria could be considered as driving forces for a larger size of the fiscal multipliers. All in all, there is a lot of uncertainty regarding the functioning of the fiscal policy transmission mechanism in Bulgaria. In addition to the general complexity of the topic itself, short data series, including episodes of significant structural changes pose further challenges to research the macroeconomic effects of fiscal policy in Bulgaria.

The purpose of this paper is to shed some light on the macroeconomic effects of fiscal policy in Bulgaria by providing a range of estimates for the fiscal multipliers. Out of the four broadly defined methodologies for evaluating output effects of fiscal shocks[9] we have chosen vector auto-regression models (VARs) along with the increasing number of empirical studies employing similar techniques. We start our empirical investigation by estimating a linear VAR model with recursive identification and a classic structural VAR model, developed by Blanchard and Perotti (2002). Then, we compare the results of the linear VAR models to the estimates from time-varying parameters VAR.

Our contribution to the existing body of literature is twofold. First, the paper adds to a small but growing literature on the effects of fiscal policy in Central and Eastern Europe and Bulgaria in particular[10], by applying methodologies that have been found useful in assessing fiscal multipliers in the more advanced European economies. Second, we contribute to the relatively new and so far limited research effort, employing time-varying parameter VAR models to study the output effects of fiscal policy over time. We consider the application of this methodology to be especially relevant for analyzing fiscal policy in Eastern European economies, where a lot of factors for non-linearity and time-dependent effects of fiscal stimuli have been present in the last 13 years.

The rest of the paper is structured as follows: Section 2 briefly presents the different approaches for measuring fiscal multipliers, reviews the literature on VAR models with different identification techniques and comments on the results of similar studies for other European economies. Section 3 provides a short overview of fiscal policy developments in Bulgaria in the period 1999-2011, while Section 4 describes the data that we use in the empirical study. The baseline VAR models are presented in section 5 and the model with time-varying parameters, estimated with Bayesian techniques, is presented in section 6. Section 7 compares the results of the fixed and time-varying parameter models before we present the concluding remarks in Section 8.

2. Literature Review

The growing body of research studies on fiscal multiplies utilizes several different approaches for assessing the impact of fiscal stimuli on macroeconomic developments. The most widely used approaches are the empirical estimates based on VAR models and structural model-based evaluations, such as Dynamic Stochastic General Equilibrium (DSGE) models.

An often cited shortcoming of assessments based on simulations with structural models is that the estimated multiplier is largely dependent on their theoretical construction[11] of the model. Particularly, the results are significantly influenced by the forward looking features of the models, the assumptions about the utility function of the individuals, the production function of the firms, the source of nominal rigidities and the monetary policy reaction function (see Spilimbergo et al, 2009, Perrotti, 2007, Christiano et al, 2010 and Coenen, 2012 for a review). On the other hand DSGE models are suitable for assessing fiscal multipliers by instrument since they are not subject to data restrictions when the number of explanatory variables is increased. Generally, fiscal multipliers estimated by DSGE models are lower as compared to empirical models and the share of liquidity constrained households appears to be most relevant parameter

[9] Spilimbergo et al. (2009) have grouped the most widely used methodological approaches into studies based on: Model simulations, Case studies, Vector auto-regressions (VARs) and Econometric studies of consumer behavior in response to fiscal shocks. The Literature review section provides a brief discussion of available methodologies.

[10] Muir D., and Weber A., (2013) have recently estimated a range of fiscal multipliers for Bulgaria. Bulgaria has been included in several panel studies (see for example Iztlezki et al, 2009). Only Mirdala (2009) has estimated expenditure and tax multipliers separately for Bulgaria in a SVAR study together with five other Central Eastern European economies over the period 2000 - 2008.

[11] See Coenen at al. (2012) for a detailed reference.

in influencing the size of the impact spending multipliers, as pointed out by the meta-analysis of Leeper et al. (2011).

VAR-based estimates have the advantage of being unrestricted by a predetermined theoretical construction, but on the other hand, important structural features of the economy might be omitted by the empirical model when estimating the size of the fiscal multiplier.

Another fundamental difference between the two most widely used techniques concerns the nature of the fiscal shock. In addition to the economic environment, the monetary regime and the other factors outlined in the introduction, the nature and the composition of the fiscal shock significantly influences the estimated size of the fiscal multipliers. Typically, VAR-based estimates of fiscal multipliers utilize specific temporary fiscal shocks, while structural models allow for policy evaluations based on both temporary and permanent shocks. Therefore, a comparison between the results of these two techniques is not always appropriate.

In addition to the above mentioned techniques, the effects of discretionary fiscal policy could be identified by case studies, based on well documented changes in tax policy or discretionary government spending. The benefit of this approach, followed by Romer and Romer (2010), is related to the fact that the timing of the announcement of the fiscal measure can be clearly identified. At this point of time the future expectations of the economic agents are formed, which is considered to be the relevant moment for assessing their reaction and the resulted output effect, rather than the moment of the actual implementation of the measure. This methodology offers certain advantages over other more commonly used approaches for identification of discretionary fiscal policy shocks, but it requires very long data series with the presence of many such episodes of exogenous fiscal shocks. Data series of this kind, however, are not available for Bulgaria[12].

Several empirical studies evaluate the effects of fiscal policy based on micro data by analyzing consumer behavior following a tax policy change. Analysis of this type can be useful in drawing conclusions on the change in individuals' consumption and saving patterns, but they also require specific data, which is rarely available.

As mentioned earlier, fiscal multipliers are commonly assessed by the use of VAR models with different identification techniques. As Caldara and Kamps (2008) note, these empirical models have become the main econometric tool for assessing the effect of fiscal and monetary policy. This is the approach that we follow in this paper.

VAR-based empirical studies can provide valuable information about the output effects of fiscal policy but similarly to the other estimation approaches they also tend to suffer from several drawbacks. A major issue in the application of VAR-based empirical studies is the method of identification of the presumably exogenous fiscal shocks. As demonstrated by Caldera and Camps (2008), different identification schemes of fiscal shocks can significantly affect estimates. Generally, five groups of identification approaches used in the VAR-based studies can be outlined.

As a starting point, the recursive approach, followed by Sims (1980), Fatas and Mihov (2001), Alfonso and Sousa (2009) and Giuliodori and Beetsma (2004) is often used. This approach is based on the recursive Cholesky decomposition of the variance-covariance matrix of the model residuals and requires strong and sometimes arguable assumptions about the contemporaneous relations between the variables in the model specification. The recursive identification scheme is used to evaluate fiscal policy effects in several studies on the new members of the EU (i.e. Mirdala, 2009 and Lendvai, 2007).

Second, the structural VAR approach proposed by Blanchard and Perotti (2002) and further extended in Perotti (2005) is among the most widely applied fiscal shock identification schemes. The approach of Blanchard and Perotti (2002) is based on out-of-the-model institutional information on the automatic responses of government spending and taxes to economic activity (budgetary output elasticities) and requires some assumptions about the period of time which is needed for the government to implement

[12] Moreover, this methodology can only be applied to measures that can be assessed as purely exogenous and not related to recent economic developments so as to make sure that there is no endogeneity bias in the estimation.

discretionary fiscal measures in response to output innovations. This approach (henceforth BP approach) is extensively applied in studies on fiscal multipliers in the euro area countries[13], but it is also dominant in the analysis on the less developed European economies.[14]

Third, the sign-restrictions approach developed by Uhlig (2005) and applied by Mountford and Uhlig (2005) and Caldara and Kamps (2008) is another frequently used identification scheme in the VAR-based studies on fiscal multipliers. This methodology directly imposes restrictions on the shape of the impulse responses. The crucial specification in this approach is that following a business cycle shock, the impulse responses of output and taxes are positive for at least four quarters after the shock. The advantage of this technique is that it controls for a frequently observed problem in empirical studies related to a puzzling result of an increase in output as a response of a positive tax shock. In the same time, however, the sign-restrictions approach[15] tends to overestimate the negative response of output after a tax increase, as argued by Caldara and Kamps (2008).

Forth, Ramey and Shapiro (1998) have introduced the event-study approach to analyze the output effects resulting from of large unexpected increases in government defense spending. Similar identification techniques have been applied by Perotti (2007), Ramey (2007) and Caldara and Kamps (2008). While the application of event-study approach might provide valuable information on the output effects of fiscal shocks it requires long data series of well-documented exogenous spending shocks, which is rarely available, especially for eastern European economies. Therefore, its application is limited primarily to studies based on data for the United States[16].

Fifth, some research papers apply long-run restrictions on the responses of the variables in the VAR model, as in Blanchard and Quah (1998). The identification strategy imposes a long- run neutrality assumption on some of the variables[17]. Mirdala (2009) follows this approach to analyze the output effects of fiscal policy shocks in the some of the new member of the EU, including the Czech Republic, Hungary, Poland, the Slovak republic, Bulgaria and Romania. The results are then compared to the outcome of a VAR model with a recursive identification scheme. The two approaches provide quite similar results for both the tax and the spending multipliers. Yet, to the extent that long-run neutrality assumptions seem to be quite arguable and rarely used in studies on fiscal policy effects, we refrain from using this methodology in this paper.

All different identification schemes provide a broad range of estimates on the effects of fiscal policy on economic activity, which tend to diverge considerably, especially with respect to the output effects of tax changes, as shown by Caldara and Kapms (2008). Overall, the existing studies suggest that spending multipliers in the new Member States of the EU and the euro area peripheral economies, such as Spain and Portugal, rarely exceed values of 0.4 (cumulative effect for the first year)[18]. These values are found to be considerably lower as compared to the estimates for USA, Germany, France and UK[19]. Moreover, the persistence of the effects is usually quite short and in many cases fades away one or two quarters after the fiscal shock has taken place. The reported outcomes for the revenue multipliers are even lower - in the range of 0.1 - 0.2. Again, the effect of the shock is rarely long-lasting. Interestingly, Mirdala (2009) finds that economic output actually increases after a positive tax shock in Bulgaria, Czech Republic,

[13] See Caprioli and Momigliano (2011) for comparison of studies and estimates on the euro area, Germany, France, Italy, Spain and the UK.

[14] See for instance: Jemec et al (2011) for a study on Slovenia, Cuaresma et al (2011) for a study on five Central and Eastern European economies, Benčík (2009) for a study on Slovakia and Mançellari (2011) for a study on Albania.

[15] The sign-restrictions approach has been applied by Bencik (2009) for an analysis on the Slovakian economy.

[16] See Caprioli and Momigliano (2011) for a more detailed reference.

[17] Typically, it is assumed that government spending does not permanently effect tax revenues and the vice versa, real output does not have a permanent effect on government expenditures and inflation , inflation does not have a permanent effect on government expenditures and real output and interest rates do not have a permanent effect on any other endogenous variable of the model.

[18] It should be noted however, that in some studies what is reported is the percentage change of output following a 1% change in the fiscal variable. This definition is closer to output elasticity rather than fiscal multiplier. Therefore, comparison between the results from the different studies in not always appropriate.

[19] See Boussard et al. (2012) for summary tables of results from VAR-based expenditure and net taxes multipliers in US, Germany, France, Italy, Spain, UK, Portugal and the Euro area.

Romania, Hungary and Slovakia. This finding however, may be a result of an omitted variable bias[20] or not properly accounting for the size of the automatic stabilizers.

Most of the mentioned studies so far, however, estimate a linear, constant effect of fiscal policy on economic activity on the basis of historical data. Yet, recent theoretical and empirical studies have highlighted the instability of fiscal multipliers over time. Indeed, subsample instability has often been observed in VAR studies (Pereira, M. and Lopes, A., 2010). Specifically, the size of the fiscal multipliers is often found to be highly dependent on underlying state of the economy, as argued by Spilimbergo et al (2009), Baum and Koester (2011, 2012) and Auerbach and Gorodnichenko (2010, 2011). In most cases, fiscal multipliers tend to be larger in downturns than in expansions. This asymmetry has important fiscal policy implications, especially for the choice between frontloading and backloading the required consolidation process. Nevertheless, there are several sources of the economic- state dependent character of the fiscal stimulus impact on output that should be considered when choosing the appropriate adjustment policy.

On the one hand, fiscal multipliers might be larger in periods of economic recessions since the negative output gap allows the monetary authority to accommodate the increase in demand (as a result of expansionary fiscal measures) without having to increase interest rates, which would otherwise offset some of the effects of the fiscal stimuli.[21] Under fixed exchange rate, however, the fiscal expansion would imply increase in money demand and a corresponding increase in money supply, with no offsetting effect through a decrease in net exports.

Moreover, the share of liquidity and/or credit constrained households and companies usually increases in downturns and allows for a much stronger effect of government stimuli on private consumption and output, as greater part of the additional income would be consumed or invested, but not saved.

On the contrary, periods of severe recession could trigger high levels of precautionary savings, given the heightened risk of unemployment and lower income. This would decrease the effect of the fiscal stimulus, considering the limited second round effects on private consumption. Similarly, the corporate sector may also postpone or abandon investment projects in view of the uncertainty about the economic outlook.

High or rapidly rising government debt levels might also negatively affect the effectiveness of fiscal policy in stimulating economic output, as demonstrated by Kirchner et al. (2010) and Nickel, C. and Tudyka, A. (2013). Considering the increasing or already high level of public indebtedness, private agents would perceive the present fiscal situation as unsustainable. Therefore, the fiscal stimulus would lead to lower private consumption and higher precautionary savings, as agents expect higher taxes or lower government consumption in the future, as a result of the higher deficit today. Such argument is strongly supported in the literature on expansionary fiscal contractions (Giavazzi and Pagano, 1990)[22] and it is to a large extent supported by the latest developments in the EU.

Lastly, structural changes in the economy and major tax and spending reforms may also influence the magnitude of fiscal policy effects over time. These features are particularly relevant for the catching-up economies of the EU, such as Bulgaria.

The impact of fiscal policy on the expectations formation in the private sector, as well as the other sources of non-linear effects of fiscal policy, has been subject to extensive research in the recent years. Generally, VAR-based techniques are considered to be more appropriate than structural models for capturing the non-linear nature of the multiplier's size, especially when the economy deviates from its steady state. Among them, the use of Bayesian techniques to estimate time-varying parameter VAR models offers some advantages as it allows greater flexibility in modeling non-linearity (Pereira and

[20] The omitted variable bias might be related to the significant structural changes, experienced by these economies during the time period considered in the study. The EU accession process has significantly stimulated FDI and economic growth in the region. At the same time tax collection improved, major tax reforms were undertaken in several of these countries and some tax rates were harmonized with the higher EU levels.

[21] In the opposite case, the monetary authority would not increase the money supply as a response of the increase in output due to inflationary pressure. This, in turn would appreciate the local currency (due to increase in interest rates and capital inflows) and reduce net exports, thus offsetting the initial fiscal expansion effect on output.

[22] Giavazzi and Pagano find empirical relevance for expansionary effects of fiscal contraction for the case of Denmark in the 80s where cuts in government spending were associated with an increase in consumption even after controlling for wealth and income, and even in the presence of a substantial increase in current taxes.

Lopes, 2010)[23]. This is the approach that we follow in this paper in order to test for non-linear output effects of the fiscal policy in Bulgaria, which might have been caused by structural changes that cannot be easily identified a priori, or they may take the form of processes that last a number of years (see Kirchner at al., 2010). Such structural changes are related to the efficiency enhancing reforms in the administration and to the gradual tax reforms that have taken place over the last 15 years in Bulgaria. The alternative approach of including sub-sample or rolling- windows estimation is not appropriate mainly due to the short length of the time series. In addition, the gradual nature of some of the structural changes in Bulgaria will not be properly captured by a sub-sample estimation. On the other hand, sudden policy changes, as the introduction of the flat tax rate would not be reflected by rolling-windows estimation.

The next section provides a brief overview of economic developments in Bulgaria during the last 15 years. Given the above mentioned arguments, such an overview is important for understanding the factors that might have significantly influenced the output effects of the fiscal policy in Bulgaria.

3. Stylized facts on macroeconomic developments and fiscal policy in Bulgaria

In the years after the introduction of the Currency Board Arrangement (CBA) the macroeconomic environment in Bulgaria stabilized and a process of restructuring of the economy started. This process was accompanied by substantial privatization related capital inflows and FDI inflows, further boosted by the EU accession prospects. The inflow of FDI accelerated even further in the few years just before and after the EU accession (2005 - 2008). These developments were in line with the anticipation of high growth and relatively high risk-adjusted expected returns, underpinned by the stable and robust economic growth since 1998. Large part of the capital inflow was directed towards the private sector, reflecting the need for replacement and modernization of the outdated productive equipment in the export oriented sector. These factors, along with the accelerated real and nominal convergence processes led to substantial trade deepening and financial integration of Bulgaria within the Single Market of EU, expressed by the substantial increase in the degree of openness of the Bulgarian economy - from around 100% of GDP in 1999, up to nearly 140% of GDP in the period 2006 - 2008 (Figure 2).

Figure 1

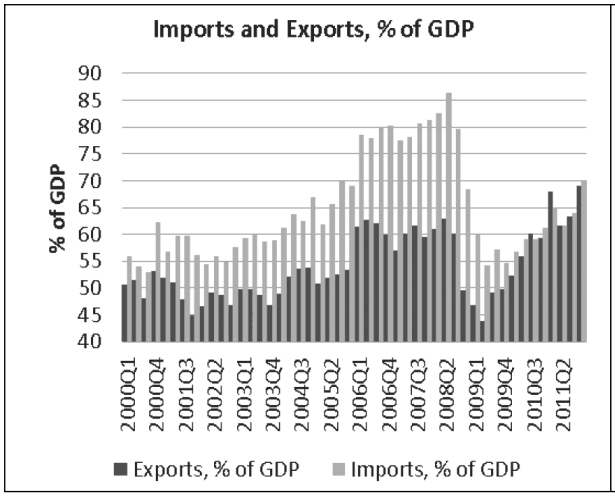
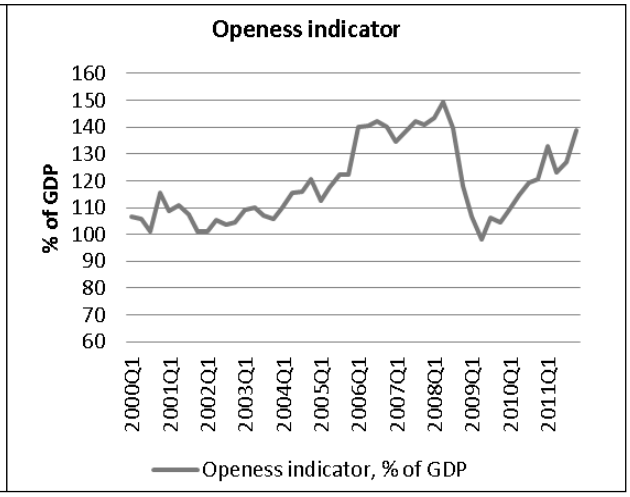


Figure 2

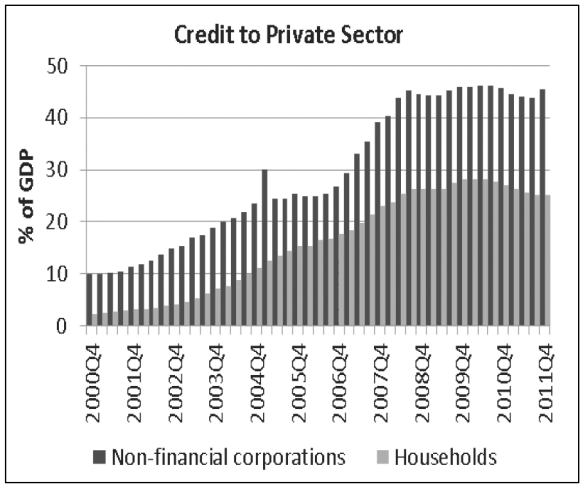


*Note: Openness is measured by import penetration, as the focus is on the import "leakage". That is: Imports/(GDP - Exports + Imports)*100. Identical measure is used in Appendix 1 "Fiscal Multipliers in Expansions and Contractions", IMF, Fiscal Monitor - April 2012. All the series in both graphs are seasonally adjusted.*

[23] Alternatively, a recent study by Baum and Koester (2011) on Germany uses threshold autoregressive model and demonstrates that the value of the fiscal multipliers is significantly larger in recession than in good times. Baum et al. (2012) apply a threshold autoregressive model for the G7 countries (excluding Italy) and again find a strong relationship between fiscal multipliers and the underlying state of the economy See also the Smooth Transition Vector Autoregressive (STVAR) approach proposed by Auerbach and Gorodnichenko (2010) and extended in Auerbach and Gorodnichenko (2011). Recently, Muir and Weber (2013) have estimated multipliers in Bulgaria depending on the state of the economy using a threshold VAR (the threshold is endogenously determined value of the output gap of -1.73%). They find that the impact of fiscal policy varies with the business cycle, with multipliers being larger in downturns than in expansions. In a downturn revenue and expenditure first year multipliers are 0.5 and 0.3 respectively and in an expansion they are 0.4 and 0.2 respectively.

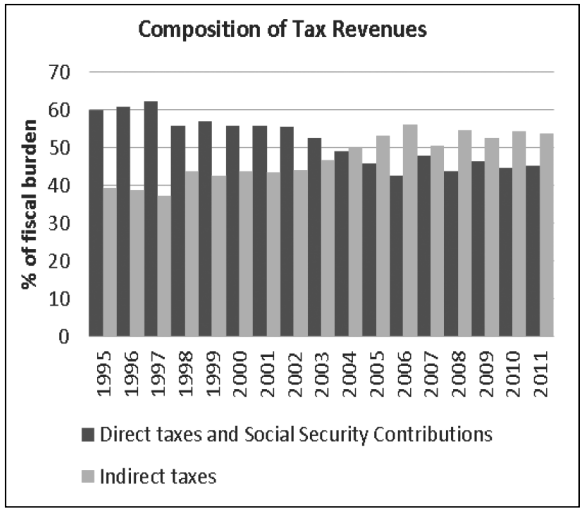
Driven by both demand and supply factors and reflecting financial deepening and EU- integration processes, the credit to the private sector accelerated rapidly since 2003. Favorable macroeconomic environment, high expected return on investment and positive income convergence expectations were the main contributing factors on the demand side. On the supply side, banks, intensified market share competition and actively expanded their operations.

Figure 3



Under the currency board arrangement, adhering to a strict fiscal policy in Bulgaria has been of extreme importance in terms of supporting the credibility and increasing the confidence in the monetary framework. Since the CBA introduction, the Bulgarian government has been running surpluses or small budget deficits (no more than 0.6% of GDP on a cash basis) and has managed to maintain neutral or countercyclical fiscal stance. In the pre-crisis years from 2005 to 2008, the cash-based fiscal surpluses averaged at 3.1% of GDP as the government was able to utilize the tax-rich growth composition of the Bulgarian economy at that time. Tax revenue increased rapidly, in particular in regards to tax receipts on goods and services, driven by the strong domestic demand and increases in excise rates in line with EU requirements. The growth of government revenues was further boosted by the implementation of a growth-oriented tax policy reform, including a gradual shift to indirect taxation, steadily decreasing income[24] and labour tax rates[25], coupled with administrative measures to improve tax compliance.[26]

Figure 4



[24] Following a gradual decrease since 1997, a flat corporate and personal income tax rate of 10% has been introduced in 2007 and 2008 respectively.

[25] Social security contributions rates were cut by 6 percentage points from 2002 to 2007 (for the pension and unemployment funds) and a further 2.4 percentage points in 2009.

[26] A prominent example for an effective tax compliance measure is the requirement for registration of all labour contracts in the National Social Security Institute in 2003, which had a significant impact on social security contributions revenue.

As a result of the prudent fiscal policy, along with significant privatization proceeds and the positive interest-rate-growth differential the government debt-to-GDP ratio declined from over 100% in 1997 to as low as 13.7% in 2008. At the same time, a substantial fiscal reserve was accumulated, exceeding 17% of GDP in the third quarter of 2008.

Figure 5

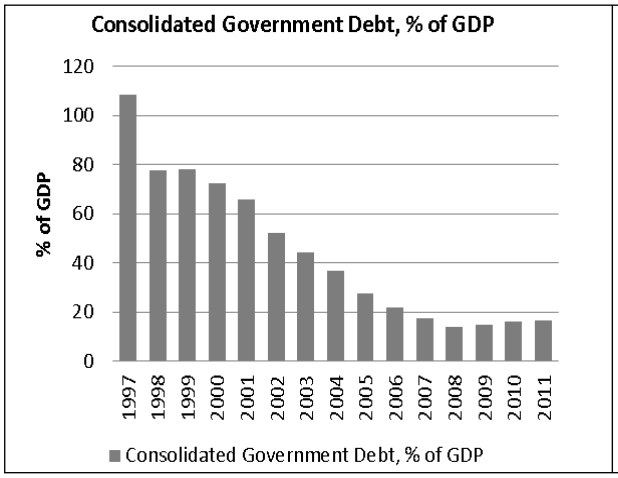
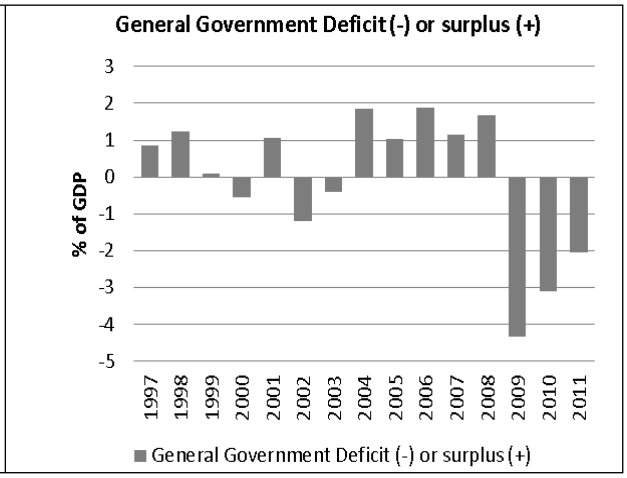


Figure 6



The recent global economic crisis represented a major external shock to the Bulgarian economy, testing its resilience, particularly against the pre-crisis background of comparatively large external imbalances. However, an orderly adjustment of the trade deficit materialized. Initially, both exports and imports contracted, with exports declining less than imports, while subsequently exports recovered at a fast pace as companies managed to redirect their production towards the external market (Figure 1).

Nevertheless, the economic slowdown put an end to tax-favorable growth composition and posed a challenge to government revenues. The negative cyclical impact on tax revenues was most notable in respect to VAT and corporate tax revenues, which fell by more than 20% in the first half of 2009. The sharp drop in government revenues coupled with higher pre-election spending in the first half of 2009 led to ESA deficit of 4.3% of GDP and an initiation of an excessive deficit procedure against Bulgaria. At that point, the fiscal reserve account of the government played an important liquidity buffer role as it considerably reduced the need for government debt issuance during a period of heightened risk perceptions, which negatively affected both the availability and the cost of loanable funds.

As a result, at the end of 2010 the Bulgarian government debt-to-GDP ratio remained as low as 16.2% - the second lowest in the EU (Figure 5). The fiscal consolidation process that followed was largely frontloaded and implemented mostly on the expenditure side. Already in 2010, the deficit was brought close to the Maastricht reference criteria at 3.1% of GDP. In 2011 the consolidation efforts continued with a nominal freeze of wages, restrained intermediation consumption and pensions and further cuts in investment, bringing the budget deficit down to 2.1% of GDP.

The onset of the global crisis and its subsequent intensification in the second half of 2008 brought about a change in the business model followed by the banks in Bulgaria. With the outbreak of the crisis the uncertainty about the future economic developments mounted and resource availability declined worldwide. As a consequence, credit institutions in Bulgaria started to adopt increasingly cautious lending practices. On the demand side, the private sector and especially households have significantly increased savings, mainly due to precautionary motives, with credit growth substantially decelerating, compared to the pre- crisis period. While corporate sector credit growth has remained positive, households have been cautions in taking new loans and preferred to repay their existing liabilities, which resulted in a slightly negative rate of change in banks' claims on households.

4. Data and Methodology

Our assessment on the fiscal multipliers in Bulgaria is based on two different estimation approaches. First, we estimate linear vector auto-regression models with two different identification schemes. One based on the recursive approach and another one based on the approach of Blanchard and Perotti (2002). Second, we analyze the variation in the size of the government consumption multiplier in Bulgaria over the last 13 years by estimating a time- varying parameter VAR with stochastic volatility.

For the purpose of this study, we have chosen to use accrual fiscal data (based on ESA'95 methodology), rather than cash-based data, where longer data series are available. This is strongly justified as it enables us to compare our results with other studies on European economies, most of which are based on ESA'95 data[27]. In addition, accrual fiscal data takes into account the payment lags in taxes, it offers a better treatment of EU funds related transfers and it accounts for the accumulation of public arrears.

All fiscal variables for the linear VAR models are taken or derived from the quarterly non- financial accounts of the general government (QNFAGG) for the period Q1 1999 - Q3 2011. The fiscal variables, as well as macroeconomic variables have been deflated by the GDP deflator (base year 2005) and log-transformed before being seasonally adjusted with TRAMO-SEATS in EViews.

4.1. The Recursive Approach

As a starting point we estimate a benchmark VAR model based on the recursive identification scheme, introduced by Sims (1980) and later applied by Fatas and Mihov (2001) to a study on the output effects of fiscal shocks. This specification allows us to compare results with the study of Mirdala (2009), which is based on the same identification scheme and includes estimates for the tax and spending multipliers in Bulgaria. Also, the results of the benchmark VAR model provide useful information about the implications from applying models with different identification schemes, when compared to the impulse responses from a model with a more sophisticated identification scheme, as the one applied by Blanchard and Perotti (2002).

The recursive approach is based on the Cholesky decomposition of innovations that allows us to identify fiscal policy shocks. The baseline VAR model in our study includes three endogenous variables in real terms: government spending, GDP and net taxes[28].

The ordering of the variables in the Cholesky decomposition has strong economic implications and requires that: (a) government spending does not react contemporaneously (in the same quarter) to any of the shocks in the other variables in the VAR model, (b) output responds contemporaneously only to shocks in government spending, (c) taxes respond contemporaneously to shocks in both government spending and output. Apart from these three endogenous variables, we also include a constant, a linear time trend and the log- transformed foreign demand for Bulgarian exports as an exogenous variable.

Then, following Fatas and Mihov (2001) we also estimate an extended model by adding private consumption or investment as a forth variable in the recursive VAR[29]. First we estimate the response of private consumption to a government spending and a tax shock. Then we follow the same procedure by replacing private consumption with investment. In the recursive specification, these two variables are ordered second - before aggregate GDP, following Fatas and Mihov (2001). The results are reported in section D3 of Appendix D.

All the details about the estimation method of the VAR model with recursive identification scheme are presented in section B1 in Appendix B.

[27] A notable exclusion is a paper by Caprioli, and Momigliano (2011) for Italy, who rely on cash-based data for government wages and intermediate consumption.

[28] The definition of government spending and net taxes follows the one used in Blanchard and Perotti (2002). Detailed information about the budgetary aggregates and the other variables used in the models is provided in Appendix A.

[29] We have also estimated a five variable VAR, similarly to Fatas and Mihov (2001) and the reduced VAR residuals are normally distributed only when the alternative definition for government spending and net taxes is used. The results are commented in the robustness check section 5.2 and shown in Appendix F. Nevertheless, we find very similar responses as in the baseline VAR.

4.2. The Blanchard and Perotti Approach

The structural VAR model, proposed by Blanchard and Perotti (2002) and extended in Perotti (2005, 2007) is also estimated with quarterly accrual fiscal data for the period 1999 - 2011, all deflated with the GDP deflator and seasonally adjusted with TRAMO-SEATS.

Since this approach is among the most widely used in the VAR-based estimates of fiscal multipliers, it will allow us to compare results with other similar studies, such as the one of Muir and Weber (2013) for Bulgaria.

The approach of Blanchard and Perotti (2002) requires certain assumptions about the tax and transfers system and utilizes supplementary estimates for the budgetary output elasticities (estimated outside the model)[30] in order to identify structural government spending and revenue shocks in the VAR setup. Then, the response of output and its main components to given exogenous fiscal impulses is estimated.

A key issue in the fiscal multipliers studies is the specific definition of the tax and expenditure aggregates that are used in the models. In the study of Blanchard and Perotti (2002) the net taxes aggregate is defined as total tax revenues minus social transfers and net interest payable, while the government spending variable is the sum of government consumption and government investment (the same as in the baseline model)[31]. The argument for not including social transfers in the expenditure aggregate and subtracting them from general government revenues is that social transfers have similar redistributional effects as taxes do.

In the original specification of our structural VAR model we follow the same fiscal variable definitions, as in Blanchard and Perotti (2002). This approach allows for comparison of results with other similar studies and it takes in consideration the plausible assumption that it usually takes more than one quarter for the government to implement changes in social payments in the event of shock to other expenditure items.

However, as a robustness check (see section 5.2.) we also apply the definition, used by Baum and Koester (2011). They define government spending as the sum of compensation of employees, intermediate consumption, public investment, social payments and subsidies, net of unemployment benefits. Such a definition ensures that there are no items in government spending aggregate that are automatically adjusted to the business cycle. There are two reasons for including social transfers in the expenditure aggregate. First, social payments represent a substantial part of total government expenditures and they are a major instrument for conducting active fiscal policy. Second, we consider that social payments are more effective as compared to tax measures in stimulating economic activity as the associated "leakages" of the fiscal stimulus, both in terms of increased demand for imports and increase of private savings, are generally more limited, given the hand-to-mouth characteristics of the targeted individuals.

For the derivation of the tax elasticity we use a methodology, developed by the OECD (see Appendix C for more details). As generally accepted in the literature we assume a zero elasticity of government spending to GDP. This assumption is plausible given that the only cyclically-dependent component of government expenditures - unemployment benefits - is not included in the government spending aggregate, whereas it is netted out from tax revenues. The rest of the social payments, the largest share of which is attributed to pensions, does not seem to follow any cyclical pattern in the case of Bulgaria.

Again, we estimate a model, which includes net taxes, government spending and output, following the aggregates definition from Blanchard and Perotti (2002).

Further details on the structural VAR approach of Blanchard and Perotti (2002) are presented in section B2 of Appendix B.

[30] See Appendix C.

[31] This approach is perhaps the most universal one in the literature and it is also applied in Jemec et al (2011) for Slovenia, Cuaresma et al. (2011) for five Central and Eastern European countries and Mirdala (2009) for Bulgaria, Romania, Poland, Czech Republic, Slovakia and Hungary.

4.3. Time Varying Parameter VAR Model

The time-varying BVAR model with stochastic volatility in this study is based on a model presented by Andrew Blake and Haroon Mumtaz from the "CCBS Technical Handbook - No.4 Applied Bayesian econometrics for central bankers".

The TVP-VAR model estimates are also based on quarterly national account data[32], including real government consumption, real private consumption and real GDP, all seasonally adjusted with TRAMO SEATS. The input data is then transformed in dlog and divided by the ratio of the variable of interest to GDP in order to obtain impulse-responses in terms of percentage of GDP. The initial values of the parameters are set using OLS estimates over the full data sample. Due to the volatility of the series and the need of theoretical consistency in the results we impose sign restrictions. This translates into an always positive response of private consumption to a government spending shock. Thus, only the size of the response remains unknown. We estimate the model using a three-variable dataset consisting of gross domestic product, private consumption and final government consumption.

A more detailed description of the estimation procedures is provided in section B3 of Appendix B.

5. Results

5.1. Linear VAR Models Results

Overall, the impulse responses of the BP SVAR are not considerably different from the responses of the VAR with the recursive identification scheme, especially in regards to the spending shocks.

The impulse response from the tax shock in the baseline VAR is an interesting exception. Specifically, the positive tax shock causes output to initially increase for eight quarters, before its response turns negative.[33] This puzzling outcome is also found in Mirdala (2009) for Bulgaria. A possible explanation could be the fact that historically after a tax cut, government revenues actually increase as tax compliance significantly improves. Most recently, such an effect was observed after the introduction the flat tax rate in 2008. This observation, however, could be one factor for an omitted variable bias.

Nevertheless, the sign of the impact tax multiplier changes in the BP SVAR and the effect on output, following a tax increase becomes negative and significant. As pointed out by Caldara and Kamps (2008) there are strongly diverging results as regards the effects of tax shocks depending on the identification approach used in the VAR. All in all, shocks in net taxes seem to be more persistent as compared to spending shocks.

More detailed analysis and figures of the different impulse responses are provided in the Appendix D.

In order to provide estimates for the absolute change in output, following a unit change in the fiscal variables we transform the original impulse responses of output by first dividing them by the standard deviation of the fiscal shock to normalize the initial impulse to 1% shock in the fiscal variable. Then, we multiply the impulse response by the ratio of the output to the fiscal variable. Since the impulse response functions are for the log- transformed variables, we use the following formula:

$$\frac{dX_{t+k}}{dF_t} = \frac{\mathrm{dlog}\, X_{t+k}}{\mathrm{dlog}\, dF_k} \frac{X_{t+k}}{F_t}$$, where k is the moment of time, in which we evaluate the multipliers in quarters, X is output, while F denotes the fiscal variable (taxes or government spending).[34]

[32] The time period of consideration for the TVP-VAR is extended to Q2 2012.

[33] These results are also confirmed for various VAR specifications with recursive estimation.

[34] The same procedure is applied for effects on private consumption or investment in the alternative VAR specification with recursive identification, following Fatas and Mihov (2001).

The next table summarizes the results for the tax and spending multipliers in the two linear VAR models.

Table 1. Cumulative tax and spending multipliers - linear VAR models

Cumulative fiscal multipliers - effect on output	Quarters			
VAR model with recursive identification:	1	4	8	12
Government spending multiplier	0.03	0.17	0.48	0.70
Net taxes multiplier	0.00	0.91	1.48	1.02
SVAR model with BP identification:	1	4	8	12
Government spending multiplier	0.01	0.41	0.87	0.92
Net taxes multiplier	-0.30*	0.19	0.43	-0.21

**denotes significance at the 5% level.*

The results from both model specifications indicate that the size of the first-year cumulative government spending multiplier is in the range of 0.2 to 0.4. The outcome is broadly consistent with the findings of Muir and Weber (2013) who estimate first-year spending multipliers in Bulgaria to be close to 0.3[35]. The spending multiplier in Bulgaria is also comparable to most of the studies on EU periphery countries and supports the argument that small open economies are usually characterized by small fiscal multipliers.[36] These values are, however, much smaller than the spending multipliers in the USA and the larger (less open) euro area economies, which are usually found to be close to unity, on average.[37] Burriel et al. (2010), for instance, estimate a SVAR model with BP identification scheme and find that the overall spending multiplier of the euro area is 0.87.

Again, there is a lot of uncertainty in regards to the size of the tax multipliers, given contrasting results from VARs with different identification techniques, but the overall output effect of tax measures appears to be small and short-lived.

This outcome is more or less in line with the existing VAR-based studies, significant part of which point to highly diverging tax multipliers, depending on the choice of identification scheme. The estimate for the impact tax multiplier in the BP SVAR specification (-0.3) is much smaller in magnitude as compared to Burriel et al (2010) for the euro area (-0.79), but somewhat above the estimates of Jemec et al (2011) for Slovenia (-0.08).[38] The results of Muir and Weber (2013) for Bulgaria, based on monthly data, suggest that first-year tax multipliers are in the range of 0.3 - 0.4[39].

Nevertheless, it should be stressed that the impulse responses in both VAR model specifications turn insignificant already in the second quarter after the shock. This problem is to a large extent related to the short length of the time series. Therefore, all the results should be considered with great caution.

Yet, the results imply that the effect of fiscal policy on economic activity in Bulgaria seems to be relatively limited and short-lived. Overall, it appears that fiscal stimulus would not lead to significant positive effects on output. Analogously, if required, fiscal contractions are not expected to weigh heavily on economic activity, even in the short-run. Therefore, it is reasonable the size of the fiscal multipliers to be taken into consideration when policy makers design consolidation or expansion strategies. Even though the appropriate pace and effectiveness of a fiscal adjustment depends on a number of other factors, the relatively small size of the fiscal multipliers in Bulgaria imply that frontloaded consolidation would be in

[35] The authors estimate a VAR based on Blanchard and Perrotti (2002), using monthly cash-based data from 2003 to mid-2012 with industrial production as a proxy for GDP. For the whole sample, both first year spending multipliers and first year revenue multipliers are found to be 0.3. They also estimate the model with quarterly accrual-based data between 1999 and 2011 and find that first year spending multipliers lie around zero and first year revenue multipliers are 0.3. Both, however, are statistically insignificant.

[36] For example Ilzetzki, Mendoza and Vegh (2011) conclude that fiscal multipliers are lower in small open economies because of the crowding out of net exports.

[37] See Boussard et al. (2012) for a summary table of VAR-based expenditure multipliers in large economies.

[38] See Boussard et al. (2012) for a summary table of VAR-based net tax multipliers in large economies.

[39] The authors report the tax multiplier with a positive sign but this is only due to representation purposes, while the interpretation remain the following: an increase in tax collections decreases economic activity.

most cases preferable than backloading the adjustment process, given the limited effects on output and the favorable impact on government debt dynamics, interest payments and fiscal sustainability.[40]

However, the size of the fiscal multiplier is not static over time and it is often found to be highly dependent on the state of the economy. This issue is addressed in section 5.3., where the focus is on the time-varying character of the government consumption multiplier in Bulgaria.[41]

5.2. Robustness Checks

5.2.1. Different Composition of Government Spending and Taxes

In this section we check the robustness of the linear VAR model results as we opt for a different classification of expenditures and net taxes, as described in Section 4.2. There are strong arguments for including social payments on the expenditure side as these account for a substantial part of total government spending in Bulgaria and represent an important instrument for stimulating internal demand. The use of the different specification requires re-estimation of the net tax elasticity, which is somewhat lower with the alternative specification. Moreover, the alternative specification allows us to run a five variable VAR model with inflation and interest rates without having estimation difficulties related to the normality of the residuals in the reduced form VAR. We run two separate models with an alternative specification of government spending and net taxes - one five-variable VAR with recursive identification scheme and one three-variable VAR with BP specification.

The outcome (presented in Figures F2, F3, F4 and F5 in Appendix F) shows that the effects of a spending and a tax shock on output are not considerably different as compared to the results of the original models. The only significant response that we observe in respect to inflation and interest rate is the impact rise of interest rates after a spending shock.

5.2.2. Replacing Aggregate GDP with Private GDP

Estimating the effects on private GDP in the linear VAR model is more economically meaningful as our main purpose is to evaluate the effects on private consumption and investment decisions as a result of a fiscal policy shock.

Following the approach of Caprioli and Momigliano (2011) in their study on Italy we simply re-estimate the original models by replacing aggregate output with private output. Overall, the sign of the output responses do not change and we only get a significant and positive spending impact multiplier for two quarters. Again, the tax multiplier is negative only in the first quarter after the shock. The impulse responses are provided in Figures F6 and F7 in Appendix F.

5.3. Time Varying Parameter VAR Model Results

The output of the TVP-VAR model is largely consistent with the results from linear VAR models, both pointing to a very limited and short-lived effect of fiscal policy shocks on economic activity.

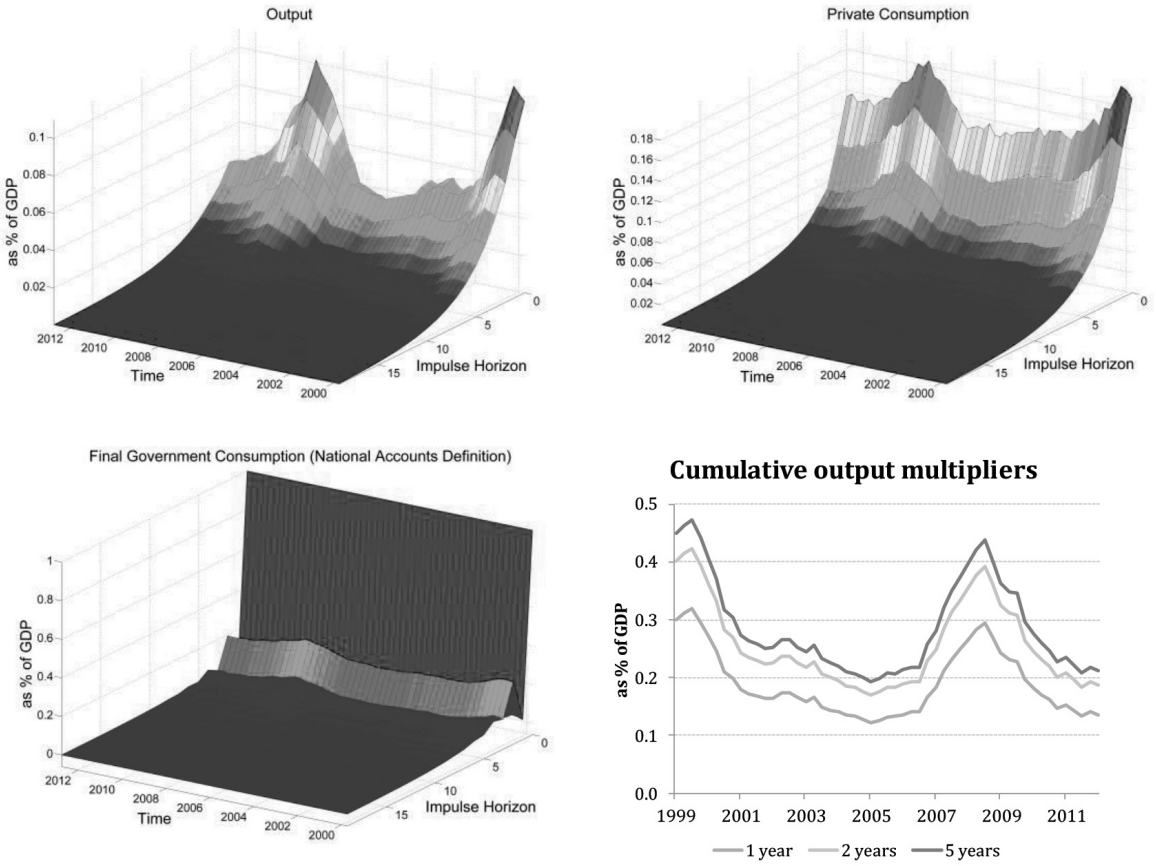
The results (presented in figure 7) indicate that the first-year cumulative government consumption multiplier is considerably larger in the years after the introduction of the currency board (0.3), compared to the period just before the 2008 crisis (0.15). As the global financial meltdown started, the size of the multiplier rapidly increases back to its levels from the beginning of the sample, before shrinking again in parallel with the economic recovery. The fiscal shock effects on private consumption are larger as compared to the GDP effects, implying that other components of GDP have been affected as well. The responses of both variables however

[40] The results are rather inconclusive in regards to the composition of the consolidation strategy, but at least on impact it appears that expenditure restraints would have less negative effect on growth than increase in taxes.

[41] We have estimated a TVP-VAR with net taxes, private consumption and output, but the results were not theoretically meaningful. This is not surprising, given the contrasting results in the linear VAR models. Generally, the empirical literature is less divided with respect to the size of the spending multipliers, while the findings for the tax multiplier are in a much broader range, depending on the identification technique used for fiscal shocks. To some extend this is due to the fiscal foresight problem and the inability of VAR models to properly account for the fact that changes in taxes are often anticipated and known ahead of the actual legislative changes take place. See Caldara and Kamps (2008) and Leeper et al. (2008) for a discussion.

varied over time in a similar manner in terms of size and duration. The impulse response of government consumption itself is rather stable throughout the sample period (both in terms of size and duration), with small increases in the beginning of the sample and during the peak of the global financial crisis.

Figure 7. Time varying impulse responses



The outcome of the TVP-VAR is in line with the threshold VAR study of Muir and Weber (2013) for Bulgaria, who find that during periods of economic expansion the first-year spending multiplier is around 0.15, while in downturns it increases up to 0.3.

The results of the TVP-VAR suggest that during the years of economic expansion other components of aggregate demand would have been increasingly crowded-out by increases in government consumption. Specifically, the response of private consumption to government spending shocks has become weaker and shorter in duration in the period 1999 - 2007. Correspondingly, the size of the first-year cumulative government consumption multiplier on output has become nearly two times smaller.

Several potential factors might explain the dynamics in the size of the fiscal multipliers in the period before the recent economic downturn.

First, in the period 2004 - 2008 the Bulgarian economy experienced high economic growth, coupled with significant deepening of the financial sector. The competition of foreign-owned financial institutions for expanding their market share led to rapid credit expansion. The external indebtedness of the private sector was also continuously rising due to the good investment opportunities offered by both the financial and non-financial corporations. Naturally, this led to a gradual decrease in the share of liquidity and credit constrained households and companies over the period. As Perotti (2005) argues relaxation of credit constraints is among the factors that could explain a decline in the effectiveness of government spending in stimulating economic activity. Kirchner et al. (2010) also provide evidence for the view that access to credit is an important determinant of the size of fiscal multipliers. In particular, the authors argue that higher availability of credit is associated with declining spending multipliers, since there are fewer credit constrained agents, who would save part of the fiscal stimulus.

Second, the rapid economic expansion and the EU accession prospects led to a steadily growing inflow of FDI and considerable acceleration of imports, thus increasing the "import leakage" of the fiscal stimulus and reducing its overall impact of the economic activity.

Third, it is generally accepted that the size of the fiscal multiplier is larger if the fiscal position of the country remains sustainable after the stimulus. Therefore, it is reasonable to expect that in the years after the introduction of the Currency Board Arrangement in 1997, the effects of fiscal policy would have been non-Keynesian in nature, as these were years of economic recovery and regaining confidence in the fiscal framework. Moreover, the high level of government debt in the beginning of the sample period would have made expansionary fiscal stimuli intolerable. Nevertheless, government debt sustainability issues were successfully mitigated in the last fifteen years as the debt-to-GDP ratio declined from over 78% in 1999 down to nearly 16% in 2011. As suggested by the literature (e.g. Perotti, 1999) debt sustainability issues are among the important factors in determining the output effect of government spending.[42]

As the global financial crisis started, the output gap rapidly deteriorated, credit growth declined (both consumer and corporate) and imports contracted. These developments might explain the fact that the size of the fiscal multipliers has nearly doubled at the peak of the crisis. As shown by Galí et al. (2007) and Corsetti et al. (2011) a government spending shock can have a larger effect on aggregate consumption to the extent that the financial crisis raises the share of credit-constrained agents. Moreover, the traditional crowing-out argument is also less applicable during periods of recession, given that the economic slowdown usually results in higher degree of firms' excess capacities, which can be brought in use by addition public expenditure.

Despite the observed increase, however, the size of the spending multiplier in Bulgaria remained as low as 0.4 at the peak of the financial crisis. Perhaps, the significant increase in the level of domestic savings during the crisis, induced mainly as a result of precautionary incentives, has been a relevant factor for limiting the increase in the multiplier's size.

In the period 2010 - 2011 economic growth stabilized, imports recovered to their pre-crisis levels and public financing sustainability concerns were largely mitigated. Companies managed to improve the utilization of the excess capacities by redirecting the production towards the external market. These developments and the continuous growth of domestic savings have probably been relevant factors for the decline of the fiscal multiplier back to levels as low as 0.2.

Overall, the TVP-VAR model results reveal important information about the changes in the output effects of government consumption shocks in Bulgaria over the last fifteen years. It appears that the effectiveness of spending shocks in stimulating economic activity varies over time according to the underlining state of the economy. This relationship is found to be valid in a number of recent empirical studies, which analyze the links between fiscal multipliers and the state of the economy.[43]

6. Conclusions and Further Work

This paper analyses the impact of fiscal policy on real economic activity in Bulgaria and provides a range of estimates for the tax and spending multipliers. We compare the results from linear structural VAR models with recursive identification and structural identification following Blanchard and Perotti (2002) to the estimates from a time-varying parameters Bayesian SVAR, with the aim of investigating changes in the effectiveness of fiscal shocks in Bulgaria over the period 1999-2011.

The results of the linear VAR models indicate that the effectiveness of fiscal policy in stimulating economic activity is generally low as first year spending multipliers do not exceed 0.4. The results regarding the tax multiplies are subject to a lot of uncertainty, as seen by the contrasting results in the

[42] The authors argue that high debt levels acts as a signal for required future fiscal adjustment, resulting from current increases in government expenditures. The anticipation of the future fiscal tightening (i.e. increase in taxation) would cause a decline in private consumption today, thus offsetting the expansionary impact of government consumption.

[43] For a summary of results from selected studies on fiscal multipliers that employ non-linear approaches see Baum A., Poplawski-Ribeiro M., and Weber A. (2012), "Fiscal Multipliers and the State of the Economy", IMF Working Paper, WP/12/286

estimated VAR models with different identification techniques, but the overall effect of tax measures on economic activity appears to be small and short-lived. These findings are in line with most of the studies on the peripheral EU Member State and support the general view that fiscal multipliers are usually small in small open economies.

The results of the two linear VAR models are broadly confirmed by the output of a TVP-VAR model, both pointing to a very limited effect of government spending shocks on economic activity. However, the TVP-VAR model reveals important information regarding the variations of the government consumption multiplier over time. Since the beginning of the sample (1999) the size of the first-year spending multiplier has been gradually decreasing from levels of around 0.3, down to a level of nearly 0.15 in 2007. As the global financial crisis started, the size of the multiplier doubled in less than two years, before decreasing again back to its pre-crisis levels, along with the economic recovery period (2010-2011). These results indicate that the underlying state of the economy appears to be an important determinant of the nonlinear effects of fiscal policy on economic growth in Bulgaria, even though further research is needed to support this view.

Therefore, exploring the factors behind the dynamics of the fiscal multiplier over time is a natural subsequent step in researching the functioning of the fiscal transmission mechanism in Bulgaria. For this purpose, evaluations based on structural models, such as DSGE models, could provide a valuable input. Data constraints and the significant structural changes in the Bulgarian economy during the last fifteen years are other relevant arguments for further research based on structural model evaluations.

Nevertheless, the findings in this study have important policy implications for the desired fiscal policy over the cycle in the case of Bulgaria. Overall, the results of the empirical models suggest that there is little to gain in terms of economic output from active fiscal policy, even during periods of economic recession.

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Appendix A. Data Description

Variables		Description and calculation	Unit	Treatment	Source
Output	y	GDP at 2005 market values	log domestic currency, milllions	Seasonal adjustment	NSI
Private output	ypr	GDP at 2005 market values - government consumption - government investment (deflated with the investment deflator)	log domestic currency, milllions	Seasonal adjustment	NSI
Consumption	con	Final consumption of households and NPISH's at 2005 market values	log domestic currency, milllions	Seasonal adjustment	NSI
Investment	inv	Gross Fixed Capital Formation at 2005 market values	log domestic currency, milllions	Seasonal adjustment	NSI
Government spending	g	Compensation of employees (ESA 95 code D1)+ intermediate consumtion (ESA 95 code P.2)+ gross fixed capital formation (ESA 95 Code P.51)	log domestic currency, milllions	deflated with GDP deflator, Seasonal adjustment	QNFAGG, NSI
Net taxes	t	General government: Indirect taxes (ESA 95 code D.2)+Direct Taxes (ESA 95 code D.5) +Social Security Contributions (ESA 95 Code D. 611) +Capital Taxes (ESA 95 code D91) - Social Benefits and payments (ESA 95 code D6O) - Subsidies (ESA 95 Code D.3)	log domestic currency, milllions	deflated with GDP deflator, Seasonal adjustment	QNFAGG, NSI
Gov. spending - alternative definition	g2	Compensation of employees (ESA 95 code D1)+ intermediate consumtion (ESA 95 code P.2)+ gross fixed capital formation (ESA 95 Code P.51)+Social Benefits and payments (ESA 95 code D6O) +Subsidies (ESA 95 Code D.3) - Unemployment Benefits	log domestic currency, milllions	deflated with GDP deflator, Seasonal adjustment	QNFAGG, NSI
Net taxes - alternative definition	t2	General government: Indirect taxes (ESA 95 code D.2)+Direct Taxes (ESA 95 code D.5) +Social Security Contributions (ESA 95 Code D. 611) - Unemployment benefits	log domestic currency, milllions	deflated with GDP deflator, Seasonal adjustment	QNFAGG, NSI
Core Inflation	infl	Year-on-year change of the core HICP index, SA	%		NSI
Interest rate	ints	overnight interbank rate in euro for the period 1999-2004 and LEONIA 2005-2011	%		BNB
Foreign Demand	fd	Index 2005=100	log	Seasonal adjustment	BNB estimates

Appendix B. Details on the Methodology

1. The Recursive Approach

The baseline VAR model in our study includes three endogenous variables in real terms: government spending (g), GDP (y) and net taxes (τ)[44]. Apart from these endogenous variables in the VAR model, we also include a constant, a linear time trend and the log- transformed foreign demand (fd) for Bulgarian exports as an exogenous variable.

The reduced-form VAR model can be expressed in the following way:

$$X_t = \mu_0 + \mu_1 t + \mu_2 fd_t + A(L)X_{t-1} + u_t, \qquad (1)$$

where *X* is a five dimensional vector and *A(L)* is a fourth-order lag polynomial[45]. The inclusion of the foreign demand variable is to account for the fact that Bulgaria is a small open economy and external

[44] We have also estimated a five variable VAR, similarly to Fatas and Mihov (2001) and the reduced VAR residuals are normally distributed only if the alternative definition for government spending and net taxes is used. The results are shown in the robustness checks section. Nevertheless, we find very similar responses as in the baseline VAR.

[45] The choice of four lags is made to ensure serially uncorrelated residuals. Formal tests as the Akaike information criterion (AIC) and other information criteria (FPE, HQ, SC) suggest the inclusion of two lags.

shocks have a strong effect on domestic output. Similar approach has also been applied by Caprioli and Momigliano (2011)[46] for the case of Italy. As the reduced form residuals u_t are usually contemporaneously correlated, it is necessary to transform them into structural shocks. This is done by multiplying equation (1) with the matrix A_0. The resulted equation is the following:

$$A_0 X_t = A_0\mu_0 + A_0\mu_1 t + A_0\mu_2 fd_t + A_0 A(L)X_{t-1} + Be_t \qquad (2)$$

The structural disturbances e_t are not correlated with each other and their variance-covariance matrix is a diagonal one. The equation $A_0u_t=Be_t$ gives us the relation between the reduced-form residuals that we observe and the structural disturbances, which we want to identify. In the recursive approach we require that B is a five dimensional identity matrix and A_0 is a lower diagonal matrix with only unit values on the diagonal. The ordering of the variables in the VAR model determines the contemporaneous relations between them. We have ordered the variables in the following order: government spending (g), private GDP (y), inflation (π), net taxes (τ) and short-term interest rates (r). Equation $A_0u_t=Be_t$ can be represented in a matrix form:

$$\begin{bmatrix} 1 & 0 & 0 \\ -\alpha_{yg} & 1 & 0 \\ -\alpha_{\tau g} & -\alpha_{\tau y} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^y \\ u_t^\tau \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_t^g \\ e_t^y \\ e_t^\tau \end{bmatrix}, \qquad (3)$$

where α_{ij} indicates how variable i responds contemporaneously to a shock in variable j .

2. The Blanchard and Perotti approach

We start again from the reduced form VAR specification from equation (1)

$$X_t = \mu_0 + \mu_1 t + \mu_2 fd + A(L)X_{t-1} + u_t \ ,$$

where $X = [t_t \ \ g_t \ \ y_t]$ is a three-dimensional vector, which includes taxes, government spending and output. Again, as in the recursive identification approach, we need to identify matrices A_0 and B , which provide the relation between the reduced-form residuals ut and the structural disturbances e_t : $A_0u_t=Be_t$. We follow a four step approach as in Jemec et al. (2011) and Gordano et al (2007). First, after the reduced form VAR model is estimated, we decompose the reduced-form residuals of taxes u_t^τ and government spending u_t^g in the following way:

$$u_t^\tau = \alpha_{\tau y} u_t^y + \beta_{\tau g} e_t^g + e_t^\tau \qquad (4)$$

$$u_t^g = \alpha_{gy} u_t^y + \beta_{g\tau} e_t^\tau + e_t^g \qquad (5)$$

The coefficients $\alpha_{\tau y}$ and α_{gy} are elements of the matrix A_0 and represent the response (both automatic and discretionary) of taxes and government spending to a shock in the economic activity. The coefficients $\beta_{\tau g}$ and $\beta_{g\tau}$ capture how the structural shock in government spending affects contemporaneously taxes and vice versa.

Following the BP approach, in the second step of the procedure we estimate the cyclically adjusted reduced-form residuals:

$$u_t^{\tau,CA} = u_t^\tau - \alpha_{\tau y} u_t^y = \beta_{\tau g} e_t^g + e_t^\tau \qquad (6)$$

$$u_t^{g,CA} = u_t^g - \alpha_{gy} u_t^y = \beta_{g\tau} e_t^\tau + e_t^g \qquad (7)$$

*CA - cyclically adjusted

[46] Similarly to Caprioli and Momigliano (2011) we have also tried to add foreign demand to the list of endogenous variables, but due to the short data series and the large numbers of parameters that had to be estimated, this approach did not provide satisfactory results.

This is done by assuming that $\alpha_{\tau y}$ and α_{gy} capture only the automatic response of taxes and government spending to an output shocks. The reasoning is that it usually takes more than one quarter for the government to respond with discretionary measures to disturbances in the economic activity. Afterwards, institutional information is used to estimate the tax and spending elasticities to GDP. For the derivation of the tax elasticity we use a methodology, developed by the OECD (see Appendix B for more details). As generally accepted in the literature we assume a zero elasticity of government spending to GDP: (α_{gy} = 0).

Another key assumption, made by Blanchard and Perotti (2002) is that taxes do not respond contemporaneously to changes in government spending as it takes at least one quarter to adopt and practically implement changes in the tax codes. So, in this case spending decisions come first. Therefore, $\beta_{g\tau} = 0$ and the structural disturbance etg can be identified directly from equation (7). The outcome is then used to estimate equation (6) by applying ordinary least squares (OLS) method. Finding the estimates for $\beta_{g\tau}$ represents the third step of the procedure.

In the last stage, we use the estimates for the cyclically-adjusted reduced form tax and spending residuals as instrumental variables to estimate the following equation:

$$u_t^y = \alpha_{y\tau} u_t^\tau + \alpha_{yg} u_t^g + e_t^y \qquad (8)$$

This step completes the estimation of all parameters in the A0 and B matrices in the BP identification strategy, which can be written in a matrix form in the following way:

$$\begin{bmatrix} 1 & 0 & -\alpha_{\tau y} \\ 0 & 1 & -\alpha_{gy} \\ -\alpha_{y\tau} & -\alpha_{yg} & 1 \end{bmatrix} \begin{bmatrix} u_t^\tau \\ u_t^g \\ u_t^y \end{bmatrix} = \begin{bmatrix} 1 & \beta_{\tau g} & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_t^\tau \\ e_t^g \\ e_t^y \end{bmatrix} \qquad (9)$$

After the A_0 and B matrices have been identified, we estimate the structural disturbances and compute the impulse response functions for the dynamic effect of the three structural shocks on taxes, government spending and output.

As noted by Caldara and Kamps (2008), the major difference between the recursive and BP approach is that the A_0 matrix is not diagonal and the exogenous elasticities of taxes and spending to output, estimated outside the model, are present as coefficient to the right-side of the main diagonal. Moreover, B is no more an identity matrix. This approach is more appropriate when estimating the effects of a tax shock. While the recursive approach implies a zero restriction on the contemporaneous effect of taxes on output (and inflation), in the BP approach these effects can be freely estimated. As we see in the next section, the BP methodology changes the sign of the impact tax multiplier for the case of Bulgaria.

3. Time-Varying Parameter VAR Model with Stochastic Volatility

The time-varying BVAR model with stochastic volatility in this study is based on a model present by Andrew Blake and Haroon Mumtaz from the "CCBS Technical Handbook - No.4 Applied Bayesian econometrics for central bankers".[47]

For the purpose of our analysis we assume the following model:

$$Y_t = c_t + \sum_{j=1}^{P} B_{j,t} Y_{t-j} + \upsilon_t, VAR(\upsilon_t) = R_t \qquad (10)$$

$$\begin{aligned} \beta_t &= \{c_t, B_{1,t} .... B_{P,t}\} \\ \beta_t &= \beta_{t-1} + e_t, VAR(e_t) = Q \end{aligned} \qquad (11)$$

[47] Available here:
http://www.bankofengland.co.uk/education/Documents/ccbs/technical_handbooks/pdf/techbook4.pdf
http://www.bankofengland.co.uk/education/Documents/ccbs/technical_handbooks/Coding/code.zip

The covariance matrix of the error term υ_t, denoted R_t, has time-varying elements. For simplicity we consider that the structure of R_t is as follows:

$$R_t = A_t^{-1} H_t A_t^{-1'} \tag{12}$$

Given that we use a three-variable model the lower triangular matrix A_t with elements $\alpha_{ij,t}$ and the diagonal matrix H_t with diagonal elements $h_{i,t}$ can be written as:

$$A_t = \begin{pmatrix} 1 & 0 & 0 \\ a_{12,t} & 1 & 0 \\ a_{13,t} & a_{23,t} & 1 \end{pmatrix}, H_t = \begin{bmatrix} h_{1,t} & 0 & 0 \\ 0 & h_{2,t} & 0 \\ 0 & 0 & h_{3,t} \end{bmatrix} \tag{13}$$

where the transition equations for the elements $\alpha_{ij,t}$ and $h_{i,t}$ are defined as:

$$\begin{aligned} a_{ij,t} &= a_{ij,t-1} + V_t, VAR(V_t) = D \\ \ln h_{i,t} &= \ln h_{i,t-1} + z_{i,t}, VAR(z_{i,t}) = g_i \end{aligned} \quad \text{for } i = 1..3 \tag{14}$$

Appendix C. Derivation of Tax Elasticity

In line with the OECD approach, the net tax elasticity is a weighted average of the elasticiticites of four tax categories (personal income tax, corporate income tax, indirect taxes and social security contributions) and unemployment benefits (taken with a minus sign). More formally:

$$\alpha_{\tau y} = \sum_i \epsilon_{\tau_i} \epsilon_{\beta_i, y} \frac{\tau_i}{\tau}$$

Where is the elasticity of tax category i to the respective macro tax base, $\epsilon_{\beta i,y}$ is the elasticity of the tax base to GDP and $\frac{\tau_i}{\tau}$ is the share of respective tax cetegory in the tax aggregate. The latter variable is positive for the four tax categories and negative for unemplyment benefits. The elstacities of the various categories to the respective tax bases are calibrated on the basis of the tax legislation and are summurized in Table 1. For all categories, the elasticiy is equal or close to 1 as the Bulgarian tax system is proportional with flat direct tax rates. It should be mentioned that for personal income tax we assume a higher elasticity until 2008, when the tax was proegressive and afterwards when a flat tax rate with no minimum non-taxable income was introduced. Since only data for aggregate direct taxes is available at the quaterly frequency, we have used quaterly cash-data profiles to interpolate the annual data for pesonal income tax and other direct taxes. Corporate income tax receivables are estimated as a residual variable.

Table C1: Budgetary elasticities relative to corresponding macroeconomic bases

Budget category	Macroeconomic base	Budgetary elasticity
Direct taxes on households	Average compensation per employee	1.2 up to 2007, 1.0 afterwards
	Employment	1.0
Social security contributions	Average compensation per employee	1.0
	Employment	1.0
Direct taxes on companies	Operating surplus	1.05
Indirect taxes	Private consumption	1.0
Unemployment-related expenditures	Number of unemployed	1.0

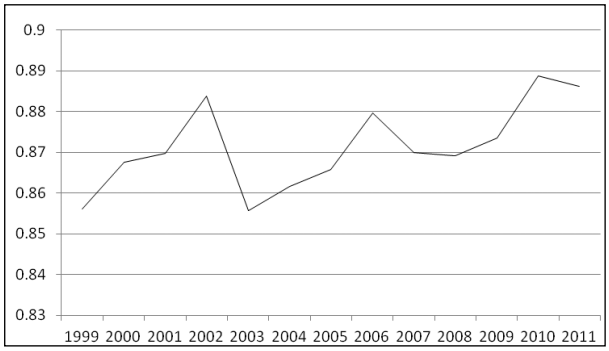
The elasticity of different tax bases with respect to output has been evaluated econometrically by using error-correction specifications. The next table summarizes these elasticities together with the information on the average share of the different tax categories in aggregate net taxes.

Table C2. Derivation of the net tax elasticity

	Elasticity with respect to GDP	Average share in net taxes 1999-2011	Weighted elasticity
Corporate income tax	0.82	0.10	0.08
Personal income tax*	0.60	0.11	0.07
Indirect taxes	1.03	0.51	0.52
Social Security Contributions	0.60	0.30	0.18
Elasticity of tax revenues			**0.85**
Unemployment spending	-1.46	0.01	-0.02
Elasticity net taxes			**0.87**

Our results are close to the net tax elasticity, estimated by Jemec and Delakorda (2011) for Slovenia (0.87) and Baum Koester (2011) for Germany (1.02). However, what we observe from the data is that the net tax elasticity is not stable across time. This is due to the gradual movement from a more progressive to a more proportional tax system and in the same time the gradual change in the structure of revenues, with a constantly increasing share of indirect taxes.

Figure C1. Time varying elasticity of net taxes



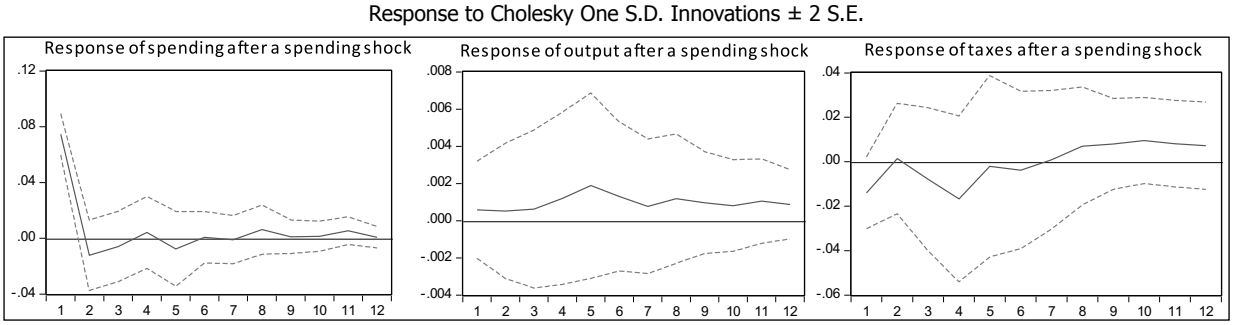
The time-variation of the elasticity is one more reason to take an advantage of a TVP Model as we do further in the paper.

Appendix D. Impulse responses

1. Government Spending Shock

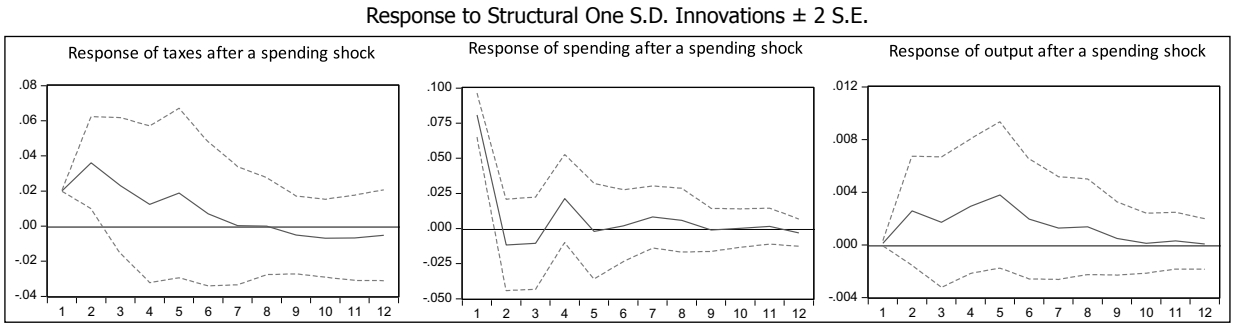
In our baseline three-variable VAR with recursive identification, output follows a hump- shaped response after a spending shock - it increases gradually until it peaks in the 5th quarter, following the expenditure shocks. The output responses are positive for all quarters after the shock, but they are not significant. The expenditure shock itself is very short-lasting and it dies away already in the second quarter. After the spending shock taxes initially decrease and then gradually increase. Again, the effect is not significantly different from zero after the first period.

Figure D1 . Responses to a spending shock in the baseline VAR with recursive identification



The results from a VAR with BP identification are not considerably different from the outcome of the model with the recursive identification scheme. Again, we observe a hump- shaped response of output, following an expenditure shock. The impact multiplier, however, is not significantly different from zero. The response of output peaks in the fifth quarter and dies away afterwards. The impulse responses are always positive, but not significantly different from zero. The expenditure shock is very short-lasting and becomes insignificantly different from zero after the first quarter. The response of taxes this time is more pronounced. It is positive until the end of the second year after the shock has taken place, but it is significant for the first two quarters only.

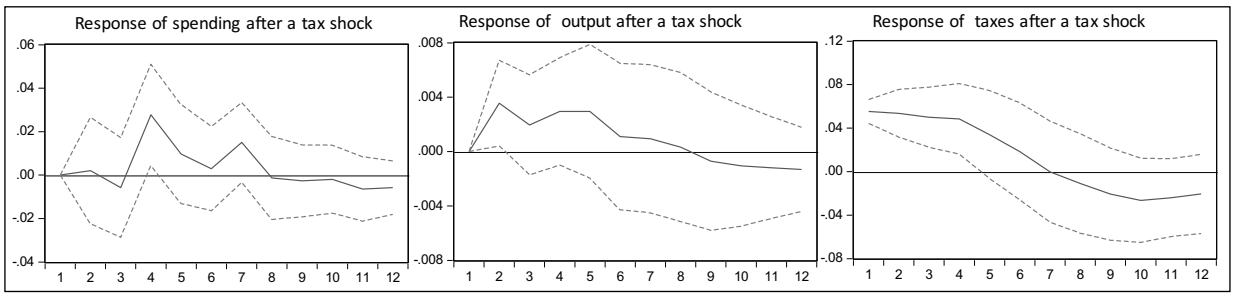
Figure D2 . Responses to a spending shock in VAR with BP identification



2. Tax Shock

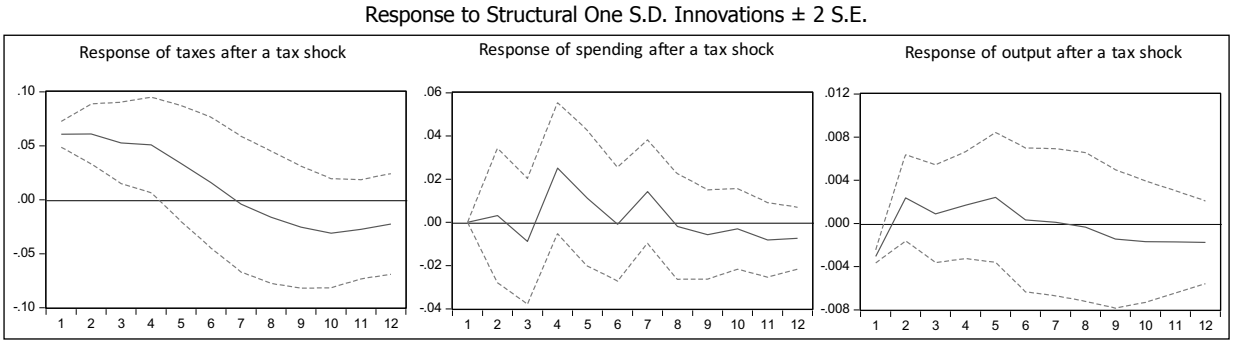
The results from the baseline VAR model provide some interesting evidence. The tax shock causes output to initially increase for eight quarters, before its response turns negative. Again, the impulse response is not significantly different from zero after the second quarter. Overall, shocks in net taxes seem to be more persistent as compared to spending shocks. The duration of the tax shock is around two years and the response is significantly positive for the first four quarters. Following a tax increase, government spending does seem to react positively and substantially. To some extent this is due to the restrictions imposed by the recursive specification. The response of spending peaks in the fourth quarter and dies away afterwards.

Figure D3. Responses to a tax shock in the baseline VAR with recursive identification



When we estimate a VAR model with BP identification, the sign of the impact tax multiplier changes and the effect on output, following a tax increase become negative and significant. The output response becomes insignificant already in the second quarter, it remains positive for four quarters before it turns negative. The response of government spending after a tax shock is very similar to the baseline model. It takes three quarters before government expenditure increases following a tax increase and the response peaks in the fifth quarter. Afterwards, the response slowly dies away. This model also confirms the fact that tax shocks are usually more persistent than shocks in government spending.

Figure D4. Responses to a tax shock in VAR with BP identification



3. Effects on Private Consumption and Investment

The responses of the other variables in the model do not change significantly after the tax or the spending shock in the alternative recursive VAR model with private consumption or investment as fourth variable. Private consumption reacts positively to a government spending shock in the first period and its response turns negative afterwards. The effect on investment is much stronger and always positive, but becomes significant only in the 3rd quarter after the shock. Both consumption and investment react in a similar way to a tax shock with a temporary increase in the first two quarters. Overall, it appears that these results are more in support of the Real Business Cycle models, which predicts a drop in private consumption as a result of expansionary fiscal policy. Nevertheless, the statistical properties of the VAR model do not allow for any strong conclusions.

Figure D5. Response of private consumption to a spending and a tax shock in a recursive VAR

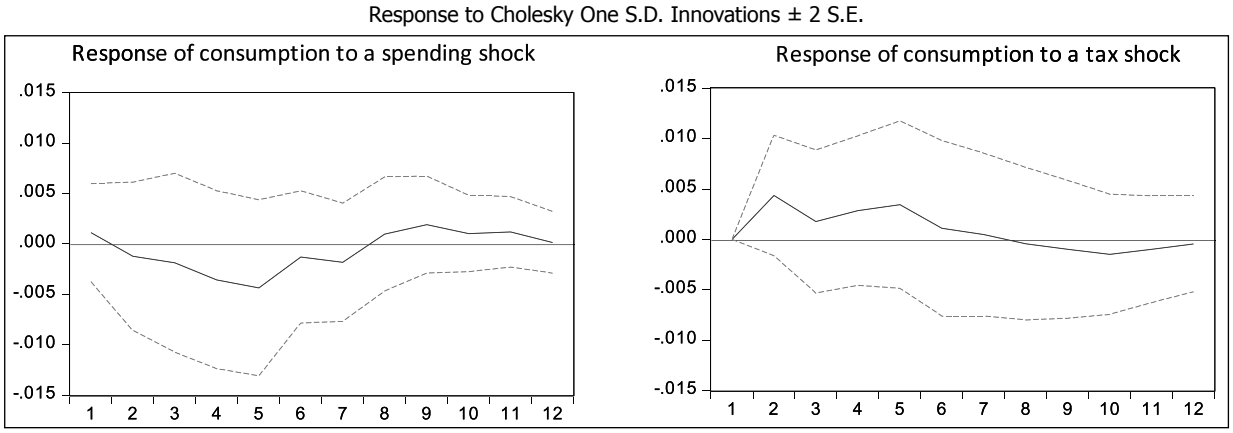
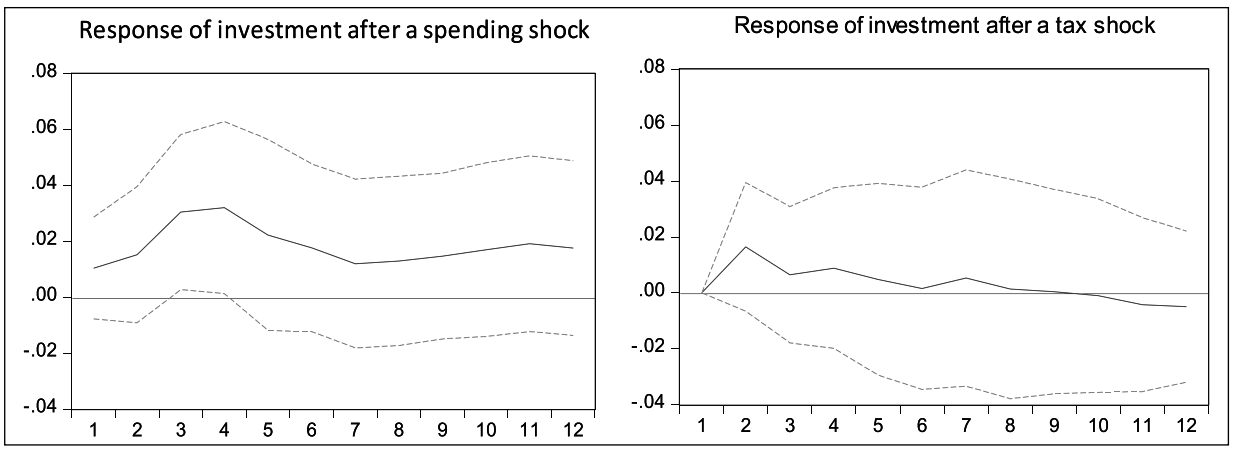


Figure D6. Response of investment to a spending and a tax shock in a recursive VAR



Appendix E. Supplementary Figures and Tables

Table E1. Unit-root tests

H0: Variable has a Unit Root	**ADF Test t-statistics**		**Phillips Perron Test t-statistics**	
	Level	**First diff.**	**Level**	**First diff.**
Output	-1.55	-3.66**	-1.28	-6.44**
Private output	-1.31	-8.54**	-1.36	-8.48**
Consumption	-2.77	-3.51*	-2.45	-6.41**
Investment	-1.36	-8.67**	-1.36	-8.49**
Government spending	-1.17	-10.31**	-1.62	-16.66**
Net taxes	-2.45	-4.19**	-2.12	-7.17**
Gov. spending – def .2	-1.23	-10.56**	-1.42	-14.49**
Net taxes - def .2	-2.02	-3.54**	-2.76	-5.71**
Core Inflation	-1.74	-3.09*	-1.89	-4.71**
Interest rate	-2.17	-3.59**	-1.51	-3.66**

** significant at the 5% level, **significant at the 1% level*

Table E2. Co-integration Test for baseline VAR specification - three variables

Unrestricted Cointegration Rank Test (Trace)			
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Prob.**
None *	0.534	52.230	0.005
At most 1	0.152	11.800	0.826
At most 2	0.056	3.041	0.872

*Johansen trace test. Indicates 1 cointegrating eqn(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level.*
***MacKinnon-Haug-Michelis (1999) p-values*

Table E3. Diagnostic tests of the baseline VAR specification

Diagnostic Tests	Baseline 3-var. VAR P-value	5-var. VAR P-value	VAR with private GDP P-value
Normality: Cholesky (Lutkepohl) - J.Bera[1]	0.317	0.326	0.701
Normality: Residual Corr. (Doornik-Hansen) - J.Bera[1]	0.194	0.027	0.673
Heteroskedasticity Test[2]	0.528	0.012	0.269
Serial Correlation LM Tests[3]			
Lag 1	0.471	0.414	0.191
Lag 2	0.271	0.263	0.401
Lag 3	0.683	0.602	0.401
Lag 4	0.304	0.015	0.211

[1]Null Hypothesis: residuals are multivariate normal, [2]Null Hypothesis: no serial correlation at lag order h, [3]Null Hypothesis: no heteroskedasticity

Appendix F. Robustness Check and Results

Figure F1. Stability of VAR specification

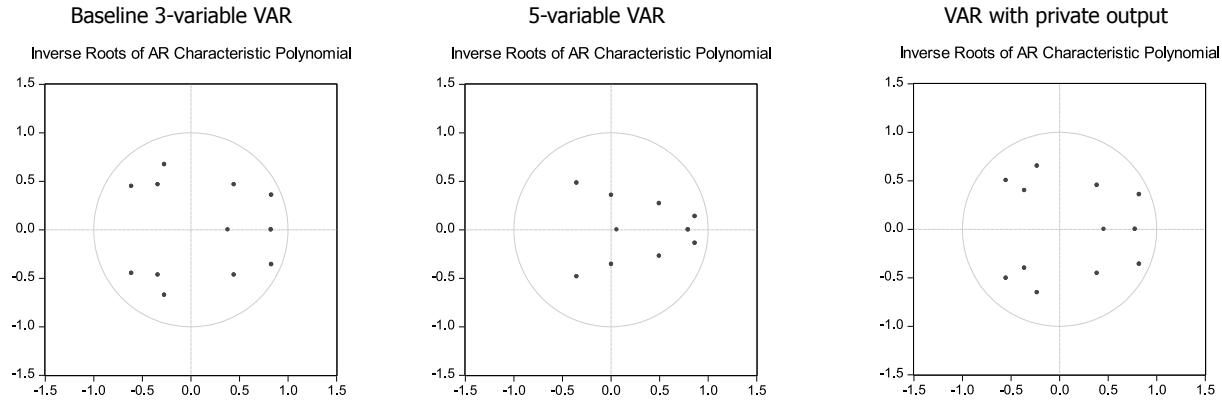


Figure F2. Five-variable VAR - responses after a spending shock

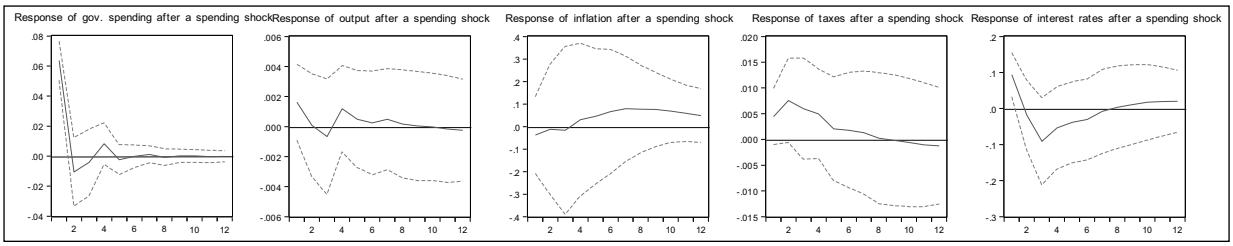


Figure F3. Five-variable VAR - responses after a tax shock

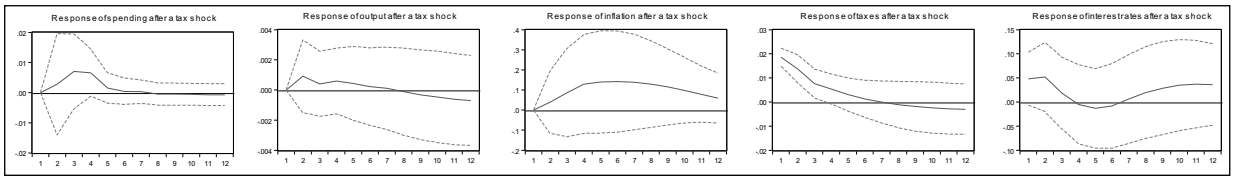


Figure F4. Three- variable SVAR with alternative definition of government spending and taxes - government tax shock

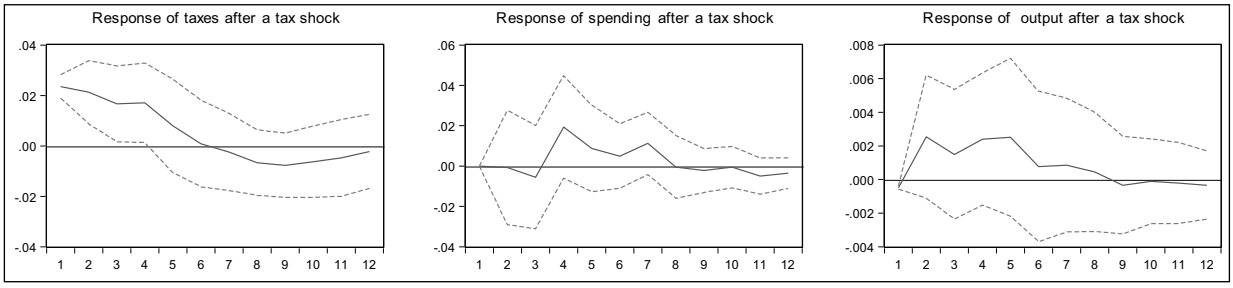


Figure F5. Three- variable SVAR with alternative definition of government spending and taxes - government spending shock

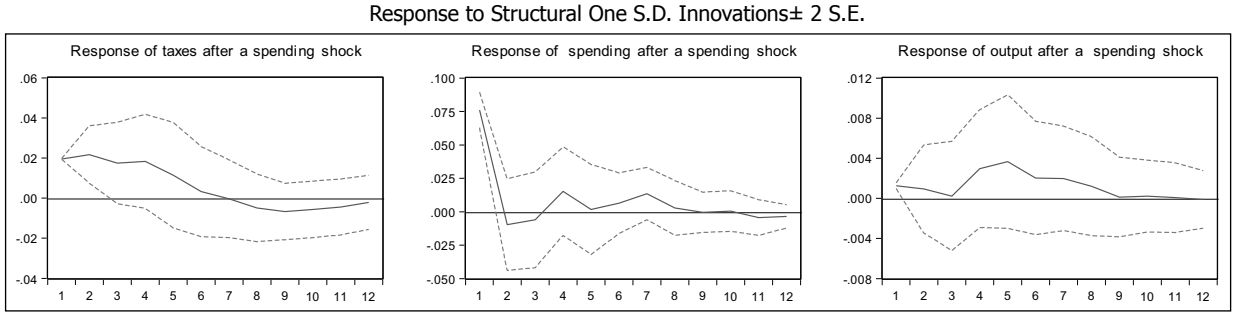


Figure F6. Three- variable SVAR with private output - responses of a spending shock

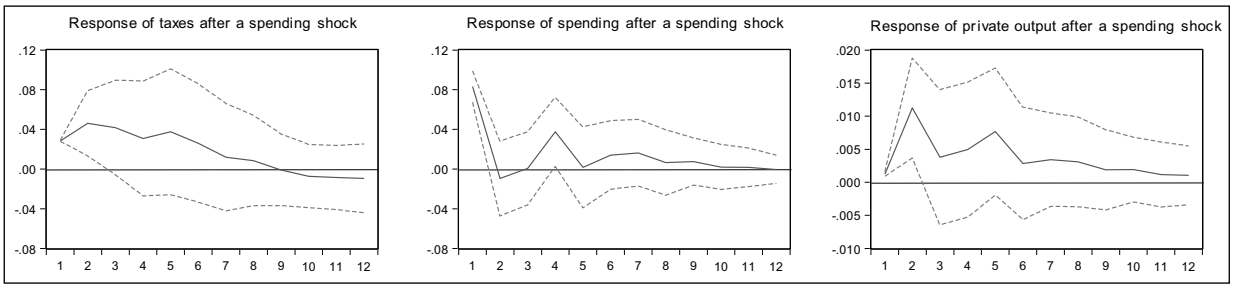
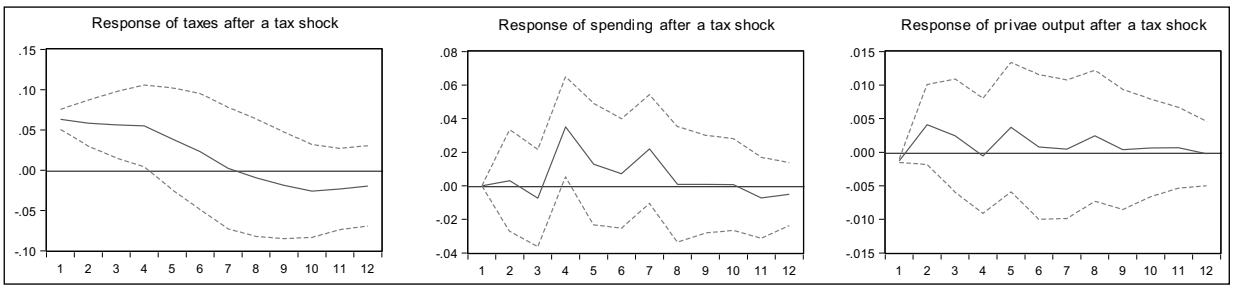


Figure F7. Three- variable SVAR with private output - responses of a tax shock



UDK 336.27:336.763.33]:330.43(4-672EU)

FISCAL DETERMINANTS OF GOVERNMENT BORROWING COSTS – DO WE HAVE ONLY OURSELVES TO BLAME?

Alan Bobetko[1], dipl. oec., Mirna Dumičić[2], M.Sc., Josip Funda[3], univ. spec. oec.

Abstract[4]

The global financial crisis and the problems in peripheral EU countries resulted in an increased attention to fiscal developments and their impact on borrowing cost for both public and private sector. Existing theoretical literature suggests that worsening of both current and expected budget balance as well as increase of public debt lead to rise of a short and long term interest rates for sovereign debtors. However, empirical results are inconclusive, especially for emerging market countries. This paper analyzes the factors that determine government bond spreads dynamics, with special emphasis on fiscal indicators. The survey covered 17 European countries, of which 9 developed and 8 emerging market economies, all of them being members of the EU except Croatia. The empirical part of the paper employs dynamic panel data method and uses Arellano and Bond estimator to get consistent estimates of parameters of interest. The results show that in the period 2004-2011 projected fiscal balance and projected public debt had a significant impact on the difference in government bond yields for emerging market countries, with effect being much stronger during the period after onset of financial crises. On the other hand, it seems that sovereign spread dynamics in developed countries is driven mostly by the global market sentiment.

JEL classification: F34, G12, H68

Keywords: Sovereign bond spreads, expected fiscal developments, EU countries, Croatia

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[4] The views expressed in this paper are not necessarily the views of the Croatian National Bank.

1. Introduction

After several years of convergence sovereign yield spreads of EU countries relative to German Bund in the late 2006 and early 2007 reached historically low levels. Situation dramatically changed, however, with the onset of global financial crisis in September 2008 when emerging market EU countries' bond spreads have exploded and even developed markets' spreads recorded a significant rise. The question arose whether such development reflect macroeconomic fundamentals, especially fiscal position of countries in Europe, or simply the global market sentiment. Did investors finally started to differentiate between countries according to the riskiness they attribute to them?

Trying to answer to these questions, this paper analyzes the factors determining spreads between long term government bond yields of selected European countries and the German government bond using dynamic panel model. We cover main spread determinants recognized in the literature; namely, credit risk, international risk aversion and the liquidity risk. Fiscal position of the government is considered to be the most important indicator of credit risk. However, it's the future solvency of the government that matters for the current bond holders so instead of current values our model includes forecasts of government balance and public debt. Besides capturing the forward looking feature of financial markets, using forecasts also solves the problem of possible endogeneity that may arise due to simultaneous determination of fiscal variables and bond spreads. To ensure the robustness of the results, our analysis also includes other potential indicators of country credit risk, i.e. GDP growth and current account balance.

Given the availability of the data on government bond yields, the survey covered 17 European countries, of which nine developed and eight emerging market economies for the 2004-2011 period. Both the analyzed period and the sample of countries contribute to the existing literature. Namely, we include the period before as well as after the onset of financial crisis which enables us to investigate whether the determinants of sovereign spreads have changed over that time. It is also interesting to see whether the spreads of developed and emerging market countries which are part of a common market with high level of financial interlinkages are driven by the same factors.

The remaining part of the paper is organized as follows. The second part briefly explains the basic theoretical determinants of government bond spreads and gives a short review of the empirical literature on government borrowing costs, with special emphasis on the studies that include fiscal indicators in the analysis. Next section describes the data used in our analysis, as well as the sources and methods of calculating certain variables. It also summarizes the basic characteristics of the spread and selected fiscal indicators movements for the observed countries during the reference period. In the fourth chapter empirical methods and the results of the estimated model are presented. The final conclusion and policy implications of the results are presented in the last chapter.

2. Literature review

In the past decade, many studies tried to identify the main determinants of government borrowing costs over some "risk free" interest rate. Many different variables were included in empirical models, from usual macroeconomic indicators and their expected values, such as GDP, inflation or different measures of external vulnerability, through the variables indicating the quality of institutions and political risk, as well as the indicators that reflect the developments in global financial markets. Although certain problems with the availability and quality of fiscal data are often mentioned, almost all the authors who explore government bond spreads use a measure of fiscal balance and the data on public debt as a primary measure of a country's credit risk, and hence one of the fundamental determinants of the required yield on government bonds.

The difference between government bond yields for different countries and the yield on selected reference "risk free" bond represents the premium required by investors to include certain bond in their portfolios. Financial theory suggests that this premium reflects the credit risk, liquidity risk and general risk aversion in the market at a given time. Therefore, empirical studies try to determine how much of the premium is determined by the particular type of risk and how the relative importance of each type of risk varies depending on the group of countries or the time period included in the analysis.

2.1. Credit risk

Empirical literature indicates that at the time of the financial market turmoil and periods of greater uncertainty market participants devote significant attention to the country credit risk focusing on macroeconomic and fiscal differences among countries.[5] This kind of risk can be broadly defined as the risk of government's inability or refusal to make required payments on its debt and is often called the risk of default. Creditworthiness or solvency of the country largely depends on the current and expected state of the actual and potential debt and its sustainability. Debt sustainability in turn depends on the expected budget surpluses / deficits, as well as on the expected economic activity and interest rates, which are affected both by domestic and international factors and policies (Codogno et al. 2003). If market perceives that there is a possibility that the government will not be able to fully and/or in time meet all its financial obligations, the investors will demand a higher premium for increased credit risk.[6]

In the empirical literature it is the credit risk that gets most attention. This can be explained by the fact that variables indicating a country's creditworthiness are to some extent under control of domestic policy makers. So countries conducting prudent fiscal policy can to some degree positively affect the cost of borrowing for both public and private sector. Many authors have therefore dealt with the influence of fiscal balance and public debt on the cost of government borrowing. In doing so, econometric methods and measures of fiscal balance, public debt and long-term interest rates often differ, and therefore the results are ambiguous.

Gale and Orszag (2003) reviewed 58 studies investigating the impact of the U.S fiscal deficit on the long-term interest rates and showed that only in slightly less than half of these studies significant positive impact was obtained. However, they stress out that studies that have used projected instead of the current fiscal deficits more often tend to show statistically significant effects of these variables. Significant effect of fiscal policy in US on long term interest rates was found in later studies as well (see, for example, Engen and Hubbard (2004), Dai and Phillipon (2005), Laubach (2009)).

Influence of fiscal variables on long term interest rates was also estimated for other countries. Faini (2006) examines the impact of the current cyclically adjusted primary balance and public debt of 11 EMU member countries on the aggregate euro zone interest rate level and also on government bond spreads for individual countries. This model specification, according to Faini, stems from the fact that changes in domestic fiscal variables affect individual country spreads, but through a spillover effect, they also affect overall the level of euro zone interest rates. The results show that changes in the EMU budget deficit have much stronger effect on the aggregate level of interest rates than the increase in the budget deficit of individual countries on their spreads, which indicates significant spillover effects. Also, the public debt on a country level has no impact on their spreads, while for euro zone as a hole it proved to be significant.

Baldacci and Kumar (2010) analyze the impact of fiscal balance and government debt on ten-year government bonds yields for 31 countries (developed and developing countries) for a period of almost thirty years. The authors showed that the effect of deterioration in public finances on long-term interest rates is significant and robust, but not linear. Moreover, the strength of the impact depends on the initial fiscal, structural and institutional conditions. The authors estimate that, especially in developing countries, debt servicing costs will significantly rise if reforms that would lead to a reduction of government expenditures growth (e.g. pensions and health) are not carried out.

Alexopoulou et al. (2009) study the determinants of differences between bond yields for Central and Eastern European countries which are members of the EU and the average euro zone government bond yield over the period 2001 to 2008. Using dynamic panel (error correction) model authors conclude that the main long run determinants of spreads are external debt as a percentage of GDP, trade openness, the difference between short-term interest rates of the countries analyzed and corresponding short-term rates in the euro zone, exchange rate, inflation and global financial terms (measured by stock market volatility index). In addition, to check whether investors perceive selected countries differently, they divide them into two groups. For the first group, which is characterized by better macroeconomic

[5] See for example Ejsing and Lemke (2009) and Sgherri and Zoli (2009).

[6] As can be seen in the recent Greek case.

fundamentals, they conclude that the main drivers of the rise in spreads are inflation rates and short-term interest rates. On the other hand, fiscal fundamentals have important influence on spreads for countries that are characterized by pronounced external vulnerability.

Nickel et al. (2009) investigated the impact of fiscal variables on the Czech Republic, Poland, Hungary, Russia and Turkey government bond spreads. Since market expectations are important for the movement in yields, as independent variables they used projected fiscal data taken from Consensus Economics forecast. Although the results of the panel data analysis indicate a significant impact of fiscal variables on the difference in yields, the regression analysis for each country shows that the deficit is statistically significant only for Hungary and Russia. The authors conclude that the variables used in the empirical literature to model the government bond spreads probably represent only a small fraction of the market indicators that are monitored, and as a particularly important but difficult to measure variables, they highlight indicators of domestic and external political risks.

2.2. General risk aversion

The general risk aversion is associated with the overall willingness of investors to bear the risk. Higher required yield indicates the lower risk appetite or higher general risk aversion at some point in time. Even without any empirical analysis it seems that this indicator plays a very important role in determining borrowing costs for the governments. This conclusion is supported by relatively similar dynamics of government bond spreads during the specific time periods, regardless the fact that macroeconomic and fiscal positions of the issuers sometimes differ considerably. It should be noted that there is no single or commonly accepted measure of risk aversion so empirical studies use different variables that in some way reflect market sentiment towards risk.

By using the method of principal components and information about the differences in corporate bond yields and the measure of volatility in the stock and foreign exchange markets Barrios et al. (2009) constructed an indicator of the general risk aversion. They analyzed the data for ten euro zone countries in the period from 2003 until 2009 and concluded that the global factors, especially the general perception of risk, are the main determinants of government bond spreads. On the other hand, the role of domestic factors such as macroeconomic fundamentals and liquidity risk associated with bonds of each country is small but not negligible. Similar results were also attained by Haugh et al. (2009) who measure general risk aversion by the difference between yields on corporate and government bonds of the euro zone. They shows that, the fiscal variables significantly affect the difference in yields, but in the majority of specifications indicator of general risk aversion can explain most of the differences in yields and it significantly enhances the effects of other variables included in the model.

The importance of market sentiment was also confirmed by Ebner (2009) who used the data on Central and Eastern Europe government bond spreads. He shows that variables that proxy market sentiment such as VDAX-NEW index, the ECB reference rate and measure of market liquidity have a dominant effect on selected countries spreads, while the variables that reflect macroeconomic and fiscal developments in most countries showed not to be statistically significant. Codogno et al. (2003) also analyze the European countries in the period before and after the introduction of a common currency. As a measure of risk aversion they use the difference in yields of the U.S. high-grade corporate bonds and the U.S. ten-year government bond. Their results imply that the difference between government bond yields of these countries in relation to the German government bond only in Italy and Spain could partially be explained by domestic macroeconomic factors, while in other observed countries spread movements are explained by external factors, respectively, risk aversion indicator.

Based on the data for eight European emerging countries, Dumicic and Ridzak (2011) investigated to what extent the latest financial market turmoil that affected sovereign bond spreads could be related to the changes in the risk appetite and what was the impact of domestic macroeconomic variables, with a special focus on external imbalances. They show that spread movements can be explained both by market sentiment measured by Deutsche Börse volatility index (VDAX) and macroeconomic fundamentals, emphasizing that external imbalances did not result with any significant effect before the crisis, but became very important after the crisis broke out.

Cota and Žigman (2011) also focus on the influence of fiscal policy on government bond spreads for nine „new" EU countries and also Mexico, Russia, Turkey, Ukraine and Croatia. They estimated regression model with panel data using seemingly unrelated regression approach and showed that deficit and the ratio of domestic debt and total public debt have significant influence on spreads before and after the crisis.

2.3. Liquidity risk

The impact of liquidity risk, as one of the theoretical determinants of the differences in yields, has also been also the subject of numerous investigations. Liquid market is considered to be a market with sufficiently large number of orders for the purchase and sale (market depth) and where large transactions have no significant impact on the price (market breadth). As with credit risk and general risk aversion, empirical research does not give the same answer to the question of how liquidity affects the differences on government bond yields.

Schwartz (2010) analyzes the movements in yield differences of euro zone member countries during the last financial crisis and seeks to determine whether the result of their increase is a consequence of a higher credit risk or reduced market liquidity, that is, increased liquidity risk. The author concludes that liquidity risk can explain a great share of the yield differences increase during the last financial crisis, in some cases up to 90%. She believes it is possible that the investors assumed EMU will not allow a default of its members, what then reduced the credit risk. In addition, she believes this high contribution of liquidity risk on spread increase is a result of the used liquidity measure, which, besides the transaction costs, also includes the price of liquidity risk. In contrast, Codogno et al. (2003) show that in the model specifications in which a measure of liquidity risk is statistically significant, its contribution to the yield spreads is weak.

3. Description and analysis of the data

3.1. Choice of variables

The empirical analysis covers the period from the first quarter of 2004 until the fourth quarter of 2011 capturing the period before and after the financial crisis. Even though the original intention was to include all countries of EU plus Croatia, due to data availability our sample was reduced to 17 European countries of which nine being developed and the rest emerging market economies. [7]

The dependent variable in our model is average quarterly sovereign spread relative to Germany. It is calculated as the difference between yield to maturity of comparable generic eurobonds for each country in the sample and the yield to maturity of a comparable benchmark generic German government bond on the basis of daily data. Data on yield to maturity for generic government bonds have been taken from the l Lynch's Database. Generic bonds are used to artificially create yield to maturity time series, which is formed by connecting bonds with certain characteristics (currency, maturity etc.). In this way, the yields on individual bonds are not monitored, since they change, inter alia, due to the changes in bond's time to maturity. Therefore, we use yields on bonds which do not exist in reality, but enable us to track the cost of long-term borrowing for individual countries over time.

To account for the credit risk the emphasis was put on developments in public finances and the main indicators used in the model were fiscal balance and public debt to GDP ratios.[8] However, since financial theory suggests that it is expected future developments rather than current ones that are more relevant for yield formation, we have used European Commission's (EC) fiscal projections as a measure of market expectations. Given that the EC publishes its detail projections twice a year, quarterly series are constructed in a way that in the second and the fourth quarter, when projections are published,

[7] Countries can be divided into two groups: the developed countries and emerging market countries. Developed countries from our sample are: Austria, Belgium, Denmark, Spain, Finland, France, Italy, Netherlands, and Sweden. Emerging market countries are: Bulgaria, Croatia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia.

[8] To assure fiscal data consistency we have used fiscal data from the Eurostat which are shown according to ESA 95 methodology.

the variable takes the average value of the published projections for the current year and subsequent periods (in the second quarter that is one year ahead and in the fourth quarter two years ahead)[9]. On the other hand, the data for the first and the third quarter were obtained as the average of the calculated values for the previous and subsequent quarter.[10] In such way we capture, at least to some degree, medium term market expectations on fiscal developments, but we also allow the possibility that market participants change their expectations in between two EC's projections as rational expectations theory would suggest.[11]

Furthermore, to obtain information on government's liquidity we have used data on general government sector interest payments on public debt as a ratio to GDP and current revenues. Such variable was also used by Alexopoulou et al. (2009) and Haugh et al. (2009). As mentioned by Alexopoulou et al. (2009) it is expected that markets would react more promptly to changes in interest payments made on public debt than to changes in the principal.

Besides fiscal indicators we have also used some other macroeconomic variables that reflect credit riskiness of a country. To take into account country's external vulnerability, the expected current account expressed in percent of GDP was introduced in the model. The larger the current account the more vulnerable country is to slowdown in capital inflows or sudden stops, so investors are expected to demand higher yields on its bonds. Expected real GDP growth was also included in some model specifications. Higher GDP growth, ceteris paribus, means that taxable base is expected to expend in the future having a positive influence on government solvency. This variable could also serve as a proxy for quality of economic policy making process in a referent country, so higher growth is expected to result in lower sovereign bond spreads.

Following the common practice in the literature we have used the Chicago Board Options Exchange Volatility Index (CBOE_VIX) as an indicator of risk aversion (or investor sentiment) on global financial markets. CBOE_VIX measures implied volatility of the S&P500 index option prices and is commonly used as a measure of market expectations and global investor sentiment.

Also, based on these indicators, a dummy variable was created that indicates the period of extreme turmoil in the financial markets and which takes the value of one in the quarters in which the value of mentioned spreads exceeds the average spread increased by two standard deviations[12]. It is expected that during the periods of high risk aversion investors mostly invest in high quality government bonds (e.g., German or U.S.), which reduces their yields. At the same time it is possible that the demand for bonds of other countries is increasing because government securities are generally considered less risky than corporate bonds and equities, but the assumption is that the spreads between the "low quality" and quality government bonds will increase.

Considering the fact that we have used the spreads on generic bonds in our model, the usual direct liquidity indicators for market instruments such as bid-ask spreads or trading volumes for a specific bond are not available. Therefore, we have decided to use an indirect liquidity indicator, following Barbosa and Costa (2010) who calculated the relative size of each country's government bond market. Using the data on the structure of public debt, we have calculated the share of an outstanding amount of a specific government's bonds in the total amount of outstanding debt securities issued by the observed countries in a certain period. Another possible solution might be to try to get the information of the underlying bonds used for calculating the generic bonds for each country, but it is still questionable weather the data obtained in such way would provide the actual information on liquidity of country bonds.[13]

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[9] E.g. for the second quarter of 2010 our observation is an average EC's forecast for 2010 and 2011. For the last quarter of the same year the average also includes 2012.

[10] E.g. our observation for the first quarter of 2010 is an average of our observations for the last quarter of 2009 and the second quarter of 2010 (see footnote 10).

[11] GDP and current account data were obtained and constructed in the same way as fiscal variables.

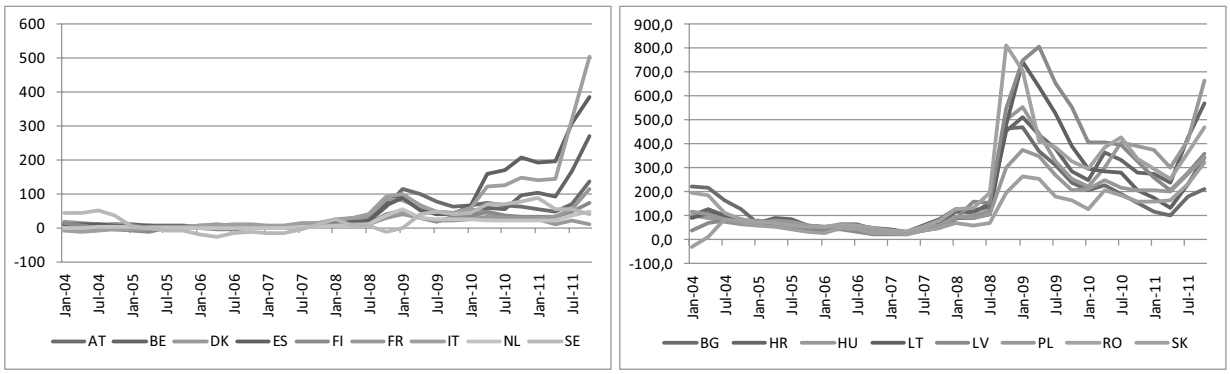
[12] A similar method of determining the period of increased volatility in financial markets was used by Dumicic and Ridzak (2011).

[13] For potential problems see Barbosa and Costa (2010), p. 9.

3.2. Data description

In the period from 2004 until the crisis, sovereign yield spreads to German government bond generally co-moved and converged to historically low levels reached during 2006 and 2007. However, after the escalation of the financial crisis in the last quarter of 2008 emerging market countries' bond spreads have exploded. After few months they started to decline again, but remained at levels higher than in the period before the financial market turmoil. Spreads for the majority of developed European countries have also increased with onset of the crisis, but in much smaller amounts. The exceptions are spreads for Spain and Italy and partly Belgium, whose risk premium increased significantly due to investors' concerns about long-term sustainability of their budget deficits and public debt that have increased substantially during the recession, as well as because of the political uncertainty.

Figure 1 Difference in government bond yields of selected European countries and benchmark German government bond



Sources: Merrill Lynch; authors' calculation.

Similar developments (relatively positive till 2007 and adverse afterwards) were recorded also in the area of public finances in most of the selected countries. The fact is that the most of the observed countries were in a long expansion that lasted till 2007 and had a favorable effect on budget revenues. Therefore, in this period countries generally exercised relatively low levels of budget deficit and some even a budget surplus. One has to stress that cyclically adjusted budget balance figures show less favorable developments. Nevertheless, relative debt indicators for most of the countries were more favorable at the end of 2007 than at the beginning of the observed period.

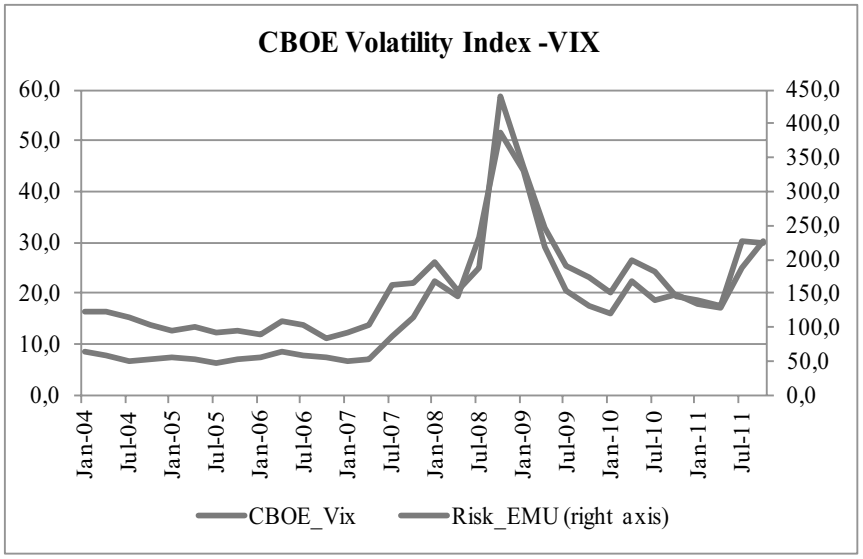
However, the escalation of the financial crisis and its spillover into the real sector of economy ultimately led to the deepest recession in the aftermath of the Second World War. In such circumstances the influence of the automatic stabilizers led to a sharp fall in government revenues. Additionally, fiscal authorities of the most developed EU countries have tried to alleviate and reverse the adverse economic trends implementing different fiscal stimulus packages, and many of them had to inject substantial funds into the financial system to preserve its stability. This resulted in an increase in state spending. On the other hand, the countries of Central and Eastern Europe generally could not afford significant stimulation of their economies with their budget resources. Smaller packages of fiscal stimulus have been recorded only in Slovakia, Slovenia and Poland while countries like Hungary, Croatia, Romania and Latvia trying to stabilize its public finances actually implemented pro-cyclical measures. This was also demanded by the international financial institutions that provided conditional financing during crisis period.

Namely, after the collapse of Lehman Brothers risk aversion on the global financial markets increased significantly. Figure 2 shows two indicators of risk aversion. The first one measures the difference between yields on generic corporate bonds in the euro zone countries, excluding financial companies, and the yield on comparable generic German bonds (Risk_EMU). The second one is The Chicago Board Options Exchange Volatility Index (CBOE_Vix) which measures implied volatility of S&P500 index option prices and is used in this paper to capture investors' risk aversion.[14] Figure 2 shows that even before the onset of financial crisis in Europe risk aversion indicators started to rise due to adverse developments in US subprime mortgage market. In the first months after the collapse of Lehman Brothers the level

[14] By using CBOE_Vix we avoid the problem of endogeneity which might be present if Risk_EMU is used instead.

of risk premium reached prohibitively high level and some of the countries in our sample lost access to international capital markets. In such circumstances, to avoid defaulting on their debt countries like Hungary or Latvia got international financial help but were forced to implement severe saving measures.

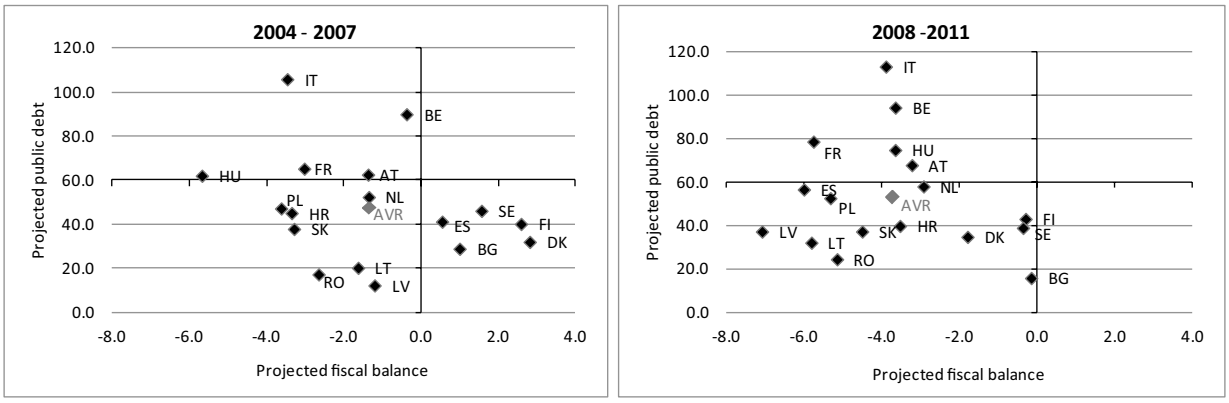
Figure 2 Risk aversion indicators



Sources: Bloomberg, authors' calculation.

Regardless of whether it was the effect of automatic stabilizers on the revenue side and / or increased costs due to the banks rescue and stimulation of economy, in all countries under review there was a noticeable deterioration in fiscal balance, and consequently the public debt (Figure 3). Average projected fiscal deficit in the period from 2004 to 2007 was around 1.5%, and in the next three years increased to 4.2% of GDP, while projected public debt increased by about 8 percentage points. Looking at the end of 2010 public debt was on average by about 18 percentage points higher than at the end of 2007, while Ireland greatly stands out as its debt increased by about 70 percentage points.

Figure 3 Fiscal developments before and after the onset of global financial crisis

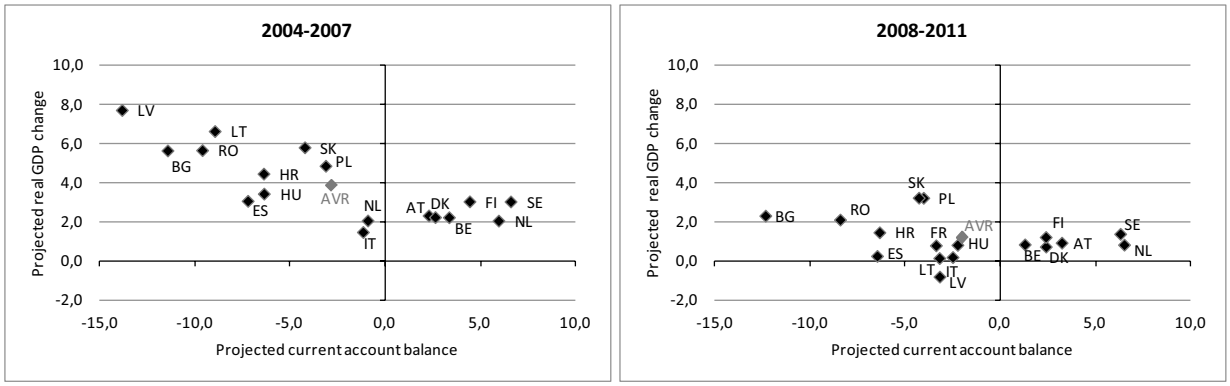


Note: Left panel shows average expected fiscal balance and public debt in the 2004-2007 period while right panel shows figures for the same variables in the 2008-2011 period. AVR = average.
Vertical red line shows 3% deficit limit as defined by the Stability and Growth Pact.
Sources: Eurostat, MF, CNB.

Not only fiscal indicators showed significant worsening during the last crisis. Average GDP growth decreased significantly during the crisis. During the 2004-2007 period it amounted to 4.5% annually and then plunged to -1.0% on average during the subsequent three years. As can be seen from Figure 4 average projected GDP growth also significantly decreased. One has to stress that in 2010 most of the countries in the sample experienced a mild growth, only Ireland, Romania and Croatia were still on a downward trend. Overall, such development added to investors' concerns regarding medium-term sustainability and could partly explain high level of yield spread in that period. On the other hand, external

imbalances measured by the current account balance somewhat shrank, especially in the emerging market countries mostly due to significant fall in imports. It seems, however, that did not offer much comfort to global investors since the external indebtness continued to rise.

Figure 4 Growth prospects and external imbalances before and after the onset of global financial crisis



Note: Left chart shows average current account balance and average real GDP change in the 2004-2007 period while right panel shows figures for the same variables in the 2008-2011 period. AVR = average.
Sources: Eurostat; CNB; authors' calculation.

Before econometric analysis it is useful to look at linear correlation coefficients between sovereign yield spreads on one side and potential explanatory variables on the other for two subperiods. Table 1 shows that for emerging market countries correlation coefficients between indicators of credit risk, liquidity risk and general risk aversion on the one side and government bond yield spreads on the other mainly show expected signs both before and after the onset of financial crisis. What is interesting is that correlation between fiscal variables and spreads for most countries was much stronger before than after the crisis. On the other hand, correlation coefficients suggest a more important role of general risk aversion after the onset of the crises. This is to some extent contrary to general belief of non-discriminating financial markets before the crisis. However, it is impossible to say whether this was really the case without a detailed econometric analysis that takes into account all the interlinkages between explanatory variables.

Results for developed countries indicate that before the crisis investors' risk aversion played the most important role in determining the spreads, while results for other variables are mixed with both positive and negative signs of correlation coefficients. And even if the sign is right, correlations are weaker than for emerging market countries. However, this is something that might have been expected. One has to keep in mind that prior to the crisis most developed countries in our sample had the highest credit rating (only Belgium and Italy had a double A rating). Investors probably saw these bonds as close substitutes and did not pay too much attention to the macroeconomic and fiscal developments. Data on spreads seem to support such conclusion. Namely, in only five percent of the cases in this period spreads were larger than 10 basis points. So it seems that decreasing level of risk aversion was playing more important role in this period as suggested by relatively high correlation coefficient between sovereign spreads of most of the countries and the VIX index. Financial and sovereign debt crisis in the EU seem to significantly change that. In most cases, correlation coefficients between fiscal indicators, especially public debt, and sovereign spreads now have the expected sign, and it seems that relation is somewhat stronger than before. On the other hand, it seems that correlation between general risk aversion and spreads has weakened.

Table 1 Correlation coefficients between sovereign spreads and selected variables

	Projected fiscal balance		Projected public debt		Projected GDP growth		Indicator of risk aversion-Vix		Liquidity indicator	
	04-07	08-11	04-07	08-11	04-07	08-11	04-07	08-11	04-07	08-11
Austria	-0,3	-0,5	0,6	0,6	-0,6	-0,5	0,3	0,4	0,3	-0,1
Belgium	-0,1	-0,2	0,2	0,4	0,0	0,2	0,7	0,1	0,4	-0,6
Denmark	-0,5	0,1	0,2	-0,4	-0,4	-0,6	0,6	0,7	0,4	0,0
Spain	-0,4	-0,2	0,7	0,7	-0,6	0,3	0,5	-0,1	0,6	0,9
Finland	0,3	-0,3	-0,2	0,2	-0,3	0,0	0,6	0,3	-0,1	0,6
France	0,7	-0,1	-0,7	0,5	0,0	0,1	0,7	0,2	0,6	-0,1
Italy	0,2	0,2	-0,2	0,5	-0,1	0,2	0,2	0,1	-0,6	-0,7
Netherland	0,2	-0,3	-0,2	0,3	0,2	-0,4	0,5	0,6	-0,3	0,4
Sweden	-0,7	-0,2	0,5	0,3	-0,6	0,5	0,3	-0,6	0,6	-0,2
Bulgaria	-0,7	0,2	0,9	-0,4	-0,7	-0,3	0,3	0,9	1,0	0,0
Hungary	0,6	0,4	-0,6	0,4	0,2	-0,3	0,3	0,5	-0,8	-0,7
Lithuania	-0,9	-0,4	0,8	-0,1	-0,3	-0,8	0,2	0,6	-0,7	-0,2
Latvia	-0,6	-0,8	0,7	0,3	-0,8	-0,9	0,1	0,5	0,5	-0,6
Poland	-0,9	-0,3	0,6	0,4	-0,5	-0,7	0,2	0,6	-0,8	-0,9
Romania	-0,1	-0,1	0,8	0,0	-0,5	-0,1	0,3	0,9	-0,6	-0,1
Slovakia	-0,6	-0,4	0,8	0,4	-0,7	-0,5	0,2	0,4	-0,5	0,5
Croatia	-0,4	-0,3	0,6	0,2	-0,2	-0,5	0,3	0,6	0,3	0,1

Source: Authors' calculation.

4. The econometric model and analysis of the results

Taking into account high persistency in sovereign spreads, as government bond spread in current quarter depends among other things on the prior spread level, in the empirical part of the paper we employ a dynamic panel model. If static models were to be estimated and the underlying dynamics ignored, significant information might be lost, resulting in poor estimation results. When a dynamic model is estimated, even if we have no interest in the coefficient on the lagged dependent variable, dynamics are allowed for in the underlying processes, which might be essential for the recovery of consistent estimates of other parameters (Bond, 2002). The inclusion of lagged quantities, in addition to accounting for rigidities in adjustment, also lessens the problem of omitted variables.

4.1. Dynamic panel analysis

Linear dynamic model is specified as:

$$y_{i,t} = \gamma_1 y_{i,t-1} + \ldots + \gamma_p y_{i,t-p} + \beta x_{i,t} + \alpha_i + \varepsilon_{i,t} \quad (1)$$

where $y_{i,t}$ is a dependent variable in time t, and $y_{i,t-1}$ lagged dependent variable, α_i is an individual fixed effect, $x_{i,t}$ is a vector of explanatory variables for unit i in period t, and $\varepsilon_{i,t}$ is the disturbance term. It is assumed that $E\{\varepsilon_{i,t}\} = 0$ and $E\{\varepsilon_{i,t}, \varepsilon_{j,s}\} = \sigma^2$ if $i=j$ and $s=t$, and 0 otherwise. The objective is to consistently estimate γ_1 to γ_p and β when α_i is a fixed effect. Since $y_{i,t-1}$ is correlated with α_i is OLS and random effect estimators are both inconsistent. It can be shown that within estimator is also inconsistent and suffers from so called Nickell bias which can be substantial and disappears only if $T \to \infty$.

If the model is first transformed by first differencing to eliminate fixed effects we again introduce correlation between differenced lagged dependant variable and differenced error term so instrumental variable approach should be used.

The transformed model is then given by:

$$\Delta y_{i,t} = \gamma_1 \Delta yi_{,t-1} + \ldots + \gamma_p \Delta yi_{,t-p} + \beta \Delta x_{i,t} + \Delta \varepsilon_{i,t} \quad (2)$$

where $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$.

In the case of the lagged dependent variable, valid instruments will be those which are correlated with $\Delta y_{i,t-1}$ and uncorrelated with $\Delta \varepsilon_{i,t}$. Anderson-Hsiao estimator could be used but even though it is consistent, it is not asymptotically efficient. Arellano and Bond (1991) showed that the most appropriate framework for obtaining estimates in this context is the generalized method of moments (GMM). GMM estimation uses a different number of instruments for the lagged dependent variable (and other endogenous variables) for each period, depending on how many are available, which increases efficiency of GMM estimator.[15]

Arellano-Bond estimator, employed in this paper, uses lagged levels of the endogenous variables as instruments. So, for example, if $t=3$ the instrument for $\Delta y_{i,t-2}$ would be $y_{i,t-1}$; if $t=4$ instrument for $\Delta y_{i,t-3}$ will be $y_{i,t-2}$ but also $y_{i,t-1}$, and so on. Arellano-Bond estimator uses instrument matrix that takes the following form

$$Z_i = \begin{bmatrix} y_{i1} & 0 & 0 & \ldots & 0 & \ldots & 0 \\ 0 & y_{i1} & y_{i2} & \ldots & 0 & \ldots & 0 \\ . & . & . & \ldots & . & \ldots & . \\ 0 & 0 & 0 & \ldots & y_{i1} & \ldots & y_{i,T-2} \end{bmatrix} \quad (3)$$

and then exploits the moment conditions $E[Z_i', \Delta \varepsilon_i] = 0$ for $i = 1, 2, \ldots, N$. Asymptotically efficient GMM estimator based on this set of moment conditions minimises the criterion

$$J_N = \left(\frac{1}{N}\sum_{i=1}^{N} \Delta v_i' Z_i\right) W_N \left(\frac{1}{N}\sum_{i=1}^{N} Z_i' \Delta v_i\right) \quad (4)$$

In the paper we use one-step estimator based upon optimal weighting matrix in the presence of homoskedasticity, and robust standard errors. Weighting matrix in this context is

$$W_{1,N} = \left[\frac{1}{N}\sum_{i=1}^{N} \left(Z_i' H Z_i\right)\right]^{-1} \quad (5)$$

and does not depend on any estimated parameters.[16,17]

If the explanatory variable x is endogenous, it is treated symmetrically with the lagged dependent variable $y_{i,t-1}$ (Bond, 2002).[18]

One has to keep in mind that if $T > 3$ the model is overidentified so the validity of instruments should be tested using the standard GMM Sargan test of overidentifying restrictions. Also, the assumption of no serial correlation in error term in the original equation has to be tested by assuming no second-order serial correlation in the residuals of the first differenced equation.

[15] The estimation may include other variables which are exogenous and therefore need not be instrumented.

[16] Where H is (t-2) square matrix with 2's on the main diagonal, -1's on the first off-diagonals and 0's elsewhere (Bond, 2002).

[17] Simulations show that asymptotic standard errors tend to be too small for two-step estimators.

[18] Important to note is the fact that lagged levels will convey meaningful information on subsequent changes in the variable only if the variable is not close to a random walk, which was pointed out by Blundell and Bond (1998).

4.2. The empirical model and the results

This section presents and comments the estimation results of specified models obtained by employing econometric strategy outlined in the previous section. General model is given by the following equation

$$spread_{i,t} = \gamma_1 spread_{i,t-1} + \beta_1 credit\_risk_{i,t} + \beta_2 risk\_aversion_{i,t} + \beta_3 liquidity_{i,t} + \alpha_i + \varepsilon_{i,t} \qquad (6)$$

All model specifications use CBOE_VIX as an indicator of global risk aversion and our measure of liquidity described in section 3.1. Regarding the credit risk, two basic specifications use only fiscal variables, namely, expected government budget balance (specification 1) and expected public debt (specification 3). We do not include fiscal balance and public debt in the same equation in order to avoid problem of collinearity. These two general specifications are than expanded by including projected GDP growth that is also expected to be an important sovereign spread determinant. Each model specification was estimated for three different time periods (on the overall period; Q1 2004 - Q4 2011), period before the onset of the crisis; Q1 2004 - Q4 2007 and period during and after the crisis; Q1 2008 - Q4 2011) and for three different groups of countries (all countries, developed countries and emerging market countries).

Tables 2-4 summarize the results of estimated models.

Table 2 Results of dynamic panel model estimation, all countries

Period	04-11				04-07				08-11			
	Model Specification				Model Specification				Model Specification			
Variables	I	II	III	IV	I	II	III	IV	I	II	III	IV
Spread (t-1)	0,57***	0,65***	0,56***	0,62***	0,78***	0,77***	0,71***	0,71	0,64***	0,57***	0,65***	0,54***
Projected fiscal balance	-1,70***	-4,07***	-	-	-0,30	0,11	-	-	-5,08***	-3,46***	-	-
Projected public debt	-	-	1,09***	1,09***	-	-	0,87***	0,82***	-	-	1,31***	1,59***
Projected GDP growth	-	6,40***	-	4,37***	-	-1,95***	-	-0,62*	-	-5,70***	-	-9,29***
Risk aversion indicator-VIX	5,85***	5,63***	6,02***	5,65***	1,95***	1,95***	2,07***	2,06***	4,84***	4,67***	4,87***	4,58***
Liquidity indicator	15,42	-44,48	-16,25	-59,79	-5,94***	-5,20***	-6,67**	-5,36*	-4,89	-35,31	-45,87	-54,84
Constant	-0,02	146,39	-43,13	195,77	12,02*	21,49**	-25,02	28,87	-12,66	187,99	158,82	242,76
AR2 -probabiltiy values-H0: no autocorrelation	0,09	0,10	0,07	0,10	0,53	0,57	0,57	0,57	0,46	0,56	0,37	0,65

Notes: AR2 – second order autocorrelation;
*significance level - * 10%, ** 5%, *** 1%*
Source: Authors' calculation.

Table 3 Results of dynamic panel model estimation, developed countries

Period	04-11				04-07				08-11			
	Model Specification				Model Specification				Model Specification			
Variables	I	II	III	IV	I	II	III	IV	I	II	III	IV
Spread (t-1)	1,22***	1,22***	1,25***	1,22***	1,14***	1,29***	1,26***	1,24***	1,23***	1,2***	1,22***	1,18***
Projected fiscal balance	4,16**	1,81			3,50	9,44			3,45**	0,17		
Projected public debt			-0,57	-0,15			-1,19	-1,26			-0,18	0,16
Projected GDP growth		5,32**		6,99***		0,93		-1,52		8,19***		8,56***
Risk aversion indicator-VIX	0,94***	1,16***	0,89***	1,22***	0,47***	0,44***	0,36**	0,32**	1,07***	1,38***	1,16***	1,42***
Liquidity indicator	-6,77	-4,94	-7,31	-4,07	-17,11	-19,87*	-22,50**	-20,9	-16,90**	-9,49*	-18,50**	-8,51
Constant	53,94	18,74	89,75	13,08	177,51	205,65**	297,75	287,4**	148,29	49,76	162,86**	28,18
AR2 -probabiltiy values-H0: no autocorrelation	0,23	0,23	0,13	0,25	0,40	0,68	0,72	0,68	0,05	0,07	0,06	0,08

Notes: AR2 – second order autocorrelation;
*significance level - * 10%, ** 5%, *** 1%*
Source: Authors' calculation.

Table 4 Results of dynamic panel model estimation, emerging market countries

Period	04-11				04-07				08-11			
	Model Specification				Model Specification				Model Specification			
Variables	I	II	III	IV	I	II	III	IV	I	II	III	IV
Spread (t-1)	0,45***	0,54***	0,48***	0,49***	0,71***	0,68***	0,58***	0,59***	0,45***	0,55***	0,50***	0,50***
Projected fiscal balance	-10,88*	-13,76**			-3,70*	-2,80			-12,02*	-15,34**		
Projected public debt			2,73*	2,80*			2,01***	1,66**			3,47*	3,52*
Projected GDP growth		6,55		0,61		-6,87***		-3,49		7,15		-0,06
Risk aversion indicator-VIX	8,72***	8,81***	8,83***	8,83***	2,77***	2,91***	2,90***	2,95***	9,59***	9,71***	10,07***	10,08***
Liquidity indicator	-65,47	-58,73	-66,83	-65,02	-13,32	-8,51	-14,01	-12,67	55,62	51,40	54,16	56,90
Constant	-73,70***	-129,04**	-142,88**	-151,25**	-25,74**	12,02	-77,38***	-47,58	-182,49***	-235,37***	-296,00***	-300,64**
AR2 -probabiltiy values-H0: no autocorrelation	0,20	0,23	0,2	0,2	0,61	0,69	0,82	0,87	0,14	0,17	0,15	0,15

*Notes: AR2 – second order autocorrelation; significance level - * 10%, ** 5%, *** 1%*
Source: Authors' calculation.

The first lag of the dependent variable is highly significant in all three observed periods and in all three groups of countries, justifying usage of dynamic panel model. Also, results suggest there is no second order autocorrelation in the first-difference version of different model specifications at the usual significance level, indicating they are well specified.

Table 2 shows panel results when all countries are included in our sample. When looking at the whole period results indicate that fiscal variables and general risk aversion played an important role with the latter indicator having the largest influence on sovereign spreads dynamics. The results also suggest that projected fiscal balance has larger impact on spreads than public debt which is in line with the results presented in empirical literature. For projected GDP growth we get counterintuitive result. Estimation results show that it is significant but it has a wrong sign.

When the sample is split in two periods; Q1 2004 - Q4 2007 and Q1 2008 - Q4 2011, it seems that results from full sample panel estimation are greatly determined by the reaction of the spreads in crisis period. Namely, before the crisis projected fiscal balance is insignificant and public debt and projected GDP seem to be the main indicators of countries credit risk, but relatively low coefficients next to them indicate that they did not have important role in determining the spreads. It could be concluded that liquidity risk and general risk aversion were the most important drivers of sovereign spread dynamics.

After the onset of the financial crisis all credit risk indicators are significant and have expected sign while liquidity risk indicator lost significance. Apart from that, their influence on spreads is much larger than before, indicating that in the crisis period investors started to pay more attention to country specific macroeconomic and fiscal developments and to differentiate more between the countries.

However, the significance of credit risk indicators seems to be due to reaction of spreads to macroeconomic and fiscal factors of emerging market countries. Namely, results for developed countries (displayed in Table 3) show that their credit risk indicators are either insignificant or they have counterintuitive sign in all three different periods. It seems that risk aversion and liquidity risk were main determinants of spread dynamics for developed countries before and after the onset of the crisis, although liquidity indicator lost significance in some model specifications. These results are somewhat contrary to results presented in for example Barrios at al. (2009)) where authors concluded that fiscal variables together with market liquidity and general risk aversion played important role in determining spreads of developed EU countries in recent period. Answer to these different estimations could be in construction of fiscal variables. Namely, explanatory variables in Barrios et al. are expressed relative to Germany, while we use original data. So it is possible that when it comes to developed EU countries investors compare country specific factors with that of Germany. In that case we could expect to see an increase in sovereign spreads if, let say, expected public debt for a certain country increases more than for Germany, and if it increases less, spreads should fall despite there is worsening of fiscal indicators.

On the other hand, estimation results presented in Table 4 suggest that credit risk factors are very important in determining the bond spreads of emerging markets countries. Projected fiscal balance and projected public debt are both significant and with right sign before and after of the onset of financial crisis in most model specifications. Projected fiscal balance only loses its significance when projected GDP growth is included in the Model 2 in the pre-crisis period, but then projected GDP growth is significant and with the expected sign. Also, coefficients next to fiscal variables are much higher than the ones obtained for whole sample of countries. Table 4 shows that relatively high coefficient next to fiscal balance is primarily consequence of a several times larger reaction of spreads to fiscal balance in the period after the onset of financial crisis.

Risk aversion component for emerging market countries is highly significant in all three different periods and its impact is much higher in crisis period. Results also suggest that it has larger influence for emerging market countries than for developed countries, especially in the crisis period. On the other hand, liquidity risk seems to have no influence on movements in sovereign spreads of emerging market countries before and after the onset of crisis.

5. Conclusion

The crisis has changed the world we live in, or at least our perception of it. After they reached historically low levels in the pre-crisis period, sovereign speeds exploded in the late 2008 and early 2009. For some countries increase was so dramatic pushing them into sovereign debt crisis. By analyzing data for 17 European countries with a special focus on fiscal variables this paper tried to answer what were the main drivers of such developments. Did macroeconomic and fiscal situation really become so much worse? Or did investors simply start to pay more attention to previously ignored factors?

Simple descriptive data analysis shows that macroeconomic and fiscal situation really did worsen significantly with the onset of the crisis. After several years of robust growth and declining fiscal imbalances Europe was hit by the worst recession in more than sixty years. Fiscal deficits reached level not seen in years and public debt figures skyrocketed in some countries. In the same time, growth prospects for many countries became much weaker. Such developments have an adverse effect on government solvency so it is reasonable to expect that spreads should be affected. In addition, it seems that investors started to pay much more attention to factors neglected during the prosperous times, such as fiscal sustainability. Namely, even in the period 2004-2007 macroeconomic and fiscal developments were not homogenous, but this has not been reflected in the different spread levels among countries, as their differences were negligible.

Econometric analysis was conducted using dynamic panel data model and Arellano-Bond estimator which is in our opinion the most appropriate for our purpose. The results for the entire sample (all countries and the whole period) confirm our prior belief and are also in line with the empirical literature. Both general risk aversion and fiscal variables as indicators of credit risk are proven to be statistically significant determinants of sovereign yield spreads. The results are robust to the use of different fiscal indicator; namely, fiscal balance vs. public debt. The liquidity indicator, on the other hand, statistically does not differ from zero, even thought it has the expected sign.

All model specifications offer some interesting insights when estimated on two subperiods (2004-2007, 2008-2011). It seems that spreads reacted much more strongly on changes in overall market risk aversion after the onset of the crises. The initial shock of the crisis (Lehman Brothers) never died away completely, and many subsequent events resulted in spreads detaining on much higher level than before the crisis (almost on 100 percent higher level regardless of the indicator used to measure general risk aversion). In such an environment these results are in line with expectations. Also as expected, credit risk indicators were shown to be much more important determinant of spreads during 2008-2011 period. The results confirm that markets like both saving and growth. So if the expected growth went up or the fiscal policy was projected to become more prudent, the markets were demanding lower spreads.

Estimating the model separately for developed and emerging market countries suggests that aforementioned results are mostly driven by the latter. It seems that the general risk aversion is the most important determinant of developed countries' bond spreads and the credit risk indicators were either statistically insignificant or had a wrong sign. One possible explanation would be that investors do not react to changes in macroeconomic or fiscal situation, but to the changes compared to "referent" country, in this case Germany. So, this might imply that not only dependent but also explanatory variables should be defined relative to relevant German indicator. On the other hand, the crisis changed how markets react on expected macroeconomic and fiscal developments in emerging market countries in the sample. Coefficients next to fiscal and general risk aversion indicators are much higher in 2008-2011 period than before. Such results would suggest that emerging market countries came under the magnifying glass of investors while developed countries got into trouble a little bit later.

At the end, one could conclude that countries should only partly blame themselves for increased borrowing costs. Even though there is not much a single country can do to change a market sentiment, evidence suggest there is a certain manoeuvring space for the domestic policy makers to contribute with their actions to a decline of their borrowing cost, and consequently to support the long-term sustainability of public finances. This is an important lesson for policy makers. There is, however, a lesson for financial market as well, as their role in adequate risk pricing should be played with a much greater caution. By neglecting important signs of unsustainable imbalances and signalling that countries are in "a good shape" they failed to be a corrective of unsound policies. The future will show whether these lessons have been learned.

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CREDIT GROWTH AND CAPITAL BUFFERS: EMPIRICAL EVIDENCE FROM CENTRAL AND EASTERN EUROPEAN COUNTRIES[1]

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Abstract

Excessive credit growth is often considered to be an indicator of future problems in the financial sector. This paper examines the issue of how to determine whether the observed level of private sector credit is excessive in the context of the "countercyclical capital buffer", a macroprudential tool proposed in the new regulatory framework of Basel III by the Basel Committee on Banking Supervision. An empirical analysis of selected Central and Eastern European countries, including the Czech Republic, provides alternative estimates of excessive private credit and shows that the HP filter calculation proposed by the Basel Committee is not necessarily a suitable indicator of excessive credit growth for converging countries.

JEL Codes: G01, G18, G21.

Keywords: Basel regulation, credit growth, financial crisis countercyclical buffer.

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Nontechnical Summary

The historical experience of the CEE countries with the credit boom in 2004-2007 offers the possibility of applying the method proposed by the Basel Committee within its Basel III regulatory package to calculate and discuss what countercyclical capital buffer level these countries might have had if the newly proposed regulation on the creation of capital buffers had existed before the crisis.

The motivation for this analysis is to determine how suitable the Basel Committee's proposed method for calculating excessive credit using the Hodrick-Prescott (HP) filter for the credit-to- GDP series is for the countries of Central and Eastern Europe. In these countries, rapid credit expansion may simply mean convergence to values typical of the advanced nations, and not excessive borrowing. For this type of country, we propose to use a method involving estimation of the equilibrium private credit level obtained using economic fundamentals.

The HP filter method applied on credit-to-GDP has its drawbacks. A time series trend is dependent to a significant extent on the length of the chosen time series and the calculation is very sensitive to the smoothing parameter (lambda). A big problem as regards practical application in macroprudential policy is "end-point bias", which generates a highly unreliable estimate of the trend at the end of the data period. Another relevant question is whether the credit ratio should take into account other denominators besides GDP, such as financial assets or total assets of the private sector.

The paper offers a so-called "out of sample method" (OOS) based on estimating the model on a different sample of countries and applying the elasticities so obtained to the data for the countries for which the equilibrium credit level is being estimated. We draw upon the existing studies on this topic, which use the developed countries of the EU or OECD as appropriate countries for OOS comparison (Kiss et al., 2006; Égert et al., 2006).

We use the PMG (pooled mean group) estimation method, introduced for panel estimates by Pesaran et al. (1999). This method can be used to estimate the long-run relationship between the credit-to-GDP ratio and other variables, which is identical for all countries, whereas the short-run adjustment to this long-run relationship can differ across countries. The PMG model therefore allows heterogeneity of the estimates for individual countries in the short run. However, the long- run relationship of the cointegrated variables is common to all the countries in the sample.

The OOS calculations may in some cases imply significantly different conclusions regarding excessive credit compared to the calculations using the HP filter. According to the HP filter, the credit-to-GDP gap indicates excessive credit in the recent period not only for the Czech Republic, but also, for example, for Slovakia, Lithuania, Romania and Poland, whereas the OOS estimate does not confirm this excessive credit level. By contrast, Bulgaria, Estonia, Latvia and Slovenia had excessive credit-to-GDP ratios according to the OOS method. Finally, the size of the capital buffer was calculated for individual CEE countries using the two alternative methods using the mid-2008 data as the starting point for the buffer calculation.

1. Introduction

The Basel III reforms to the banking sector regulatory framework agreed in 2010 contain an important macroprudential element intended to dampen the potential procyclicality of the previous capital regulation. The Basel Committee on Banking Supervision (BCBS, 2010a) has introduced a "countercyclical capital buffer" aimed at protecting the banking sector from periods of excessive credit growth, which have often been associated with growth in systemic risk. In good times, banks will - in accordance with set rules - create a capital reserve which can then be used to moderate contractions in the supply of credit by banks in times of recession.

One region that recorded a boom in lending to the private sector in the lead-up to the global financial crisis was the Central and East European (CEE) countries.[3] The observed credit expansion was driven by many factors relating to both the demand and supply side of the credit market. Although the credit growth in these transition economies started from very low levels, the rate of growth in many countries has raised concerns about how sustainable such growth is in the medium term and whether it poses significant risks to the stability of the financial sector.

This paper aims to draw on the historical experience of the CEE countries with credit expansion and, using the method proposed by the Basel Committee, to calculate and discuss what the countercyclical capital buffer level these countries might have had if the newly proposed regulation on the creation of capital buffers had existed before the crisis. The motivation for this analysis is to determine how suitable the Basel Committee's proposed method for calculating excessive credit using the Hodrick-Prescott (HP) filter is for the countries of Central and Eastern Europe. In these countries, rapid credit expansion may simply mean convergence to values typical of the advanced nations, and not excessive borrowing. For this type of country, we propose to use a method involving estimation of the equilibrium private credit level computed using economic fundamentals. Given that different countries have different characteristics, the Basel Committee allows national regulators to exercise discretion and specify different methods for setting the countercyclical capital buffer.

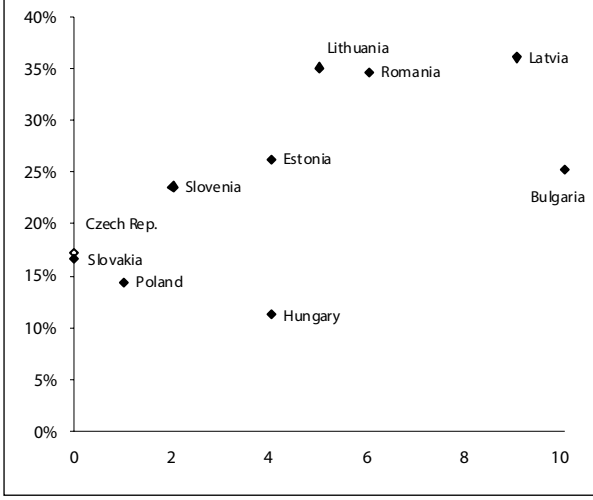
The paper is structured as follows. Section 2 discusses the risks associated with excessive credit expansion, looks at the situation in selected EU countries before the global financial crisis broke out, and briefly examines the logic of the countercyclical capital buffer as proposed by the Basel Committee. Section 3 takes a closer look at the disadvantages of applying the HP filter method and proposes an alternative technique for calculating excessive credit - the out-of-sample method. Both these calculation methods are then used on data for ten CEE countries. Section 4 illustrates the different implications of the alternative indicators of excessive credit growth for the countercyclical capital buffer settings of the banking sectors of the countries analysed. The conclusion attempts to generalise the results of the analysis and formulate recommendations for the national authorities responsible for macroprudential policy.

[3] In this study, the group of CEE countries consists of Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

2. Excessive Credit Growth

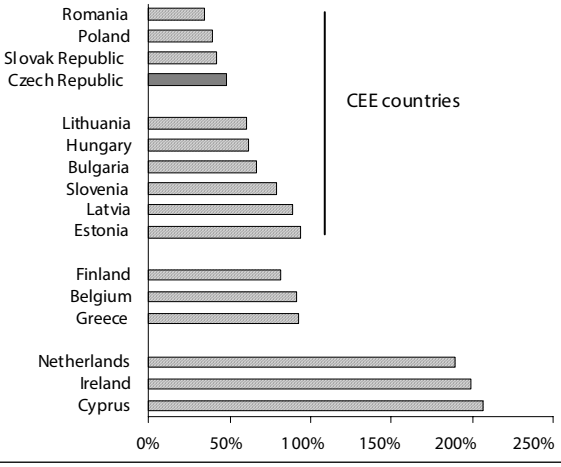
Credit growth in CEE countries has caught the attention of many studies over the past decade. These studies have tried to identify not only the determinants of credit growth, but also its equilibrium level (Enoch and Ötker-Robe, 2007; Égert et al., 2006). The credit boom in some transition economies was strong enough to raise concerns about whether this trend was simply a manifestation of convergence to the average credit levels in advanced nations, or whether it was a case of excessive growth posing a risk to macroeconomic and financial stability (Hilbers et al., 2005). The central banks and supervisory authorities of some countries even assessed the situation as critical and in 2004-2007 introduced a series of tools for limiting credit growth (Dragulin, 2008; Herzberg, 2008). These tools generally included monetary policy tools (increases in official interest rates or reserve requirements justified by policymakers with reference to "rapid credit growth"), regulatory measures (increased risk weights on selected loans, restrictions on loan-to- value and/or debt-to-income ratios, increases in provisioning rates, tighter regulation of large exposures and tougher rules on collateral valuation), soft non-binding measures (the introduction of guidelines and recommendations) and also very "hard" administrative restrictions on credit portfolio growth (as applied, for example, in Bulgaria). The extent of the measures, as measured by the number of different tools used to limit credit growth in individual countries, was correlated to a large degree with the credit growth rate (see Figure 1). While the number of policy measures might not be the best proxy for the degree of policy interventions, given the available data and information it at least serves as a relatively reliable indicator of policymakers' effort. At the same time, it is difficult to assess the effectiveness of the tools used, since most of them were applied just before the global financial crisis erupted. The decline in credit growth observed since then may thus have been due more to the sharp economic contraction and reduced demand for loans. The studies conducted up to now tend to conclude that the aforementioned tools are pretty ineffective and that credit booms can be limited in only a very limited way during good times (Kraft, 2005; Herzberg, 2008).

Figure 1: Credit Growth and Number of Tools Applied to Limit Credit Booms
(x-axis: number of measures; y-axis: average year-on-year real credit growth in 2005-2007)



Source: IMF, national authorities´ websites

Figure 2: Private Credit Ratios in Selected EU Countries
(x-axis: credit-to-GDP ratio as of 2007 Q4)



Source: IMF IFS, authors´ calculations

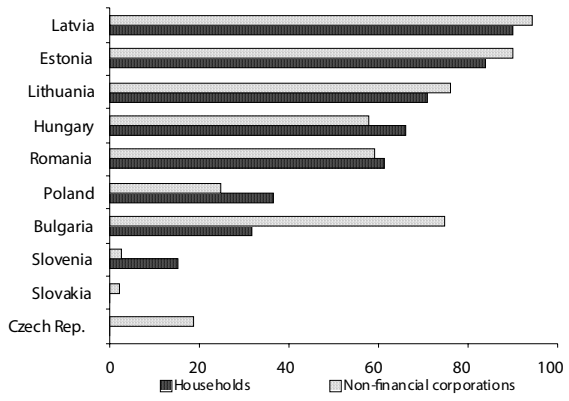
Despite the comparatively strong credit boom observed in 2003-2007, the stock of loans in many CEE countries in the pre-crisis year 2007 was still relatively low, especially in comparison with other EU countries (see Figure 2). Nevertheless, in terms of the private-credit-to-GDP ratio, some countries of the region had reached levels typical of some euro area countries. The question therefore arises whether they were already showing excessive credit levels. One limitation of this comparison is that is based solely on data on domestic bank loans. This indicator understates total private credit, as it neglects loans provided by non-bank financial intermediaries and loans provided directly from abroad.

Excessive credit growth can threaten macroeconomic stability in many ways. Given that lending supports consumption, growth in private sector loans can over-stimulate aggregate demand beyond the framework of potential output and cause the economy to overheat, with knock-on effects on inflation, the current account deficit, interest rates and the real exchange rate.

At the same time, lending institutions can, in an economic growth phase, have over-optimistic expectations about borrowers' future ability to repay their debts and therefore very often lend to high-risk borrowers. The upshot is that the bulk of "potentially" bad loans arise during upward phases of the credit cycle. In some CEE countries, private loans were provided in foreign currency because foreign interest rates were lower (see Figure 3). This further increases the risks for the banking sector, because if the domestic currency depreciates, the volume of credit expressed in the domestic currency rises, debt servicing costs go up, and foreign exchange risk turns into credit risk. In many cases, therefore, the aforementioned measures to contain credit growth were targeted primarily at reducing growth in foreign currency loans (Steiner, 2011). Furthermore, if a domestic credit boom is financed from foreign sources, as was the case in several CEE countries (except for the Czech Republic, Slovakia and Poland), the risk of the domestic banking sector having insufficient balance-sheet liquidity (roll-over risk) increases. In economic bad times, domestic banks face a high risk of outflows of short-term foreign funds that cannot be financed by the sale of liquid assets (Hilbers et al., 2005).[4] Although this study, focusing on excessive credit growth, would benefit from an analysis of different loan types, such detailed disaggregated data is not available in a sufficiently long time series for the countries under examination.

Figure 3: Shares of Foreign Currency Bank Loans

(as of end-2009; as % of total loans to given sector)

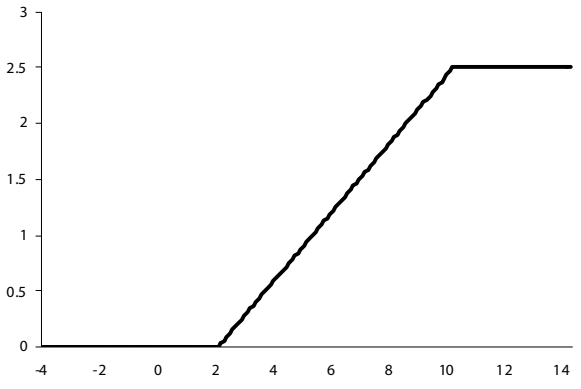


Note: Slovak Republic and Slovenia were already members of the euro area in 2009, so their foreign currency loans comprise currencies other than EUR.

Source: CNB

Figure 4: Countercyclical Capital Buffer

(% of RWA as function of credit-to-GDP gap in p.p.)



Source: ECB

A bursting of the credit bubble and negative macroeconomic developments, leading to external financing constraints and growth in non-performing loans (NPLs), can therefore cause the banking sector serious difficulties. IMF (2004) estimates that more than 75% of credit booms were followed by banking or currency crises. This fear is consistent with existing studies in the field of early warning signals, according to which excessive credit growth can be considered one of the most reliable indicators of future problems in the banking sector (Borio and Lowe, 2002; Borio and Drehmann, 2009; Jimenez and Saurina, 2006; Saurina et al., 2008).

As part of the preparation of the new Basel III regulatory framework for banks, the Basel Committee (BCBS, 2010) has proposed several tools for reducing the procyclical behaviour of the banking sector.[5]

[4] In this regard, the Czech Republic has a very favourable deposit-to-loan ratio. For a comparison with other EU countries, see CNB (2010, section 1.3.1).

[5] The issue of procyclicality of the financial system and its sources and potential consequences was discussed in a thematic paper in last year's CNB Financial Stability Report 2009/2010 (Geršl and Jakubík, 2010).

One of the key tools is a proposal for banks to create countercyclical capital buffers during credit booms.[6] Such buffers, expressed as a percentage of risk-weighted assets (RWA) and covered by high quality capital (Tier 1, or even core Tier 1), would be set by the regulator within the range of 0% to 2.5%. As a guide for the setting of the buffer, the Basel Committee is proposing to use and regularly publish the difference between the current private credit ratio as a percentage of GDP and its trend value estimated using the HP filter (the "credit- to-GDP gap"). However, regulators may also use other methods to calculate the trend and other variables, such as the prices of various relevant assets and credit conditions. In bad times, this capital buffer would be "released" in order to slow any fall in the credit supply and thereby reduce the procyclicality of the financial system.

The Basel Committee document itself (BCBS, 2010b) proposes to use the aforementioned guide as follows. The capital buffer would start to be created when the credit-to-GDP gap exceeded two percentage points. If the gap reached 10 percentage points or more, the buffer would reach the aforementioned maximum of 2.5% of RWA. For gaps of between 2 and 10 percentage points, the buffer would vary linearly between 0% and 2.5%. For example, for a gap of six percentage points the buffer would be 1.25% of RWA (see Figure 4). For cross-border exposures, the buffer set by the regulator in the foreign jurisdiction would apply. For cross-border banking groups, the capital buffer would be applied on both a solo and a consolidated basis.

It became clear during the discussion phase within the Basel Committee that a simple filtering technique would in many cases not necessarily lead to reliable estimates of excessive credit, so the final version of Basel III (BCBS, 2010b) gives regulators considerable discretion to set the buffer. The primary aim of the buffer, however, is not to restrict credit growth, but to create a capital reserve to give the banking sector greater protection from sudden changes in the credit cycle. At the same time, the Basel Committee documents emphasise the complementarity of this buffer with other macroprudential tools (BCBS, 2010b, p. 5), such as various limits on key indicators of borrowers' ability to repay loans (the loan-to-collateral and loan-to-income ratios).

3. Methods for Estimating the Equilibrium Credit Level

A major problem in constructing an excessive credit growth indicator is determining what level of credit is excessive and might pose a threat to the financial sector. One traditional method is to apply the statistical Hodrick-Prescott (HP) filter, which obtains the trend from a time series. By comparing the actual credit-to-GDP ratio with its long-term trend obtained using the HP filter we can then estimate whether or not the credit level is excessive. This method is used quite routinely in the literature (Borio and Lowe, 2002; Borio and Drehmann, 2009). Hilbers et al. (2005), for example, consider a credit-to-GDP gap of greater than five percentage points to be an indicator of excessive credit in the economy.

Although the HP filter method is used quite often to determine trends in macroeconomic variables, it does have its drawbacks. A time series trend is dependent to a significant extent on the length of the chosen time series and the calculation is very sensitive to the smoothing parameter (lambda). A big problem as regards practical application in macroprudential policy is "end-point bias", which generates a highly unreliable estimate of the trend at the end of the data period.[7] Macroprudential policy, which, by contrast, requires assessment of the trend on the basis of current (i.e. end-of-period) data, would therefore be reliant on indicators subject to a high degree of uncertainty. In the case of some CEE countries with relatively short time series, credit growth is incorporated directly into the trend itself by the HP filter, i.e. excess credit growth is counted as a trend (Cottarelli et al., 2005). Another relevant question is whether the credit ratio should take into account other denominators besides GDP, such as financial assets or total assets of the private sector. Although GDP is correlated to a significant extent with private sector income and therefore serves as an indicator of the ability to repay a given amount of

[6] With regard to the objective of reducing the procyclicality of the financial system, the Basel Committee stated explicitly in its December 2009 consultative document (BCBS, 2009) that the aim of this buffer was to "achieve the broader macroprudential goal of protecting the banking sector from periods of excess credit growth".

[7] One way of dealing with end-point bias is to extend the time series into the future by means of prediction. This, however, can introduce further uncertainty into the estimate linked with the quality of the prediction.

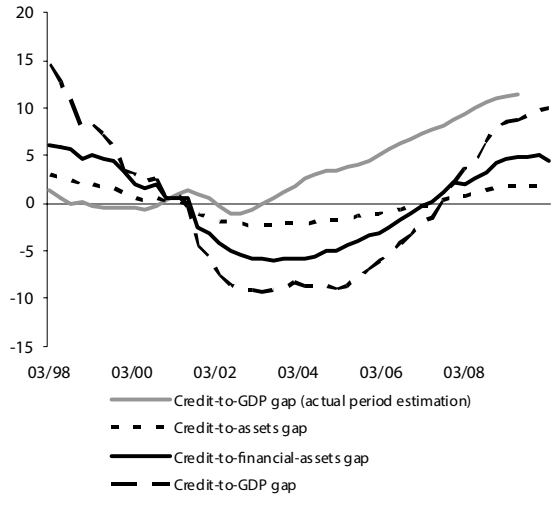
loans, holdings of financial assets (deposits and securities investments) and non-financial assets (e.g. real estate) are also relevant to the evaluation of excessive credit.

Figure 5 presents credit gaps with alternative denominators (GDP and financial assets and total assets of the private sector) calculated using the HP filter on data for bank loans in the Czech Republic with a high lambda parameter equal to 400,000. Such a high value of lambda was proposed in Basel III with the argument that the credit cycle is usually longer than the business cycle. The filter is applied to quarterly data for the period 1998-2010, which, however, is regarded as relatively short from the international perspective (Basel III recommends at least a 20- year period). The estimates indicate that the current level of bank loans is below the long-term trend. However, the trend estimate is subject to a range of problems related to the short time series and above all to extraordinary factors linked with a fall in credit volume in 1998-2002 caused by a banking crisis in the 1990s and the clean-up of bank balance sheets ahead of the privatisation of large banks.

As regards simulating possible macroprudential policy in the past, it makes more sense to apply the HP filter recursively, i.e. in each past period using only the data that were available in that period (at the end of 2005, for example, the trend value and therefore also the gap between the observed credit level and the trend is calculated on 1998-2005 data). This simulates the situation that the macroprudential policy-maker would hypothetically have found itself in had it been required to decide whether excessive credit growth was emerging. The calculated credit gaps expressed as a percentage of GDP indicate that the Czech Republic would have found itself in a situation of excessive credit as early as 2004 (see Figure 5). However, the aforementioned drawbacks of the HP filter play an even greater role in the calculated gap, as the problem period of 1998-2002 influences the trend.

Figure 5: Credit Gaps in the Czech Republic with Alternative Denominators

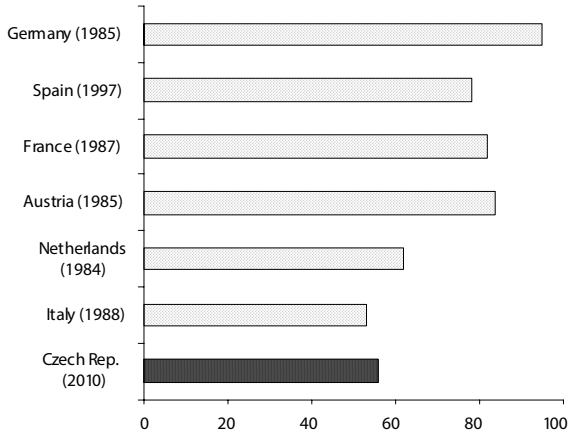
(in %)



Source: CNB, authors´ calculations

Figure 6: Credit-to-GDP Ratios for a Similar Level of Economic Development

(in %; GDP per capita, in PPP, constant 2005 international $; approximately $22,500 for the Czech Rep as of 2010)



Source: IMF IFS, WB WDI, authors´ calculations

The main criticism of the HP filter technique, however, is that it does not take into account economic fundamentals that affect the equilibrium stock of loans. An alternative method is to estimate the equilibrium private credit level in relation to key economic variables (such as the level of development of the economy measured in terms of real GDP per capita).This method says that if GDP per capita - as a proxy for the standard of living of an economy - is the main and only economic fundamental, all countries with the same level of development should have a similar equilibrium credit level. Poorer countries should have a lower equilibrium credit level than wealthier countries. A positive linkage between the credit-to-GDP ratio and the economic development of a country is referred to as financial deepening (see Terrones and Mendoza, 2004). A comparison of bank loans as a percentage of GDP for the Czech Republic in 2010

and selected euro area countries in years when they were at a similar level of economic development indicates, in contrast to the HP filter findings, that the credit ratio in the Czech Republic is below the level consistent with its economic level (see Figure 6).

Other economic fundamentals besides the above-mentioned GDP per capita should also be considered as factors influencing the equilibrium credit level in a particular country, and a suitable econometric model should therefore be employed. However, given that the CEE countries started from very low private credit levels, the estimation of such a model on data for these countries would capture the rapid growth caused by convergence towards the average level of the advanced nations. As Égert et al. (2006, p. 14) point out, such estimated elasticities of the relationships between fundamentals and credit would be overstated. At the same time, the estimates would reflect not the equilibrium level, but only the present relationship between economic fundamentals and private credit.

For this reason, the existing literature suggests using out-of-sample (OOS) panel estimation, i.e. estimating the model on a different sample of countries ("in-sample countries") and applying the elasticities obtained to the data for the countries for which the equilibrium credit level is being estimated ("out-of-sample countries"). This approach assumes a priori that the stock of credit of the in-sample countries, which serve for estimating elasticities, is at equilibrium on average, which is quite a significant assumption. Therefore, one needs to choose a suitable group of "in- sample" countries that best meets the need to estimate the correct equilibrium relationships between economic fundamentals and private credit. The existing studies on this topic therefore normally use the developed countries of the EU or OECD as appropriate countries for comparison (Kiss et al., 2006; Égert et al., 2006). For this study, the advanced EU countries were used as in- sample countries. While a possible approach would be to narrow down the number of sample countries to the ones similar in structure to the CEE countries, the econometric methodology used and the availability of data in the time dimension do not allow us to significantly reduce the number of in-sample countries. However, owing to the current debate regarding the excessive debt of the PIIGS[8] countries, these countries were omitted from the calculation of the equilibrium credit level.[9]

However, to estimate the equilibrium elasticities for the given countries, the proper set of fundamental variables influencing the credit-to-GDP ratio must be found. As the analysis of possible credit determinants is beyond the scope of this paper, we refer to previous studies for a comprehensive discussion regarding possible credit determinants; see, for example, Égert et al. (2006) and the references therein. Based on these studies, we use data on aggregate household consumption, government debt, short-term interest rates, unemployment, inflation measured by the GDP deflator and the CPI index, and GDP per capita.

The data were mostly obtained from the International Monetary Fund's IFS (International Financial Statistics) database, which provides the required macroeconomic data with a sufficient history (which is vital for estimating long-run relationships). For this reason, we used data for a 30-year period (1980-2010). The available statistics on bank loans to the private sector were used as the credit indicator. As stated earlier, these statistics slightly underestimate the total credit of the private sector, as they do not include non-bank financial intermediaries (e.g. leasing) and cross-border loans.[10] However, as the financial system in CEE countries is primarily bank-based, using bank credit only should not introduce considerable bias into our estimates.

We applied a set of panel unit root tests for the above-mentioned variables, and some of them were found to be nonstationary in levels, i.e. I(1) processes. A more detailed summary of the results is provided in the Appendix. Further, cointegration was tested for selected groups of variables using the Johansen Fisher Panel Cointegration Test. The results confirmed one cointegration relationship between the credit-to-GDP ratio, the household consumption-to-GDP ratio and GDP per capita for the set of in-sample countries. As discussed above, the presence of the GDP per capita variable in the long-run relationship is desirable as it captures the different degree of wealth of the economy, which therefore also influences the equilibrium private credit level (Terrones and Mendoza, 2004).

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[8] Portugal, Italy, Ireland, Greece and Spain.

[9] However, nations that are structurally quite different from the CEE countries, such as the United Kingdom, remain in the sample of control countries. This may skew the results of the analysis towards higher equilibrium credit values for a given set of economic fundamentals. Nevertheless, the method used (see later in the text) would control for the cyclical component of excessive debt in the sample of countries used.

[10] A detailed description of the available data is provided in the Appendix.

A variety of econometric methods can be used for OOS estimation. Nevertheless, given the properties of the variables used, traditional panel methods run into the problem of nonstationary time series, mutual regression of which can lead to spurious results. The traditional solution to the problem of nonstationarity of variables involves differentiating them. This step allows us to obtain the short-run relationship between the variables by regression, but the longer-run relationship is lost in the differentiation. The long-run relationship between nonstationary variables can be better estimated if the variables are cointegrated. This fact is used by the ECM (error correction model) method, which estimates not only the long-run relationship between the cointegrated variables, but also the potential deviation from this long-run relationship, which is gradually corrected through short-run adjustments.

Based on the characteristics of the time series used and the character of our study, focusing on the long-term equilibrium credit level, we employ the PMG (pooled mean group) estimation method, introduced for panel estimates by Pesaran et al. (1999). The PMG estimator is an error correction form of the autoregressive distributive lag (ARDL) model, where the dependent variable in its first differences is explained by the lagged independent and dependent variables in both levels and first differences. This method can be used to estimate the long-run relationship between the credit- to-GDP ratio and other variables, which is identical for all countries, whereas the short-run adjustment to this long-run relationship can differ across countries. The PMG model therefore allows heterogeneity of the estimates for individual countries in the short run. However, the long- run relationship of the cointegrated variables is common to all the countries in the sample. The equation is expressed as follows:

$$\Delta y_{i,t} = \rho_i (y_{i,t-1} - \sum_{h=1}^{v} \alpha_{i,h} x_{i,h,t}) + \sum_{j=1}^{p-1} \beta_{i,j} \Delta y_{i,t-j} + \sum_{h=1}^{v} \sum_{j=0}^{q-1} \gamma_{i,h,j} \Delta x_{i,h,t-j} + c_i + \varepsilon_{i,t} ,$$

where y is the dependent variable, x is the independent variable, max1 and max2 represent the maximum lags used, and α, β, γ and ρ are the estimated coefficients. Parameter ρ is the country specific error correction term. Coefficient α represents the long-term relationship, which is specific for each cross-section in the case of the so-called mean-group (MG) estimator or the same for every country in the case of the PMG estimator. For more details see Pesaran et al. (1999).

The long-term relationship of the given equation is taken as a cointegrated relationship, which was found for the credit-to-GDP ratio, the household consumption-to-GDP ratio and GDP per capita. We also employed a different set of other variables and their lags that might affect the short-run adjustment of the credit-to-GDP ratio to its long-run relationship. For example, the government debt-to-GDP ratio might capture any crowding out of bank lending to the private sector.[11] Also, the real interest rate, or changes therein, should, as the cost of financing, be in a negative relationship with the explained variable. However, these variables were not significant even at the 15% level.

The following equation gives the final estimates of the coefficients of the long-run relationship between the cointegrated variables and the values of the coefficients and the constant term in the short run, which are presented below as the mean of all the estimates for the countries concerned.[12]

$$\begin{aligned} \Delta\,(\text{credit/gdp})_t = & \underset{(**)}{-0.035}(\text{credit/gdp}_{t-1} - \underset{(***)}{(0.7}\text{cons/gdp}_t + \underset{(***)}{0.013}\text{gdp/pop}_t)) + && \}\text{long-run relationship} \\ & + \underset{(**)}{0.87}\Delta(\text{cons/gdp})_t - \underset{(*)}{0.07}\text{inf}_t + \underset{(***)}{0.014} && \}\text{short-run adjustment} \end{aligned}$$

*Note: *, ** and *** denote significance of the estimated coefficients at the 10, 5 and 1% levels respectively.*

[11] For this reason, we would expect a negative relationship between the government debt ratio and loans to the private sector. The fact that a less indebted government sector would be able to provide more significant support if the banking sector ran into serious problems is relevant for assessing whether the current private sector credit level is excessive with regard to financial stability.

[12] Based on the Hausman test, we cannot reject the null hypothesis of PMG being an efficient estimator, so PMG is preferred over its mean-group (MG) counterpart. The MG estimator is the simple non-weighted mean of the regression estimates for each country. The Hausman statistic $\chi^2(2)$ is equal to 0.9 (p-value = 0.637). Furthermore, only those variables which were significant at least at the 10% confidence level were kept in the estimated equation. Also, a more empirical approach was used as in Sekine (2001), so inflation is present in the short-run part of the equation but not in the long-run part. Moreover, the low value of the correlation coefficient between cons/gdp and gdp/pop indicates no possible multicollinearity problem.

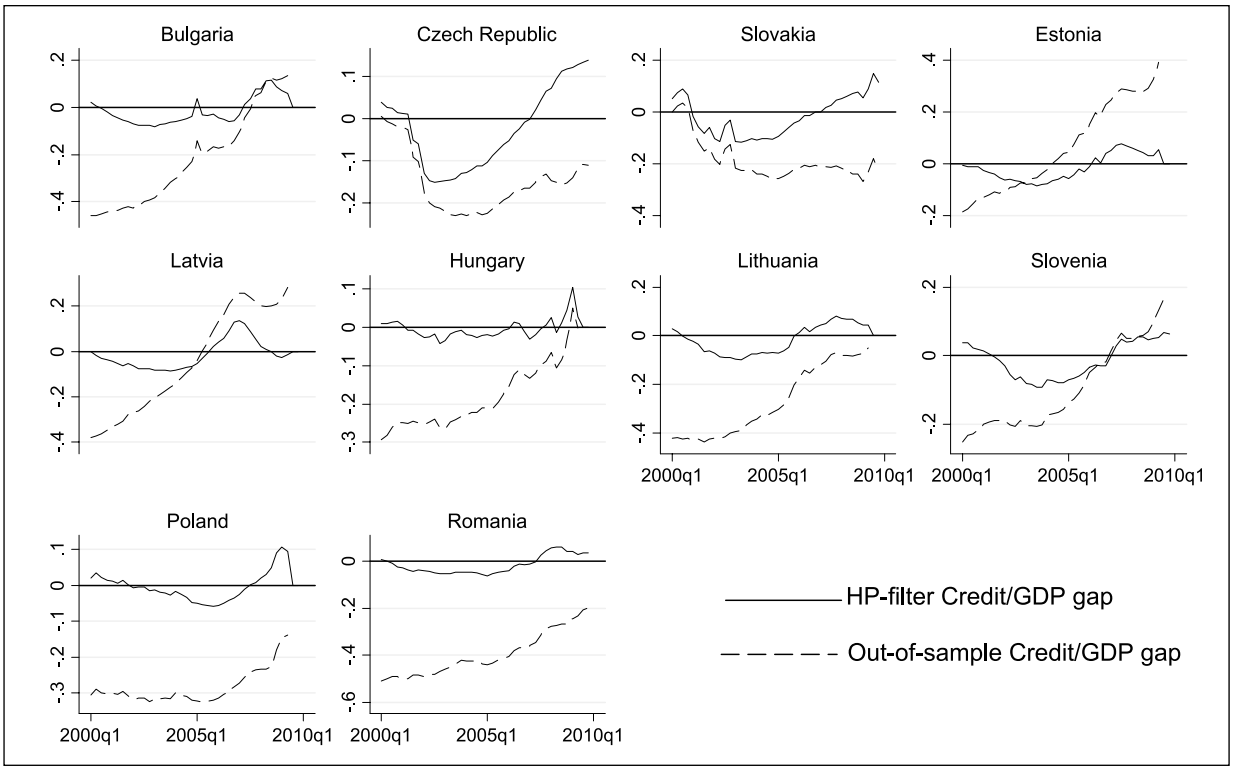
Credit/gdp represents the ratio of private sector credit to GDP, *cons/gdp* denotes the ratio of household consumption to GDP, *gdp/pop* is GDP per capita in thousands of dollars and *inf* is the change in the price level, expressed as the year-on-year change in the GDP deflator.

On the basis of the model, short-run adjustment dynamics towards the long-run trend is given as a function of the change in the consumption-to-GDP ratio and as a function of inflation. Based on the estimated coefficients, we can conclude that in the long-run relationship the credit-to-GDP ratio increases with increasing wealth of the economy and with an increasing consumption-to- GDP ratio. This factor then positively affects the explained variable in the short-run relationship as well, while inflation acts in the opposite direction. These conclusions are in accordance with intuition as regards the effects of the variables used on the credit-to-GDP ratio.

The estimated parameters of the model were applied to the data for the CEE countries to obtain values of the "equilibrium" credit ratio. As we are interested in the long-run fundamental-based level of the credit-to-GDP ratio, we used only the coefficients of the estimated long-run relationship between the cointegrated variables. This approach controls in parallel for the credit cycle of in-sample countries, as only equilibrium sensitivities between credit and economic fundamentals are extracted. The results indicate that the OOS calculations may in some cases imply significantly different conclusions regarding excessive credit compared to the HP filter values computed on the end-2009 data (see Figure 7). According to the HP filter, the credit-to- GDP gap indicates excessive credit in the recent period not only for the Czech Republic, but also, for example, for Slovakia, Lithuania, Romania and Poland, whereas the econometric estimate does not confirm this excessive credit level (values in the positive part of the chart indicates excessive private credit-to-GDP ratios). By contrast, Bulgaria, Estonia, Latvia and Slovenia now have excessive credit-to-GDP ratios according to the OOS method. It is clear, therefore, that the two calculation methods used give contradictory results in some cases.

Figure 7: Comparison of Credit-to-GDP Ratios for Various Calculation Methods

(in p.p.)



Source: IMF IFS, authors' calculations

As mentioned at the beginning of the study, further refinement of the estimates with respect to different loan types and their currency denomination would be desirable. However, current data limitations leave this additional analysis as a future research question.

4. Implications for the Size of the Capital Buffer

One of the questions associated with the new Basel III rules is whether the requirement to create a countercyclical capital buffer would contribute to the creation of capital reserves in those CEE countries which experienced significant problems in their banking sectors during the global financial crisis. In the following simulation, the size of the capital buffer is calculated for individual CEE countries using the two aforementioned methods, i.e. the HP filter method and the econometric OOS method. As the crisis did not manifest itself fully in the CEE countries until late 2008 and (in particular) 2009, i.e. after the collapse of Lehman Brothers in September 2008, we set mid-2008 as the starting point for the buffer calculation.

Table 1: Simulation of Countercyclical Buffer Calculation
(data as of 2008 Q2)

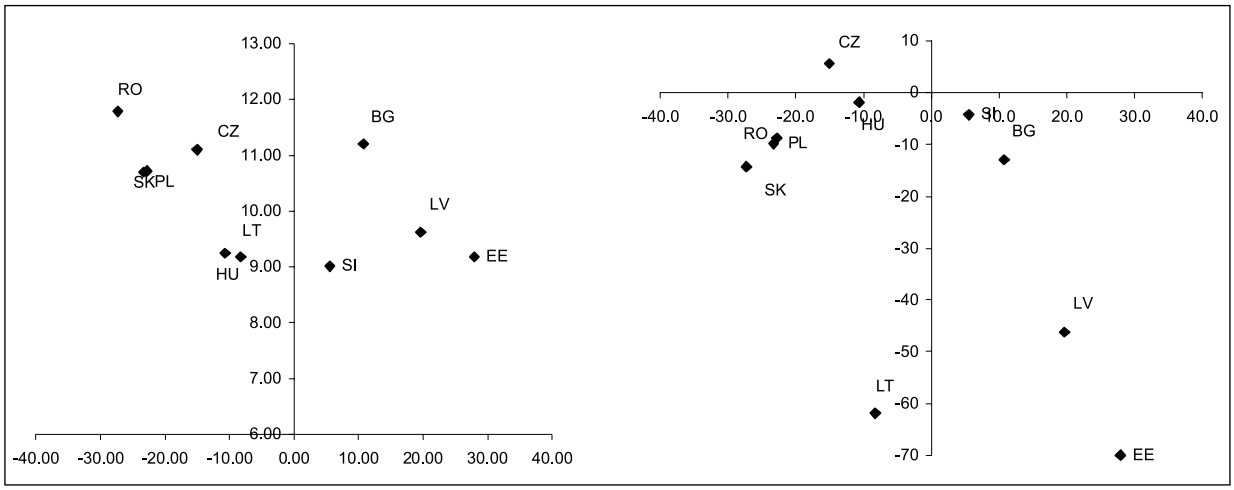
	Credit-to-GDP gap (%)		Countercyclical capital buffer (% of RWA)	
	HP filter	Out-of-sample	HP filter	Out-of-sample
Bulgaria	11.4	10.8	2.5	2.5
Czech Rep.	9.5	-15.0	2.4	0.0
Estonia	5.3	27.9	1.0	2.5
Lithuania	6.9	-8.3	1.5	0.0
Latvia	1.0	19.6	0.0	2.5
Hungary	-1.4	-10.7	0.0	0.0
Poland	3.0	-23.3	0.3	0.0
Romania	6.1	-27.3	1.3	0.0
Slovakia	6.1	-22.8	1.3	0.0
Slovenia	5.4	5.5	1.1	1.1

Source: authors´ calculations

The results of this simple simulation indicate that only four countries needed a countercyclical capital buffer according to the OOS method (Bulgaria, Estonia and Latvia needed the maximum possible 2.5% of RWA, while Slovenia needed 1.1% of RWA).

Figure 8: Credit-to-GDP gap via out-of-sample and Tier 1 ratio in 2008

(gap in p.p.; Tier 1 capital ratio in 2008)



Source: IMF, authors´ calculations

Figure 9: Credit-to-GDP gap via out-of-sample and change in RoE

(gap in p.p.; change in RoE of banking sector in p.p.)

Source: IMF, authors´ calculations

It is relevant to ask whether the banking sectors of these countries had a sufficient capital reserve already in 2008 and were building a "would-be" capital buffer composed of high-quality loss- bearing capital (such as common shares and retained earnings, i.e. in essence a major part of Tier 1 capital) in

anticipation of possible problems in the banking sector due to the credit boom. Figure 8 indicates that the countries identified by the OOS method as having excessive credit ratios (i.e. Estonia, Latvia and Slovenia) had relatively low Tier 1 capitalisation. The only exception was Bulgaria, which had set its minimum regulatory limit for total capital adequacy at a higher level (12%) than the traditional 8%, a fact which is also reflected in a higher observed Tier 1 ratio.

Several indicators can be used to compare the impacts of the crisis on the banking sectors of individual countries. In this paper, we look at the change in banking sector profits between 2008 and 2009 (in p.p. of return on equity, RoE), as profitability reflects both credit and market losses as well as the impact of possible higher funding costs on pre-provision income. A simple graphical analysis reveals that two countries identified by the OOS method as having excessive credit ratios (Estonia and Latvia) recorded large losses in their banking sectors in 2009, causing the RoE to decline dramatically (see Figure 9). Two of the countries identified, namely Latvia and Slovenia, saw their governments stepping in and providing public support in 2009. It is worth mentioning that the HP method would not have identified the problems building up in the Latvian and Estonian economies, which were hit hard by the crisis and, especially in the case of Latvia, suffered very high real costs.

5. Conclusions and Policy Lessons

This paper discusses methods for calculating excessive private sector credit in the Central and Eastern European countries and their suitability as regards the input needed to calculate the countercyclical capital buffer introduced by the Basel Committee on Banking Supervision (BCBS, 2010). The BCBS has recommended the use of an excessive credit indicator based on the Hodrick-Prescott (HP) filter technique as a guide for setting this buffer.

The paper shows that the HP filter-based calculation of the excessive credit indicator is not necessarily appropriate in certain cases. For the CEE countries in particular, rapid credit expansion may simply mean convergence to values typical of the advanced nations, and not excessive borrowing. As an alternative, the paper suggests considering excessive credit calculation methods that better reflect the evolution of a country's economic fundamentals. One such method is an out-of-sample technique based on estimates for advanced EU countries which are subsequently used to calculate the equilibrium credit levels of the CEE countries.

Although statistical filtering techniques such as the HP filter do have a role to play in the analysis as a first step in the interpretation of the available data, a broader set of indicators and methods should be employed to determine a country's position in the credit cycle. Our chosen method, based on economic fundamentals, would have better identified the problem of excessive credit in those CEE countries whose banking sectors recorded serious problems during the crisis. Although this calculation technique also has its limitations and could be further developed, it can at least be considered by the macroprudential authority responsible for setting capital buffers as a complementary indicator of excessive credit, especially for small converging economies.

There is a clear policy lesson arising from our analysis for macroprudential policy, in which countercyclical buffers will serve as one of the main instruments: national authorities cannot rely on a single indicator only and have to apply judgement, ideally supported by a variety of analyses that help them to identify the position of the economy in the credit cycle with respect to economic fundamentals. Given the current preparatory phase for the implementation of Basel III, including the countercyclical capital buffer, it is crucial to start building a robust, credible and transparent buffer regime that policymakers will apply through the credit cycle once Basel III is fully implemented.

This issue is especially important within the EU, as Basel III will be implemented in the EU countries as part of the Capital Requirements Directive ("CRD IV") and the Capital Requirements Regulation, which will be binding on all EU countries and will be centred on the idea of a "single rulebook" (or "maximum harmonisation"). The European Commission published rather advanced drafts of both documents in July 2011 and wants to finalise them by the end of 2011 or in early 2012. Throughout the proposal, the call for a single rulebook is clearly visible and national discretions are limited across a number of regulatory

issues. In the area of capital buffers, while the July 2011 proposal gives national policymakers discretion in setting the buffer rate, it limits the discretion regarding the methods and variables used to calculate the buffer, as it requires the set of variables to be agreed on within the European Systemic Risk Board.[13] Nevertheless, the idea of "maximum harmonisation" is still under review in relevant European fora given that it could effectively prevent national policymakers from strengthening the prudential requirements and thus hamper their ability to conduct national macroprudential policy effectively.

[13] The proposal allows for a part of the buffer to be set independently of ESRB guidance, but this part could be reviewed only annually (as opposed to the quarterly review of the countercyclical buffer), the variables used could be of a structural nature and no international reciprocity would apply. Clearly, such a "structural" buffer at hand for national policymakers would not be a too effective instrument for macroprudential policy.

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Appendix

A. Detailed Description of the Data Time Series Used

Table A1

Time Series' Codes	Description
IMF IFS: AF.ZF...	National Currency per US Dollar average period
IMF IFS: 22D..Z	Claims on private sector
IMF IFS: 32D..ZF...	
IMF IFS: 32AN.ZW...	Claims on general government (net)
IMF IFS: 222A..ZF...	Claims on general government (net)
IMF IFS: 60P..ZF...	Interest rate
IMF IFS: 64...ZF...	Index CPI
IMF IFS: 67R..ZF...	Unemployment rate
IMF IFS: 99Z..ZF...	Population
IMF IFS: 96F..ZW...	Household consumption expenditures (incl. NPISH) *
IMF IFS: 99BIPZF...	Deflator HDP (base year = 2005)
IMF IFS: 99B..ZF...	Gross Domestic Product in the National Currency
WB WDI: NY.GDP.PCAP.PP.KD	GDP per capita, PPP (constant 2005 international $) **

*Note: *NPISH = Non-Profit Institutions Serving Households*
*** Linearly interpolated from yearly to quarterly frequency*
Source: IMF IFS Database, WB WDI Database

Time series of interest rates for some countries were completed using the ECB and Eurostat databases and data provided by national central banks.

B. Panel Unit Root Tests

The standard set of panel unit root tests was applied, i.e. Levin, Lin and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003) and Fisher-type tests using ADF and PP tests - see Maddala and Wu (1999) and Choi (2001). Since the set of tests generates extensive output, the results are presented parsimoniously as a summary table for particular variables. However, detailed results are available upon request.

Table A2

Variable	Result	Note
consumption / gdp	I(1)	Not confirmed by LLCH
credit / gdp	I(1)	
gdp per capita	I(1)	
gdp per capita in PPP	I(1)	
government debt / gdp	I(0)	
inflation (cpi)	I(0)	
inflation (deflator)	I(0)	Not confirmed by LLCH
lending rate	I(0)	
real lending rate	I(0)	Not confirmed by LLCH
unemployment rate	I(0)	

Note: LLCH = Levin, Lin and Chu test for common unit roots across countries.
Source: authors´ computation

UDK 339.72.053.1(4-11)"2000/2011"

FOREIGN CURRENCY LENDING: THE "FLOW" AND THE "STOCK" PROBLEM

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26 April 2013

1. Introduction

When analysing the lessons to be learned from the crisis, some questions come up again and again: *'Why was the overrun of sub-prime lending not prevented?" Why were global imbalances not prevented?';* or the one most frequently heard here and now: *'Why was foreign currency lending not stopped?'* In general, why was the 'flow' allowed to go on increasing to eventually grow into an unmanageable 'stock' hovering like a permanent sword of Damocles.[3]

In any era, social or political system, the most obvious answer is to find a scapegoat (conspiracy theory): the irresponsible, debt-financed spending was due to somebody's or some group's irresponsible, potentially pre-planned, in some versions coordinated actions. In this event the only reliable cure is to find and punish the 'culprits'. 'Irresponsible lending' is obviously the fault of the world of finance, the irresponsible banks. This approach gives rise to frequently heard grossly prejudicial statements that convey negative connotations about the banking world through their very wording: governments *'failed to protect the people from bankers and banks'*, banks *'ruined borrowers'*, *'hundreds of thousands of people are caught in the debt trap'*. In a paper that we wrote more than a decade ago, which is still valid in this respect, we stated that *the objectivity of discussion is often undermined by personal grievances, excessive pathos and the belief in the moral indisputability of criticism. In recent years this attitude has claimed its place in picture magazines and the Sunday supplements of newspapers; from this point, it is only one step to the 'common man' blaming the 'rule of the financial world', bankers and the stock exchange for his sorry plight'* (Csontos, Király and László, 1997).

Demagogue charlatans and sciolists have ostentatiously reinforced these half-truths (hinting that people have been 'cheated', banks have obtained 'illegitimate income'), and the 'solution' is found quickly: the financial world and banks need to be punished, which will put all wrong right (the origin and spread of such views is summarised by Várhegyi, 2011).

However, in the cross-fire of attacks both the banking world and economic policymakers are trying hard to forget their own mistakes. We rightfully expect the doctor to give us a clear explanation of the risks we are assuming before we go under the scalpel. This is no different in the case of banking products. A responsible adult is not the same as a 'homo universalis'. It is also a legitimate expectation that regulatory authorities recognise harmful trends in the economy and take action to ward them off.

Researchers, economic analysts and economic politicians cannot limit themselves to presenting randomly selected phenomena and correlations out of context. They are aware that the existence, development and stability of financial intermediaries are important pillars of economic growth and balance. It is an essential element of the economic approach that alternating saving and borrowing, i.e., reallocating income facilitates the smoothing of consumption over the life cycle. Credit is the organic part of 'normal' economic operations; without credits and savings economic growth slows down. The credit

[1] MNB, the Central Bank of Hungary.

[2] MNB, the Central Bank of Hungary.

[3] Parliamentary inquiry commissions have also been set up to answer those questions; examples included the Angelides commission in the U.S. (2011) and the Papcsák commission in Hungary (2011). The Angelides Commission looked into the antecedents of the U.S. financial crisis while the Hungarian Papcsák Commission investigated the evolution of foreign currency lending in Hungary. The differences in the approaches of the two commissions are explained by the different cultural traditions of the two countries.

market resolves the inefficiency of the temporal 'barter economy' just as the thing called money solved the efficiency problems of the barter economy. The institutionalised form of the swapping of savings and borrowings is the system of financial intermediaries: 'banks'[4] and money and capital markets. Sifting through the claims giving rise to 'visceral vengeance', giving a functional explanation for the development of the financial system, analysing the operational distortions in the course of that development may help us not only to better understand the object of our fears but also to find better answers to the question posed at the beginning of the introduction. The recognition and explanation of potential mistakes facilitates their avoidance at later times and curbs the proliferation of conspiracy theories.

This paper focuses on a single element of the complex of problems outlined above: foreign currency lending in Hungary, giving more emphasis to the separation of the problems of 'flow' and 'stock' than is customary in literature and analysing their different characteristics. In the first half of the paper we heavily rely on the literature of 'financial dollarisation' when we examine the rational considerations underlying the decisions of the various entities, investigate the background to seemingly rational decisions, show how the apparently rational decisions of numerous entities led to an unstable, systemically unsustainable balance. In the second half of the paper we examine the 'stock problem' much less analysed in literature (in respect of foreign currency lending, we might say it has NOT been analysed at all), that is, we examine potential solutions, their motivations and pitfalls. The paper concludes that there is no 'royal way,' no single 'ultimate weapon', only cooperative solutions exist where the unavoidable losses are shared, or alternative roads that offer acceptable solutions to individual groups but fail to present a 'single and ultimate way out'.

Our analysis is in no way to be considered as an academic treatise; instead, it is a loose collection of hypotheses and views derived from the 'daily economic policy practice' of the recent past. The strictly scientific assessment is still to come.

2. Building up of imbalances (the 'flow' problem) 2001-2008

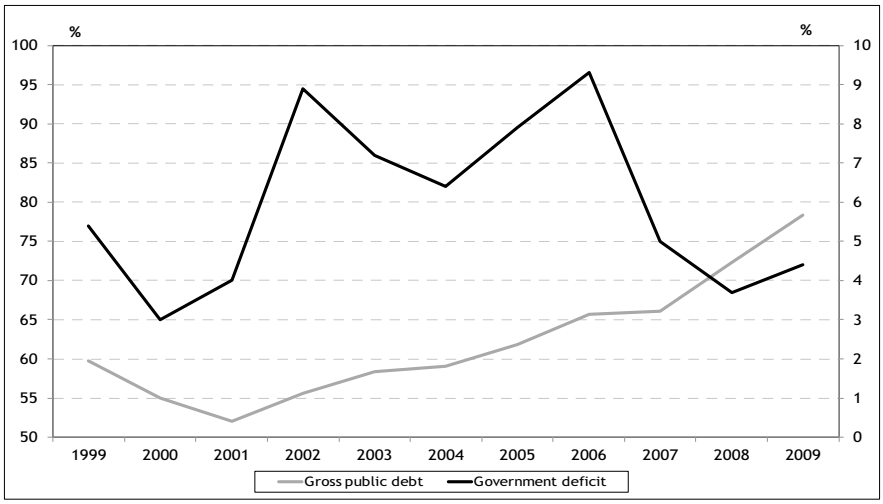
'Foreign currency lending' is not a phenomenon unique to Hungary: its appearance and fast growth cannot be explained exclusively by country-specific factors. So-called 'financial dollarisation' is a well-known phenomenon in developing countries (the paper of Calvo from 1999 is generally considered to be the first classic), and as its well-known consequence, after devaluation the probability of bank crises increases, economic growth is slower and more volatile, and financial intermediation is shallower in the affected countries (see for instance Nocoló, Honohan and Ize, 2005, Levy Yeyati, 2005). Subsequently, numerous analysts looked at South American and East Asian countries as well as the issue of the so-called 'financial euroisation' in Eastern Europe (e.g., Ize and Levy Yeyati, 2003, Ize 2005, Backe-Zumer 2005, Basso et al 2007, Luca-Petrova 2008, Rosenberg-Tirpák 2008, Neanidis-Savva 2009, Zettelmeyer et al 2010, EBCI 2010, Banai et al 2010a, Bethlendi 2011). While the first studies focused on the 'dollarisation' on the deposit side, subsequent analyses, including practically all studies of Eastern Europe, considered both deposit- and lending-side euroisation; they even identified the peculiarity of Eastern European euroisation that in a number of countries the euroisation of deposits and loans moved in opposite directions (Basso et al 2007 p 37).

2.1. Macroeconomic environment in the years of FX lending

In Hungary as a result of the 'fiscal alcoholism' (Kopits 2006), the fiscal deficit between 2001 and 2008 was considerably higher than the 3 percent Maastricht criterion.. As a consequence of the persistently high general government deficit the public debt as a percentage of GDP rose from 52 percent in 2001 to close to 73 per cent by end-2009. The negative fiscal developments were substantially aggravated by the introduction of the 13th month pension, the 50 per cent salary increase for public servants and the generous housing loan subsidy system (Chart 1). Government expenditures did not stimulate the economy at the extent envisaged; indeed, the growth rate was the lowest in international comparison and the public debt to GDP ratio increased.

[4] We say banks for the sake of simplicity; in effect, this category also includes several kinds of financial institutions (financial enterprises, co-operative credit institutions, etc.)

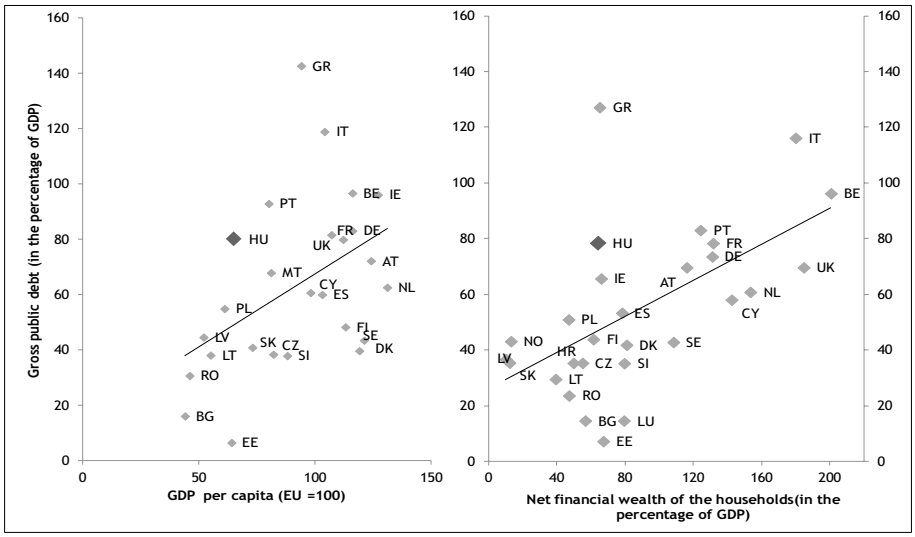
Chart 1 Public debt and budget deficit in Hungary (1999-2009)



Source: MNB database, own calculations.

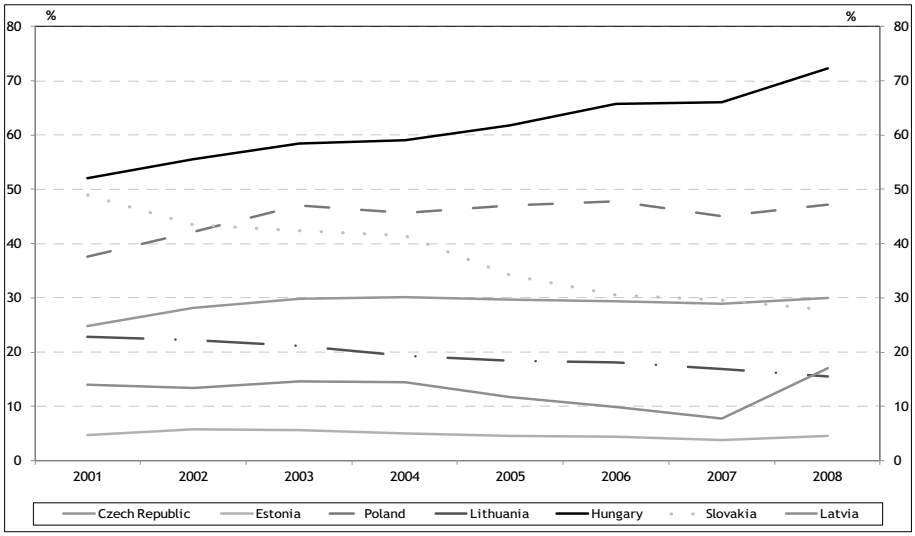
In the 2001-2008 period the public debt to GDP ratio typically fell or stagnated in other Visegrád countries and in the Baltic states while Hungary produced intensive growth. (Charts 2 and 3).

Chart 2 Public debt as a percentage of per capita GDP and the financial savings of households



Source: MNB database, own calculations.

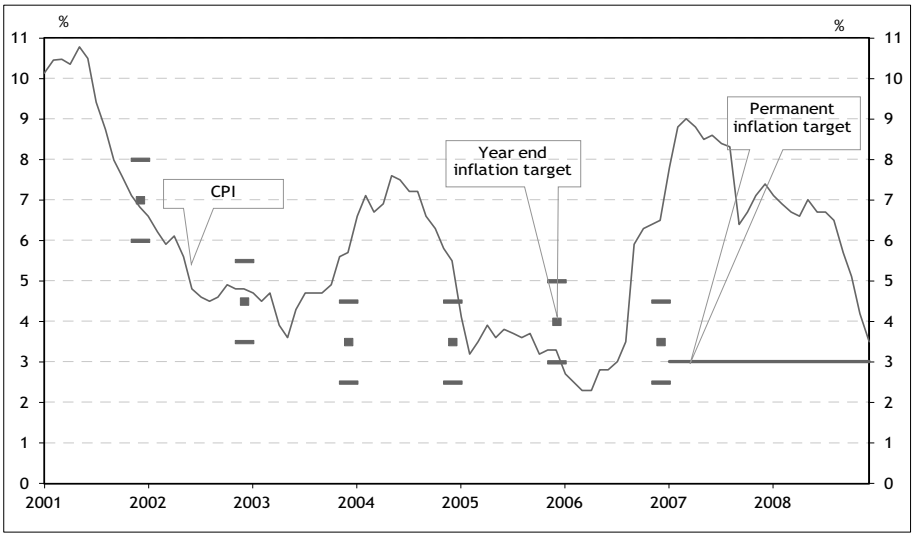
Chart 3 Growth of the public debt/GDP ratio in the countries of the region



Source: IMF WEO.

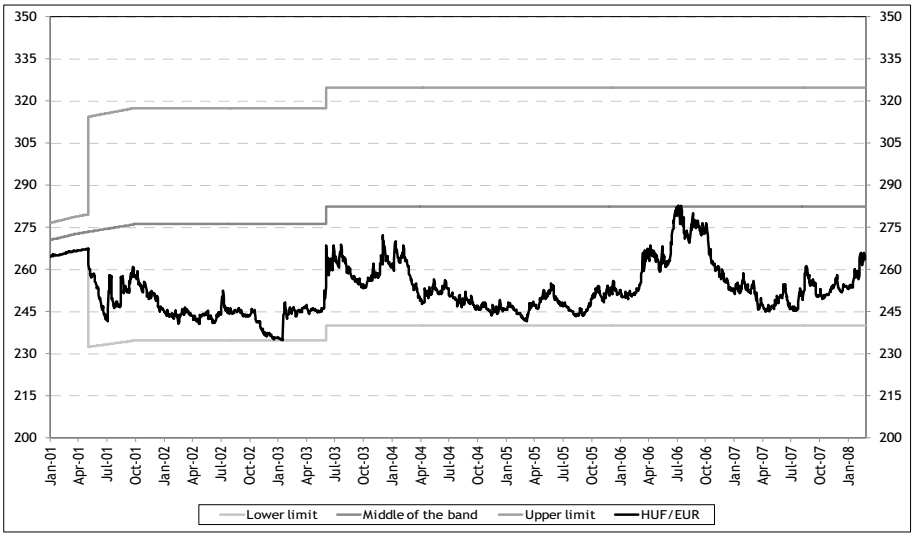
In 2001, when the forint became fully convertible, Hungary also became part of the global money market. In the same year the previous crawling peg was replaced by the floating exchange rate regime with a broad floatation band, and inflation targeting was introduced. The uncertainties of the initial years (it was not sufficiently transparent that the National Bank has no explicit exchange rate target) and the existence of the band in combination reflected the 'fear of floating' (Calvo-Reinhardt 2002), which undermined public confidence in the commitment of the central bank to the inflation target. In a large part of the period the exchange rate stuck to the strong edge of the band with negligible fluctuations, while inflation was unable to reach the target level set by the central bank even with substantial fluctuations (Charts 4 and 5). The high budget deficit and the growing public debt resulted in permanent demand-side inflation pressure; therefore, the central bank could prevent the continuous devaluation of the forint only by keeping the base rate high. Consequently, a substantial interest differential emerged compared to many European countries.

Chart 4 Inflation - actual and target



Source: MNB, http://www.mnb.hu/Monetaris_politika/monetaris-politika/mnbhu_infcelkituzes_hu.

Chart 5 The forint in the exchange rate band



Source: MNB, http://www.mnb.hu/Root/Dokumentumtar/MNB/Statisztika/mnbhu_statisztikai_idosorok/hu0303_sav.xls.

Different money market segments started to grow and became increasingly liquid: in addition to the government bond market, HUF interbank market and spot FX market, which had been significant already in the nineties, the markets of FX and interest rate derivative instruments produced an explosive growth in the 2000s (primarily the FX swap market, interest rate forward market and cross currency

market). (Páles et al. 2010, Csávás et al. 2007) In the 90s foreign-owned banks became dominant in Hungary mostly due to the absence of domestic capital accumulation, bringing with them considerable technology (i.e., knowledge) transfer. Financial intermediation deepened and became cheaper (Király et al. 2000).

We keep this macroeconomic environment in focus while examining the potential motivations and behaviour of the various parties. A rational core can be identified in the decisions of every actor on the Hungarian foreign currency lending scene. The borrowing or disbursement of foreign currency loans in itself was not an irrational decisions; it did not result from the 'low level of financial culture of the public' or the 'irresponsible behaviour of banks'. There is also a rational explanation for the failure to cut back on foreign currency lending: this failure is not necessary incompatible with the wish to 'increase the public good'. We will show, however, how the individual rational decisions and the acceptable risks on the level of individuals in combination lead to a catastrophic ending. Our analysis is not empirical; instead, it is more of a thought experiment that tries to apply the 'common knowledge' of past economic analyses to the Hungarian case.

2.2. Households motives: rationality and irrationality

Public discourse (and political discourse) often describes the decisions of households as stemming from ignorance and deception. In studies of 'dollarisation' this motive regularly crops up as one of the causes of incurring debt in a foreign currency: households that are not aware of the law of uncovered interest rate parity (and why should they be?) get into debt 'unknowingly' (Zettelmeyer et al 2010, Pelényi and Bilek (2009)) showed that Hungarian households that incurred debt in foreign currencies were completely heterogeneous in terms of education, wealth and risk-aversion, unlike Austrian households, where borrowing in Swiss franc was more typical in wealthy households. This empirical fact might as well lead us to conclude that a significant part of the borrowers shared the common characteristic of 'ignorance', that is, the whole story stemmed from an irrational decision. Below we will show that the decision to borrow in foreign currencies could be justified by rational considerations and the main reason was not 'ignorance' at all.

One motive of the borrowing of households in foreign currency, empirically confirmed a long time ago (Ize 2007), is the so-called 'portfolio approach': if the variance of inflation is greater than the volatility of the real exchange rate of the foreign currency, then the choice of the foreign currency is rational even in the presence of uncovered interest rate parity because borrowers may conclude from the volatile inflation a similar volatility of the interest rates controlled by monetary policy.[5] Basso et al (2007) showed that the substantial interest rate differential typical in Eastern European countries can be analysed in this framework; as a result of this, households prefer borrowing in foreign currency while the same consideration works against depositing in foreign currency – this is why we find a negative correlation between foreign currency deposits and loans in Hungary as well. The surge of foreign currency loans in Eastern Europe including Hungary occurred in an extremely low global interest rate environment; most analysts hold that the significant interest rate differential between the domestic and foreign interest rates was a major factor in the keen demand for foreign currency loans.

Inflation in Hungary was persistently very high and volatile in the period under review; moreover, it was generally above the target. In the absence of anchored expectations[6] monetary policy strived to curb inflation primarily through relatively high interest rates, by keeping the exchange rate at the strong edge of the band. Thus interest rates in Hungary were 6-8 percentage points higher than in Switzerland but they also exceeded euro interest rates by 4-6 percentage points (Chart 6). Moreover, this differential was almost fully reflected in the cost of funds of foreign-owned banks as the spread of funds from the parent banks tended to be negligible before the crisis (Páles and Homolya, 2011). Consequently, the market rate of HUF loans was drastically higher than that of FX loans while access to preferential-rate HUF loans became increasingly limited.

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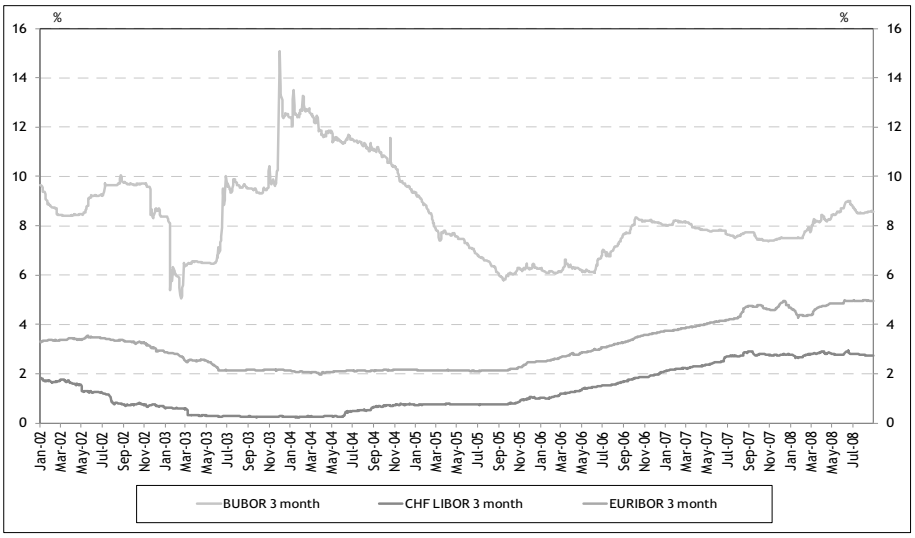
[5] This type of reasoning used to be present in the arguments of numerous financial analysts in favour of foreign currency lending

[6] Since the hyperinflation of the mid-90s Hungarian economic agents have always expected high inflation and perceive inflation to be considerably higher than it really is.

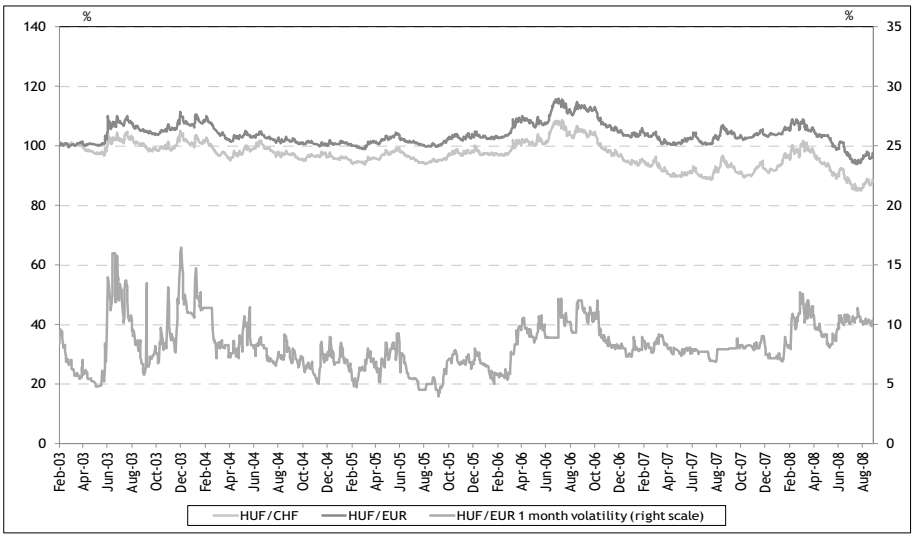
Chart 6 Interest rates in Hungary, in the euro area and in Switzerland



Source: Datastream.

Meanwhile, because of the exchange rate band maintained for a long period and the 'fear of floating' - mentioned in the macroeconomic summary - the exchange rate of the forint vis-à-vis the euro was relatively stable; it even strengthened between 2003 and the onset of the crisis. The forint was similarly stable vis-à-vis the Swiss franc as the EUR/CHF cross rate did not move substantively in the period examined. The 1-month volatility of the euro exchange rate was between 5 and 15 per cent (Chart 7). This is not particularly high considering that due to the interest rate differential, the instalments of a 20-year euro loan may be as much as 40 per cent lower than they would be for a HUF loan of the same size.

Chart 7 HUF exchange rate vis-à-vis the CHF and the EUR and the volatility of the latter



Source: Bloomberg.
Note: The exchange rate on 1 February 2003 was considered to be 100.

The idea that getting indebted in foreign currency was 'risk free' was also suggested by the apparent proximity of the accession to the euro area: even though the date of entry kept moving forward, an accession date in 2013 appeared realistic even directly before the crisis (e.g., the analysts of Goldman Sachs forecast such date in the summer of 2008[7]). Though Hungarian households increased their debt in CHF rather than in EUR, as we indicated, the two currencies typically moved in tandem during the period. Converging economies are characterised by the real appreciation of the exchange rate, which

7 http://www.origo.hu/archivum/20080708-magyar-euro-londoni-elemzok-nem-kizart-a-2013as-bevezetes.html

term in a low-inflation environment means a nominal appreciation in the medium. Thus, households could have perceived a stable, slightly appreciating exchange rate to be self-evident (a similar conclusion was reached by Csajbók et al. 2010).

To refute the claim to irrational 'ignorance', we can enumerate several arguments that supported borrowing in foreign currencies: the high and volatile inflation and interest rate environment in Hungary, the significant interest rate differential, the low volatility of exchange rates, the proximity of the introduction of the euro. In such an environment borrowing in foreign currency appears to be a good solution even in the longer run.

Calculations show that until the summer of 2010, taking out a CHF and HUF loan for the same amount clearly resulted in lower instalments for the CHF loan, and CHF instalments departed significantly from HUF loan payments only in the summer of 2011 (Papcsák report 2011, p. 16). It can be shown that even at a HUF/CHF exchange rate of 220 it is true that taking into consideration both exchange rate changes and interest payment, the burden of servicing the foreign currency loan was lower than the burden of a HUF loan of the same magnitude.

Based on this reasoning we can conclude that borrowing in foreign currency was a decision supported by rational motives. This rationality, however, was based on an erroneous perception: the observation of the absence of exchange rate volatility, which suggested that it would stay that way forever. It was because of that perception that borrowers opted for loans with the near-maximum instalments affordable along their expected income path and they failed to reckon with the inevitable increase in the volatility of exchange rates in the long term. Taking into account the volatility of Hungarian inflation and exchange rates, the same households could have afforded only a smaller loan in HUF: the absence of fiscal discipline created an economic environment that would have allowed for significantly less HUF borrowing by households. In reality, the opposite happened: by choosing loans based on the instalments *assumed* to be affordable, households got into *significantly higher* debt than they could have afforded in HUF terms. In other words, the excessive borrowing of households was attributable to clients borrowing more than they could effectively afford. This also means that some households could be present on the credit market only because of the erroneous assumptions (persistent high interest rate differential, persistent stable exchange rate).

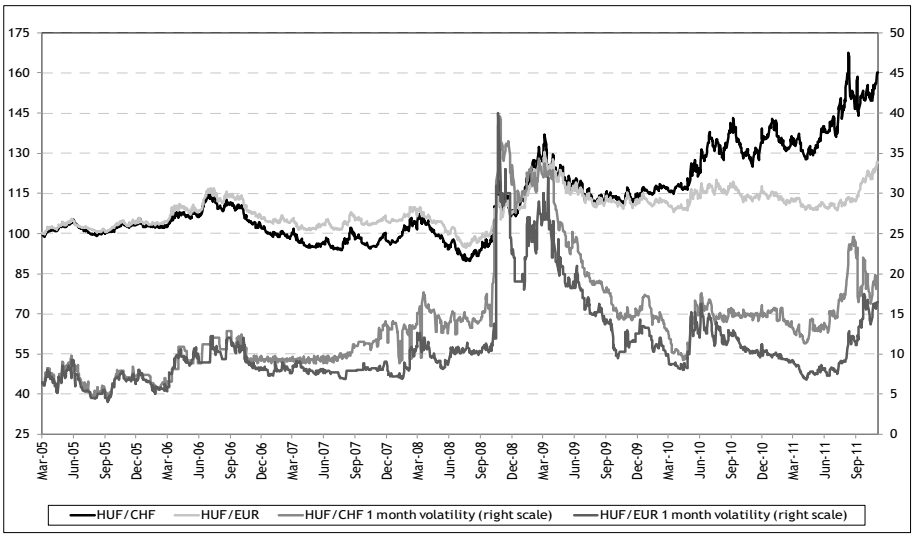
The persistently high HUF interest rate and persistently strong HUF exchange rate, which gave households a false sense of stability, masked the fundamental instability of the economy which arose from 'fiscal alcoholism', that is, the high debt levels of the government compared to the region or to the whole of the European Union. Hungarian households had insufficient savings and excessive borrowing against the backdrop of the over-spending by the government. The decisions of households did not reckon with the variable of government overspending (if you like, the classic, frictionless, non-learning hypothesis of rational expectations did not apply).

2.3. Banks motives: profit-seeking and risk-based competition

Households represented the demand for FX loans.. The supply came from banks (financial intermediaries). Let us now look at the rationality of their decisions.

In the 2001-2008 period competition in the banking sector was intensifying: as the corporate market saturated, competition on the retail market increasingly came to the fore (Banai et al 2010b, Banai et al 2011). In the period of exuberance before the crisis banks, particularly foreign-owned ones, had access to extremely cheap foreign currency funding and FX swaps even for longer terms. Making use of the low cost of funds they offered FX loans at interest rates below forint rates. The CHF and EUR exchange rates did not radically depart from each other and their volatilities were not substantially different - in light of the approaching introduction of the euro it seemed to be a rational decision to borrow in foreign currency and lend in foreign currency; the euro and Swiss franc appeared to be perfect substitutes (Charts 7 and 8).

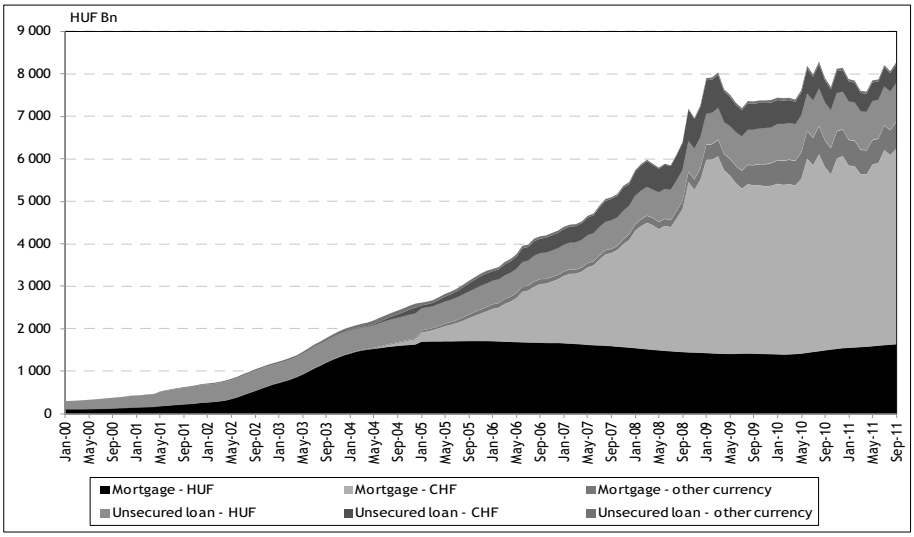
Chart 8 HUF exchange rate vis-à-vis the CHF and the EUR, and their volatility (2005-2011)



Source: Bloomberg.
Note: Data about the volatility of CHF exchange rate is available only from March 2005 on. Still, the volatility in the period of the CHF lending boom is clearly visible. For exchange rates, 1 March 2005 = 100.

From a microprudential aspect the banking system worked quite rationally. Its own FX position remained closed, the on-balance-sheet mismatch resulting from FX lending was closed using foreign funding or FX swap transactions. For future losses from the credit risk of clients - without any natural hedging against exchange rate movement - the high margin that could be applied due to the low cost of funds seemed sufficient at the time (taking into consideration the foreign exchange volatility of the time). The initial absence of competition and the interest rates being substantially lower than the former rates of forint loans allowed banks to achieve higher profitability when entering the household market segment. Initially some banks offered exchange rate insurance but the more expensive loan was soon pushed to the sideline by its cheaper uninsured counterpart. Expected losses were considerably reduced by the fact that a large portion of foreign currency loans were mortgage-backed (Chart 9), and given the market conditions of the time, no more than 5-10 percent of loss was envisaged on real estate collateral. Particularly in the initial period of 2004-2006, LTV ratios were decidedly low in international comparison.

Chart 9 Household loan portfolio of the banking system

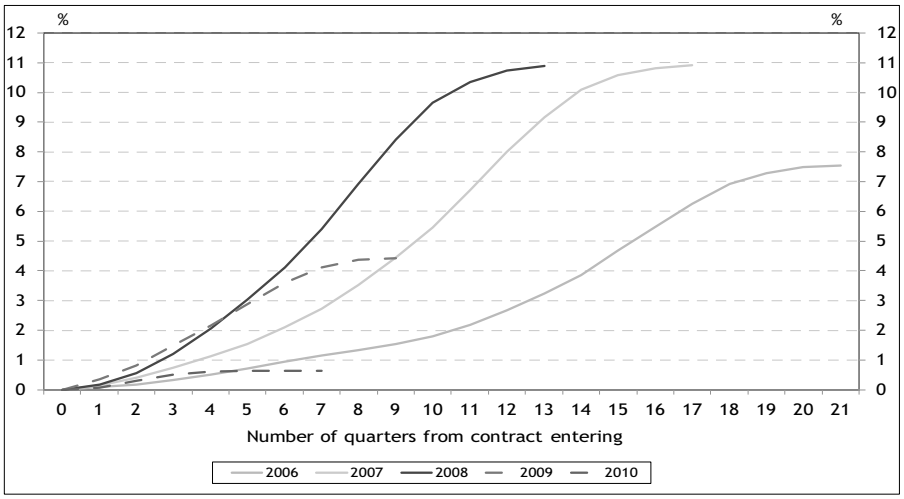


Source: MNB database, own calculations.

Abundant liquidity and the seemingly high margins available to cover losses spurred banks to take on excessive risks: the risk-based competition characteristic of the 2003-2008 period (Banai et al 2010b,

2011) resulted in a major overrun of the LTV ratio and the acceptance of non-creditworthy borrowers (purely collateral based lending). Hungary also produced its sub-prime lending witnessed in the U.S, Irish, Spanish etc. mortgage markets. (Király-Mérő 2008, Király-Nagy 2008, Banai et al. 2010b) The upswing of risk based competition is shown by the performance of loans granted in different periods. It is clear (Chart 10) that the default rate of FX mortgage loans granted in 2007-2008 is substantially higher than that of earlier loans. In this respect the lending practices of banks can be called 'irresponsible' as it did not comply with the principles of responsible lending (formulated only after the onset of the crisis) even though it was fully in line with the rules effective at the time.

Chart 10 Ratio of non-performing household foreign exchange mortgage loans drawn in different periods



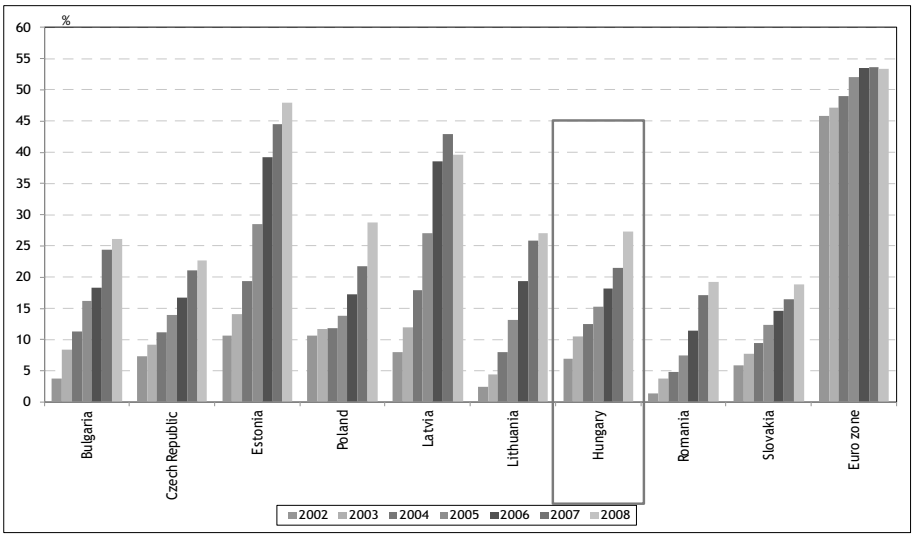
Source: Central Credit Registry, MNB estimate.

2.4. Micro-rationality vs. macro-risks

As we have seen, each decision had a rational element. Each decision contained some natural human 'greed'. Borrowers did not take out foreign currency loans for the amount they originally proposed to borrow in forints; instead, they chose a higher loan amount to go with the highest affordable instalment. The suggested amount facilitated a somewhat larger home, somewhat better furniture and a plasma TV to boot. Under the pressure of risk-based competition, banks offered their products at ever higher LTV ratios, for ever longer terms, increasing based on collateral rather than income. This was reinforced when in 2006 the consolidation of the general government started. The promise of long-term wealth after the short-term adjustment amplified foreign currency lending (smoothing of consumption) and its irrational features.

Is it possible to pin down the moment when this process started to generate an imbalance? In the years preceding FX lending subsidised household loans also contributed to the dynamic growth of the general government debt and it is uncertain whether they converged to a state of equilibrium on the systemic level. Subsidised loans facilitated the evolution of the supply side of the Hungarian rented dwelling market – however, curiously, this was not followed by the liberalization of the regulation of the market of rented homes, which could have improved market efficiency. The FX lending started in 2003 was considered by many to prudent for a long time: relative indebtedness (as a percentage of GDP) was lower than in most European countries. Moreover, the stock did not appear to be high as compared to the majority of our competitors in the region (Chart 11). If we look at the chart below, as many people did at the time, we will not necessarily notice the risk of foreign currency borrowing: the 'over-indebtedness' of households; the credit stock increases peacefully and steadily. This is why it is difficult to identify an 'overrun' and detect the accumulation of imbalances 'real time'.

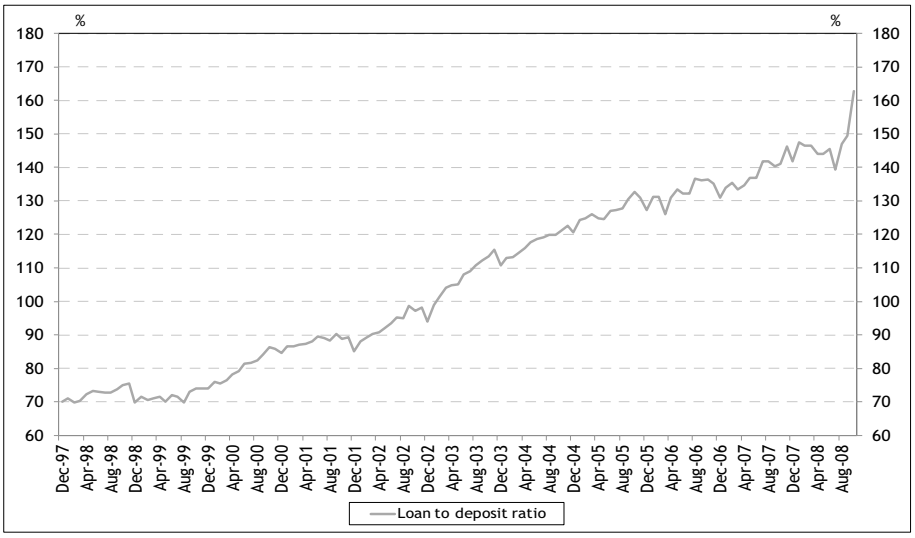
Chart 11 Household loans as a percentage of GDP in international comparison



Source: Eurostat, central banks, MNB database, own calculations.

However, there were already warning signs: the credit stock became ever greater compared to the financial wealth of households, and the debt servicing represented an ever greater portion of current income. Foreign currency denominated loans increased credit demand to a magnitude where domestic savings were no longer sufficient to cover the need – the loan-to-deposit ratio of banks rose way above 100 per cent, while the reliance of the banking system and of the country on foreign funding increased considerably. The chart below (Chart 12) shows the 'imminent danger' more clearly. A loan-to-deposit ratio substantively above 100 per cent on the level of the banking system is a sure sign of an overrun by any textbook.

Chart 12 Loan-to-deposit ratio of the domestic banking system



Source: MNB database, own calculations.

A number of analysts warned about the signs and threats, and more and more observers called attention not only to the risks of foreign currency lending as such but also to the danger of overindebtedness and sub-prime lending.[8] These risks can be mitigated, mostly through prudential instruments, and excessive lending can be curbed. Hilbers et al. lists numerous instruments used internationally, some of which would have been appropriate in the case of Hungary as well. Banai et al. (2011) show the instruments that could be considered in Hungary, highlighting the ones that could have offered realistic alternatives.

[8] The author of this paper talked just about this topic in her first speech as Deputy Governor of the MNB: According to Király, the sub-prime phenomenon is with us in the form of the over 70 per cent LTV ratios of new lending, the declining margins, which are not amenable to stability (declining profitability, increasing risk), and the appearance of yen lending' (Report of Portfólió on the HFSA conference of 6 November 2007)

However, there was insufficient government will to limit foreign currency lending, and regulation failed to emerge. The literature of regulation has long established, however, that in the absence of sufficient government commitment a negative trend cannot be halted but it can be slowed down: the purpose of circumventable, 'arbitrable', imperfect regulation is exactly to get 'grains of sand' into the works. However, those grains of sand were not dropped into the works either.

The absence of government commitment is not that difficult to understand, particularly if we look for socially sensitive reasons rather than scapegoats. It is enough to look at the example of the US. In 2004 FED Governor Edward W. Gramlich addressed a warning to President Bush: in this, three years before the onset of the financial crisis, he dissected the motivations behind the surging sub-prime lending, its characteristics and its predatory nature endangering the entire money market. However, he closed the remarks, known as 'Gramlich's words of warning' ever since, with these sentences: 'Despite the caveats, the net social evaluation of these trends is probably a strong positive. The 9 million new homeowners, more than half of whom are minorities and many of whom have lower incomes, suggest that credit and ownership markets are democratizing. Millions of lower-income and minority households now have a chance to own homes and to build wealth'.[9] This quote sheds light on the value choice of Hungarian economic policy: the end result appeared 'a strong positive' as some economic growth remained despite the fiscal adjustment. The risk accepted (foreign currency debt a few years before the introduction of the euro) may have appeared low in comparison. Instead of pointing fingers, we must understand that rational decisions with an element of irrationality lead to an irrational end result.

At that time we already compared the resulting situation to the Gömböc,[10] a fine creation of Hungarian mathematicians: the system is in the state of an unstable equilibrium, from which it could have moved to a state of a 'good' stable equilibrium if the adoption of the euro had happened earlier (Antal et al. 2008). This was not to be, however. Instead, the system was removed from the unstable equilibrium by the post-Lehman crisis of 2008, and the 'Gömböc' has been trying to find its stable equilibrium point ever since, rolling to and fro (Király 2009a, Király 2009b).

The appropriate regulation of foreign currency lending and excessive borrowing came only after the onset of the crisis; however, the immediate implementation of the regulatory measures introduced since then has had a pro-cyclical effect on more than one occasions, restraining lending even further. Government Decree No. 361/2009 (XII.30) Korm. on responsible lending, adopted in 2009, set a lower loan-to-value limit and lower instalment/income ratio for foreign currency loans than for HUF loans. Despite the success of the regulation promoting responsible lending, the prohibition of FX loans[11] eliminated all scope for the renewed growth of the stock.[12] The activities of 'agents' also played a major part in the surge in lending. The new rules introduced in 2010,[13] in addition to classifying agents and imposing a registration obligation, also attempts to impose constraints on their remuneration so that agents have no interest in undertaking excessive risks. The Act on the mandatory membership of the complete credit register and the initial upload of data into the register,[14] adopted, after a lot of foot-dragging, in 2011 in the framework of the home protection legislative package, intended to address the issue of the absence of information on the indebtedness of clients.

These regulatory measures (with the exception of the blanket prohibition) will definitely help in preventing such a magnitude of over-indebtedness of households either in HUF or in foreign currency again.

3. Problem of the accumulated stock (the 'stock' period) 2008 - present

The heavy economic and social burden of the FX borrowing became clear and evident for every stakeholder during the crisis. It became evident to households that the higher volatility of exchange rates increased not only the instalments as a proportion of their income but also the amount of the debt itself. In this regard foreign currency

[9] Remarks by Governor Edward M. Gramlich, at the Financial Services Roundtable Annual Housing Policy Meeting, Chicago, Illinois May 21, 2004 http://www.federalreserve.gov/boarddocs/speeches/2004/20040521/default.htm

[10] www.gomboc.eu

[11] Act XC of 2010 and Government Decree No. 110/2011. (VII. 4.) Korm.

[12] In the framework of the so-called 'Home protection package' the blanket prohibition was lifted as of 7 July 2011 but foreign currency loans are accessible only to a very narrow group of clients.

[13] Act CL of 2009, Decree of the Minister of Finance No. 18/2010. (IV. 29.) PM and Government Decree No. 109/2010. (IV. 9.) Korm.

[14] Act CXXII of 2011

loans are different from HUF loans: the instalments of the latter may change as a result of interest rate changes but the size of the principal is 'fixed', while the amount of a foreign currency loan changes with the exchange rate, increasing at times of currency depreciation. The high unemployment and declining real income caused by the economic crisis magnify the negative effects of the already growing (as a result of the currency depreciation) debt and the current burdens of debt servicing. The high household FX loan stock unhedged against exchange rate risk renders households as well as the entire economy vulnerable, thereby adding to the sovereign risk.

For the banking system the stock of FX loans represents solvency and financing risk at the same time. The high margin previously accumulated is proving insufficient to cover the losses on the non-performing portfolio. Collateral based lending against the background of a frozen real estate market renders it impossible to enforce the collateral and to gradually write off defaulting loans. The growing solvency problems make the banking system vulnerable, which in turn increases the sovereign risk and funding costs. The FX loan stock is slow to diminish, thus it must be financed over an extended period of time, which adds to the financing risk of the banking system and the external vulnerability of the country.

Consequently, a major shift in the exchange rate (the devaluation of the forint) endangers the stability of the banking system and threatens with a social crisis simultaneously – both adding to the vulnerability of the country. The former makes economic recovery fragile through the freezing of bank lending and threatens with looming recession. In addition, it may necessitate government intervention. The latter may also impose considerable burdens on the government, which is impossible to finance against the background of the current fiscal problems. As a result, the management of the stock of FX loans has become a central issue. The resulting situation limits the manoeuvring room of monetary and fiscal policy alike and reduces the efficiency of their measures. This is why Hungarian monetary policy became pro-cyclical in the crisis: monetary easing, a natural move at times of recession, has been hindered since the onset of the crisis by the vulnerability increasing with the weakening exchange rate due to the high FX loan stock.

The evolution, costs, benefits and risks of foreign currency lending is abundantly covered in literature, while there is little to find on the potential ways of efficiently managing the existing stock.

Debt, be it the debt of the private sector or of the state, is never 'low' or 'high' in itself, only as compared to the income available for its repayment. Any debt can be outgrown if there is sufficient growth and sufficient income. If the accumulated debt of the state promotes the start of a GDP growth that remains stable, the debt is easy to outgrow. In the well-known cases of economic history leading to crises, the accumulated debt was always 'a bit more', the GDP growth achieved 'a bit slower'.

If the increase of the debt is faster than GDP growth, the debt path is clearly unsustainable. In that case there are two possible solutions:

a) the 'devaluation' of the debt
b) the reduction or write-off of the debt.

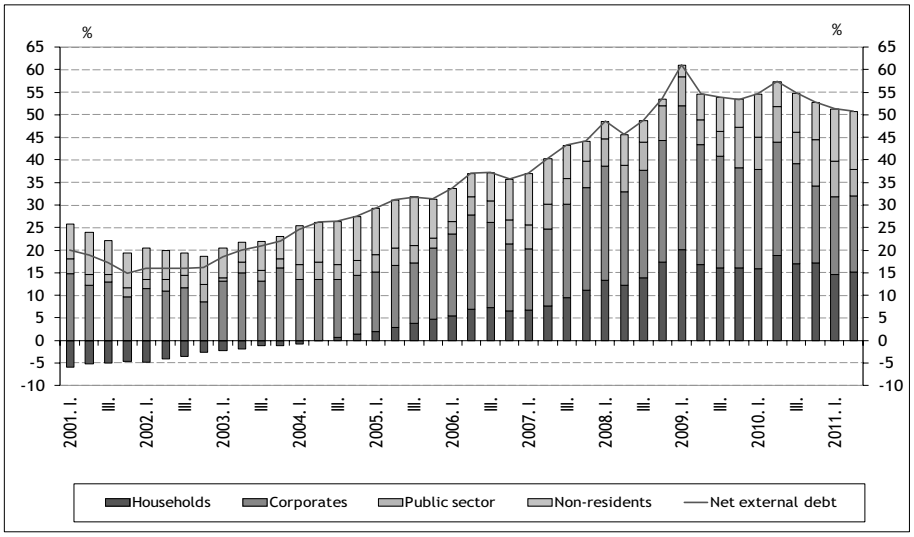
Solution a) is a favourite of governments for the reduction of debt accumulated in their own currency. When economic policymakers feel that they will be unable to outgrow the debt, they resort to the tried and tested method of inflation: if the debt cannot be outgrown, it is time to 'inflate it away'. They always propose only a very modest inflation; they suggest only devaluation that can be kept in check. There is always an esteemed economist to support that argument – this time it is the turn of Nobel-laureate or near-Nobel laureate economists, such as Krugman, Blanchard or Rogoff (Buttenwood 2011). As testified by economic history, a small inflation, even if it does not always turn into volatile, multi-digit destructive inflation, remains persistent, it is built into expectations and it undermines the efficiency of economic decisions and decreases social welfare. In retrospect it always turns out to have been the wrong solution but it always appears to be a good idea at the time. A real siren song. It is therefore better to be tied to the mast of a low inflation target by an independent central bank. Initially inflating debt away also helps private debtors as their debt is also 'reset to zero' together with the public debt (this is more or less what happened in Hungary in the nineties). One of the peculiarities of the Greek debt crisis is the fact that due to the currency union Greece is unable to quietly 'inflate away' its public debt.

However, this tried and tested recipe does not help with foreign currency denominated debt – this is the peculiarity of the present predicament of Hungary. The problem of debt denominated in other than the

country's own currency is well known in economic theory; this is the infamous 'original sin' (Eichengreen et al 2003), which is a frequent phenomenon in developing countries and causes persistent economic problems.

In Hungary, due to the absence of fiscal discipline, then as a result of the indebtedness of households not adapting to this situation, the net external debt is significant in European comparison and non-residents do not keep this debt in forints. The chart below (Chart 13) shows how the state gradually transfers the open position to the private sector parallel with the upswing in foreign currency lending.

Chart 13 GDP-proportionate open exchange rate position of individual sectors



Source: MNB database, own calculations.

The chart reveals why it is impossible to 'get rid of' foreign currency loans in one fell swoop by immediate conversion into forints. Conversion into forints does not reduce the net external debt of the country, that is, the open FX position taken from households is transferred to 'somebody'. Banks are unable to assume it as they need to close their on-balance-sheet open position by off-balance-sheet items. For them, the most important change is that as a result of the conversion, their on-balance-sheet open position may be narrowed or reversed, thus they either repay FX funds or close their swap position. *Non-resident actors* may provide the foreign currency necessary for the conversion, thereby assuming a larger open forint position; however, would be at the cost of the drastic weakening of the forint and/or drastic interest rate hikes. The *government and the central bank* would be able to assume the open FX position of households without weakening the forint. The government would be able to assume the position by changing the currency composition of future government bond issues, which, however, would aggravate the role of foreign currency funds in the financing of the public sector, significantly increasing risks. The central bank could use its foreign exchange reserves to neutralise the sale of forint by banks at the time of conversion. However, the open exchange rate position of the consolidated general government would surge as a result and investors would consider the shrinking foreign exchange reserves to be a severe risk. (Balás-Nagy 2010)

Total conversion would also be a risk for the operation of the major financial markets. Due to the conversion, banks need foreign exchange as their on-balance-sheet open position starts closing, or opening in the opposite direction. To open new positions they need spot foreign exchange, which significantly weakens the exchange rate if it is not taken over by the central bank. Therefore, this would have a negative impact on the spot foreign exchange market. Due to the closing of the on-balance-sheet open positions or the positions opened in the reverse direction, resident actors create a smaller demand for foreign exchange on the swap market, which in turn leads to the reduced liquidity of the swap market. This endangers the participation of non-residents who invested their forints obtained through swaps in Hungarian instruments to hedge the exchange rate risk.

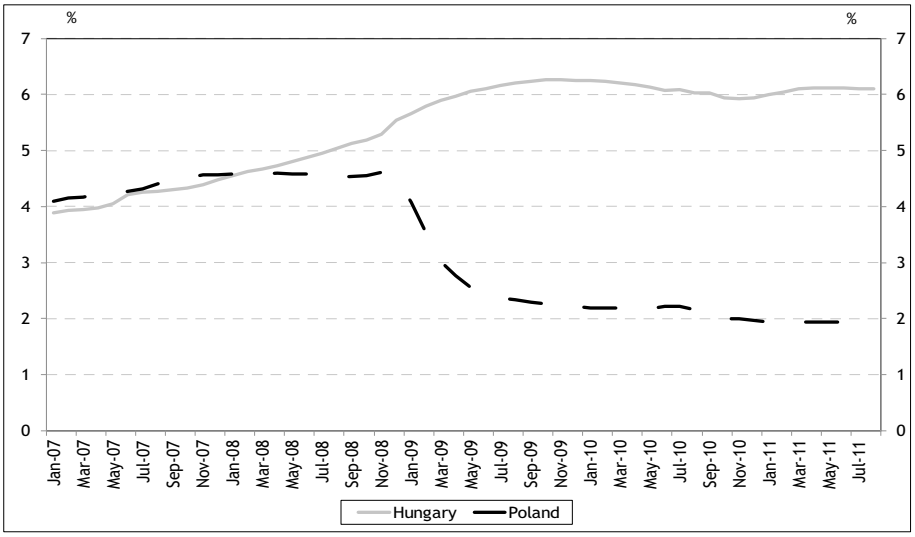
In other words, foreign currency loans cannot be 'erased', we need to learn to live with them in the longer term, expecting their gradual decline and conversion. The 'original sin' cannot be eliminated with a single confession.

Between 2002 and 2008 the stock of household loans increased from 10.3 per cent of GDP to 35.3 per cent; more than the half of this stock was denominated in Swiss franc. The magnitude of this figure cannot be judged on its own, it is impossible to say if it is 'too much' or 'too little'. Households debt of 35-36 per cent of GDP is not high in European comparison. This is true if two conditions are satisfied at the same time: there is sufficient growth in the economy, which assures a sufficiently stable growth of household income, and the debt servicing burden does not increase faster than this, that is, the disbursement of new loans slows down and the existing debt does not appreciate.

In the past four years of the financial crisis that started escalating in October 2008, there has always appeared to be a chance for that scenario to happen in Hungary. The effects of the crisis-induced recession seemed to indicate that slow recovery would start in 2010, bringing about the gradual decline of unemployment and the growth of income. The right 'recipe' for managing the temporary shortage of income was debt restructuring, which banks offered to their clients in different versions; as a result, more than 10 per cent of the total household loan stock has been restructured. The slow recovery, however, was halted by the second wave of slow-down that arose in response to the euro area crisis; as a result, economic growth in Hungary also came to a halt and in 2012 Hungary was in recession again. The first condition, the stable and predictable growth of income now seems far less likely to be achieved in the near future than it did a few months ago.

The second condition has apparently been satisfied: household lending not only slowed down but expressly stopped, with no sign of any further growth in the stock, the net savings of households surged, which is primarily the result of the accelerated repayment of loans. In the case of a transparently floating rate forint debt this would have meant the definitive reduction of the debt stock, promising the opportunity to outgrow the debt. There were two factors working against this with various intensity: on the one hand, the increased volatility of the HUF exchange rate and on the other hand the absence of fixed-margin lending tied to a reference rate. The appreciation of the Swiss franc against the euro and the weakening of the forint against the euro increased debt at a rate over income growth, therefore the debt stock as a percentage of income did not decline but increased slightly. The absence of transparent pricing allowed banks to incorporate their increased cost of funds into their lending rates. The outcome of the possibility to unilaterally modify interest rates is clearly shown by the comparison of the development of interest rates during the crisis in Poland and in Hungary. In Poland the interest rates on CHF loans are tied to a reference rate, thus they have been steadily declining since the start of the crisis, offsetting the increase of the instalments attributable to the depreciation of the currency. In Hungary, in contrast, the lending rates have also been significantly above their pre-crisis levels (Chart 14). Thus instalments increased faster than it would have been justified by the growth of the debt due to the currency depreciation of the debt – consequently, the ratio of debt servicing to current income increased even further.

Chart 14 Average interest rates of the CHF loan stock in Hungary and in Poland



Source: BNP website, MNB database, own calculations.

3.1. Attempts at a solution

Excessive indebtedness can be curbed by reducing the debt itself (debt forgiveness in one form or another) or by lowering the debt service (introduction of lower interest rates or extension of term). Clearly, the reduction of the debt will also reduce the debt servicing (instalment), while solutions reducing the instalments only leave the debt unchanged. In the case of debt denominated in foreign currency both the debt and the debt servicing can be decreased by the conversion of FX loans into preferential rate loans (at interest rates below the prevailing market rates). The debt and debt servicing can be reduced uniformly for all borrowers or only for selected groups of borrowers. Common solutions applied internationally tend to target clients in the most difficult plight first, who are unable to outgrow and/or service the debt.

The proposed solutions should have started by client segmentation, and worked out, in cooperation with the stakeholder groups, the cost sharing for the various arrangements to reduce debt or debt servicing. This is not what happened: measures so far have generally been introduced without coordination or cooperation – sometimes aggravating economic and social risks.

The overwhelming majority of measures tried to help in meeting repayment obligations that is, mitigating the pain of the slow erosion of the portfolio.

One form of temporary relief regulated by the government was the **exchange rate cap** introduced in the framework of the 'Home protection package'. It was not a real option to solve borrowers' problems since it was only a tool to gain time. The introduction of the exchange rate cap implicitly assumed that the exchange rate will be better at the end of the transitional period. Else the scheme would have been able only to postpone defaults. The take-up of the instrument has been negligible so on the basis of the agreement concluded between the Government and the Hungarian Banking Association in December 2011 a more favourable exchange rate cap was introduced. Under this program foreign currency mortgage loan debtors without delinquency longer than 90 day could enter the exchange rate cap scheme. Participating debtors may pay their instalments at fixed exchange rates – HUF/CHF 180, HUF/EUR 250 and HUF/JPY 2.5 – until 30 June 2017. Participants in the scheme share the difference between the fixed exchange rate and the actual exchange rate in a manner that the principal part of the instalment is recorded on a separate HUF technical account under the debtor's name, while the interest part of the instalment is shared 50/50 by the state and banks. Debtors will need to start settling the difference that accrues on their separate HUF accounts after a grace period of five years. All exchange rate differentials above a certain exchange rate (HUF/CHF 270, HUF/EUR 340 and HUF/JPY 3.3) will be borne by the state. Until 31 December 2012 only 30.8 per cent of FX mortgages entered the program which was well under the expectations (Table I). Entering the program would be rational for any debtors since they would receive transfers from the state and the bank, without waiving any rights. Due to decreasing credit risk the program also has benefits for the banking system and the state.

Table I: Dynamics of participation in the exchange rate cap scheme

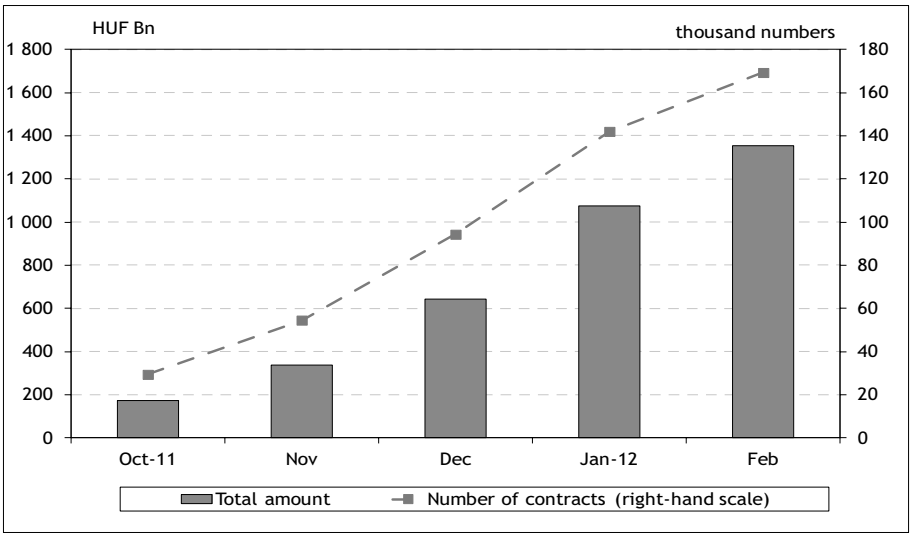
	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Number of contracts	20 168	35 444	47 950	63 258	76 852	88 260	99 584
Loan stock (billion HUF)	180,9	309,5	468,3	596,5	712,8	812,7	916,2
Proportion to total FX loan portfolio	4,69%	8,34%	12,58%	16,37%	19,66%	28,04%	30,85%

Source: HFSA.

Restructuring by banks also serves to reduce instalments temporarily. Without any legal obligation, having realised the significant long term risk of the problem, banks have been trying to temporarily reduce the debt servicing burden on their clients. Restructuring started at the onset of the crisis, and by now over 10 per cent of the mortgage loans of households have been renegotiated. As a rule, banks ease the terms of payment for a period of 1 to 3 years, helping their customers weather the most difficult period. Restructuring does not mean any debt reduction and tends to reduce the debt servicing burden only temporarily; consequently, it may offer a definitive solution only to customers who are able to outgrow the debt in the longer term.

The only government measure that resulted in any significant debt relief was the so-called **early repayment scheme**[15] announced in the framework of the Country Protection Program. Debtors with foreign currency denominated mortgage loans could repay their total debt (total prepayment) at an exchange rate of CHF/HUF 180 for Swiss franc denominated loans, EUR/HUF 250 for euro denominated loans and JPY/HUF 2 for Japanese yen denominated loans. Mostly existing savings can be used for this purpose as the regulation provides for no mandatory HUF lending for the refinancing. The Government provided this opportunity only on a temporary basis: the intention of early repayment had to be notified by the end of 2011 and 60 days were available thereafter to conduct the transaction. Early repayment meant substantial debt relief, amounting to 20 to 30 per cent depending on the prevailing exchange rate, primarily to clients with considerable wealth or high credit rating, i.e., the top segment of FX borrowers. Banks were the definite losers in the early repayment scheme as the government obliged them to write off debt of this magnitude from their capital, overriding existing private contracts. . By the closing of the early repayment programme at end-February 2012, households had repaid foreign currency denominated loans amounting – at market value – to approximately HUF 1,350 billion. Corresponding to a higher-than-expected participation of 24.1 percent as a proportion of total outstanding loans, this meant the termination of nearly 170,000 loan agreements (Chart 15). This solution could be elegantly called 'bail-in',[16] whereby banks are involved in the solution of the debt problem, but examples for such a unilaterally imposed bail-in cannot be found elsewhere in Europe. The banking sector had huge loss due to this scheme but their foreign parents supported them with capital injections. The measure reallocated income (capital) from the banking sector to better-off clients. Finally, FX swap facility of the Magyar Nemzeti Bank was needed to mitigate the program's negative effect on the HUF exchange rate.

Chart 15 Fully repayed FX-mortgage loans



Source: MNB database, own calculations.

3.2. What is the way forward?

Foreign exchange risk is not easy to live with but it is possible: if economic policy is stable and predictable, the exchange rate fluctuations have a bearable impact on the change of debt servicing burdens. This risk is not comfortable but it is tolerable. It is possible to relieve households of the exchange rate risk but some other entity must assume that risk. Under the existing rules the banking system is not allowed to maintain open positions. Non-residents will take over the exchange rate risk but at a price, which is the substantial devaluation of the forint. The assumption of the exchange rate

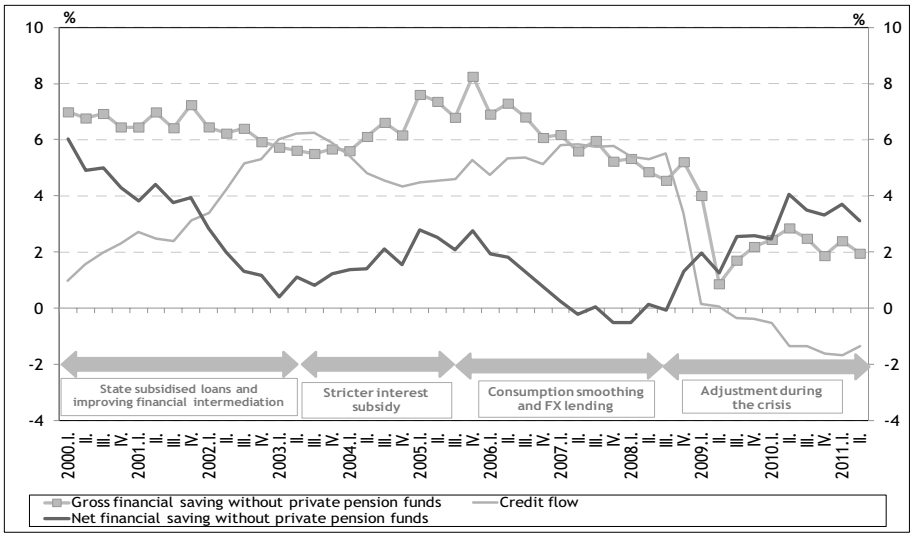
[15] Act CXXI of 2011

[16] 'Bail-in' is the paraphrase for 'bail-out'. While 'bale-out' is the 'terminus technicus' for saving those in bankruptcy, 'bail-in' is the involvement of the banks in the solution of the debt problems of others (mostly sovereign entities) through the partial devaluation of their assets (i.e., government bonds). This is what happened, for instance, in the case of Greece, in several steps –– though the participation of banks was strictly voluntary.

risk by the central bank or the government increases the unpredictability of the public debt and it entails the risk of further downgrading of the country in the middle of a sovereign debt crisis (Balás-Nagy 2010). The growth of the debt burden on households has been significantly aggravated by the fact that making use of the prevailing regulations (no mandatory pricing rule with fixed margin and a reference rate), the banking system passed on its increased cost of funding and the burdens of its deteriorating portfolio to performing debtors. This practice can be reversed definitively only by the introduction of a transparent pricing system that the central bank and the HFSA have been urging for a while.

That is, if GDP falls or remains stagnant while the debt is continuously revalued, its interest rate is changed and as a result, it increases steadily or even drastically -– then the burden appears less and less possible to outgrow and we increasingly feel that it is too much compared to the available financial assets and discretionary income. The adaptation of households during the crisis has been brutal: net financial savings rose radically (Chart 16). Still, the burden failed to lighten. What appeared to be manageable at end-2009 and in 2010 without any special intervention with a balanced, stable economic policy, was shown in a completely different light in mid-2011 after the sudden deterioration of growth prospects and the radical shift in the EUR/CHF exchange rate.

Chart 16 The net lending/net borrowing of households



Source: MNB database, own calculations.

In this severe situation the unilateral 'exchange rate fixing' by the Swiss central bank was a relief – but without the consistent improvement of growth prospects the partial trap may increasingly become a social trap. The explosive growth hoped by many is in effect not possible. In the short term the 'law of debt conservation' is valid because the debt stock can be dismantled only in the long term. Naturally, burdens can be reallocated, but this has its consequences. The excessive burden on the banking system is immediately reflected in the decline of lending, which in turn worsens growth, labour market conditions and social welfare. The general government is also unable to assume the burden without limitations. This would require it to take out new loans ceteris paribus, which increases its risks and budget expenditures. Moreover, when considering government involvement, the interest of citizens who did not borrow and thus did not increase their welfare by taking on extra risks also needs to be taken into account.

Consequently, the management of the situation must be based on the consensus of all three parties and imply the proportionate sharing of burdens. This should be taken into account when promoting the reduction of the debt. In addition, it is also important to spread the losses over time, which is promoted if the solvency of borrowers is maintained with all available means. Finally, the maintenance of the stability of the banking system and the promotion of lending are of outstanding importance because the management of the problem is even more painful in the absence of economic growth.

4. Conclusion

Above we have described how the foreign currency loan stock, one of the greatest risks of the economy at present, was accumulated in Hungary. We have seen that even though borrowing and lending in foreign currency may have been a rational decision in many respects before the crisis, some erroneous assumptions have by now grown into an enormous problem for banks, clients and government entities alike.

Households have been forced to reduce their consumption, significantly lower their standards of living and, in many cases, continuously face the threat of bankruptcy and eviction. The government must tackle this problem amidst the crisis, which not only threatens a social crisis but it also represents a significant risk factor and has a negative impact on growth. Because of the high risk premiums, the interest expenditure of the general government has increased while low growth erodes revenues. The accumulated stock of debt also constrains growth in the banking sector. This stock must be financed continuously, which ties up foreign currency liquidity all the time. Portfolio deterioration, which appeared to be close to its end in mid-2010, regained momentum in 2011 as growth prospects worsened and exchange rate volatility increased. The capital buffer, which was decreased by the bank levy, provided cover for the deterioration – but there is less and less capital available to reverse the declining trend in lending. The halt of lending by the banking system is the main macroprudential problem at present. Without growth, the increasing non-performing portfolio represents an ever growing proportion within the balance sheet, while financial intermediation is still far from its pre-crisis level. Without the activity of financial intermediation economic slowdown may be aggravated.

In that situation, idealistic charlatans mushroom with their apparently trivial, potentially fatal solutions. The proposal urging to refuse the repayment of loans borrowed from international vulture capitalist is based on the same rational as the one urging our compatriots to sue banks for granting foreign currency loans and to refuse repayment. In the cacophony, rational ideas (the reduction of the burdens of over-indebted households though loss sharing) and incoherent philosophies about the sinful banks are often mingled. It is our job to understand and explain: there is no royal way - there is no piece-of-cake solution. There are only experiments and partial solution, painful for borrowers, banks, the government and non-indebted taxpayers alike.

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ESTIMATING PROBABILITY OF DEFAULT AND COMPARING IT TO CREDIT RATING CLASSIFICATION BY BANKS

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Abstract

Credit risk is the main risk in the banking sector and is as such one of key issues for financial stability. We estimate various PD models and use them in the application to credit rating classification. Models include firm specific characteristics and macroeconomic or time effects. By linking estimated firms' PDs with all their relations to banks we find that estimated PDs and credit ratings exhibit quite different measures of firms' creditworthiness. Results also suggest that in the crisis banks kept riskier borrowers in higher credit grades. This could be due to additional borrower-related information that banks take into consideration in assessing borrowers' riskiness, to the lags in reclassification process or a possible underestimation of systemic risk factors by banks.

JEL classification: G21, G33, C25

Keywords: Credit risk, Probability of default, Credit overdue, Credit ratings, Probit model

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1. Introduction

After the start of the crisis in 2007 credit risk has become one of the main issues for analysts and researchers. The deteriorated financial and macroeconomic situation forced many firms into bankruptcy or to a significantly constrained business activity. Banks were to a large extent unprepared to such a large shock in economic activity so they suffered huge credit losses in the following years. Although it is clear that credit risk increases in economic downturn, this effect might be amplified when banks ex-ante overestimate the creditworthiness of borrowers. Under conditions of fierce competition and especially in periods of high credit growth banks might indeed be willing to assign higher credit ratings to obligors, which could cause problems in their portfolios when economic situation worsens.

Knowing why do some firms default while others don't and what are the main factors that drive credit risk is very important for financial stability. Since the pioneering work of Altman (1968), who uses discriminant analysis technique to model credit risk, a large set of studies find that credit risk is in general driven by idiosyncratic and systematic factors (Bangia et al., 2002, Jimenez & Saurina, 2004, Carling et al., 2007, Bonfim, 2009). The importance of macroeconomic effects is to capture counter-cyclicality and correlation of default probabilities. On the other hand there is also a strong reverse effect of credit risk on macroeconomic activity. In recent study Gilchrist and Zakrajšek (2012) find that a level of credit risk statistically significantly explains the movement of economic activity. They construct a credit spread index (GZ spread) which indicates high counter-cyclicality movement and has high predictive power for variety of economic indicators.

This paper analyses credit risk of Slovenian non-financial firms using an indicator of firm default based on credit overdue. We focus on modeling default probability and use similar approach as those proposed by Carling et al. (2007) and Bonfim (2009). The results obtained suggests that probability of default (PD) can be explained by firm specific characteristics as well as macroeconomic or time effects. While macro variables influence all firms equally, and thus drive average default probability, firm specific variables are crucial to distinguish between firms' creditworthiness. Similar as Bonfim (2009), we find a model that includes time dummies as time effects to perform slightly better than model with macroeconomic variables. This result is expected, since time dummies also capture institutional, regulatory or other systematic changes in time.

The main contribution of this paper is that we compare the estimated PDs to credit rating classification by banks. We select two models that best fit the data and link the estimated firm-level PDs with all credit grades which are given to borrowers by banks. We find that estimated PDs and credit ratings by banks often exhibit quite different measures of credit risk. The results also suggest that in the crisis banks allow for higher risk borrowers in credit grades A, B and C. This could be due to additional borrower-related information that banks take into consideration in assessing borrowers' riskiness, to the lags in reclassification process or a possible underestimation of systemic risk factors by banks.

The rest of the paper is structured as follows. Next section presents the data. Section 3 describes the modeling approach used to estimate the probability of default. Estimation results of various credit risk models and an application of the models in analysis of credit rating classification is presented in Section 4. Section 5 concludes the paper.

2. Data

Three different data sources are combined to construct dataset used in the econometric analysis. First, balance sheet and income statement data for all Slovenian firms are collected by the Agency of the Republic of Slovenia for Public Legal Records and Related Services (AJPES) at yearly basis. The analysis is restricted only to non-financial corporations. Second, data about credit exposures, credit ratings, credit overdue, etc. are gathered in Credit register at Bank of Slovenia. The banks are mandatory to report these data every month, but since firms' balance sheet and income statement data are only available at yearly basis, we use the end-of-year data. Third, to capture the business cycle effects when modeling PD, we use a set of macroeconomic and financial series which are obtained from Statistical Office of the Republic of Slovenia (SURS) and from Bank of Slovenia.

Two different subsets of the data are used for modeling probability of default and in comparison of the estimated PDs to credit rating classification by banks. Hence we present each of them separately.

2.1. Data for modeling PD

Under the framework of Basel II the obligor defaults on his credit obligation if (1) he is unlikely to pay the obligation or (2) is passed overdue more than 90 days (BCBS, 2006). Since it is difficult to set the objective criteria for unlikeliness of paying the obligation, we derive the indicator of firm default from credit overdue. Firm i is in default if its principal or interest payments are more than 90 days overdue in at least one bank in year t. The stock of defaulted firms increased significantly in the crisis, from 3.9% in 2007 to 9.9% in 2010.

To model the PD we use yearly data from 2007 to 2010. Since PD is the probability that a firm will default in year t given that it did not default in year t-1, all firms who have for the first time taken the loan (in any bank) in year t are excluded form the sample. Firms that were in the state of default for two or more consecutive years are also excluded and only their first migration to the state of default is taken into account. Similar to Bonfim (2009), we keep all the firms that defaulted twice or more in a given sample, but not in two consecutive years.

The firm's financial ratios like measures of liquidity, solvency, indebtedness, cash flow, profitability, etc. are key inputs to PD models. They capture firm specific effects and reflect the riskiness of firms. The sample additionally excludes firms with significant outlier in some of their characteristics so that all the observations in the 1st and the 100th percentile are dropped. Table 1 presents the summary statistics for some financial ratios and the other firm's characteristics for defaulted and non-defaulted firms, which are taken into account in the analysis, for the period 2007-2010. We now turn to the descriptive analysis of the variables.

Total sales which is a measure of firm size indicates that defaulted firms are on average smaller. Similar result is found by other researchers like Carling et. al (2007), Psillaki et. al (2010), Antao & Lacerda (2011) and Kavčič (2005). Smaller firms are less diversified and rely on less or perhaps on a single project. They are often also more financially constrained comparing to larger firms and may have problems in raising funds in economic downturns (Bernanke et. al, 1996, 1999).

Defaulted firms are on average younger, have lower liquidity, higher leverage, lower cash flow, worse operating performance and have lower interest coverage, comparing to non-defaulted firms. A significantly useful indicator to separate between firms in default and non-default is also a variable which measures a number of days a firm has blocked bank account per year. It shows that in a given sample defaulted firms' bank accounts were on average blocked 106 days per year, whereas accounts for firms with no default were on average blocked only 6 days per year.

Somewhat less expectedly firms in default have on average higher amount of total credit. Jimenez & Saurina (2004) indeed show that there is an inverse relationship between the size of the loan and the

probability of default since larger loans are more carefully screened. The difference between the two approaches is that their research is done at loan level, whereas this analysis is at firm level, where the default occurs if a firm defaults in any bank in year t.

Table 1: Summary statistics for firms with and without defaults for the period 2007-2010

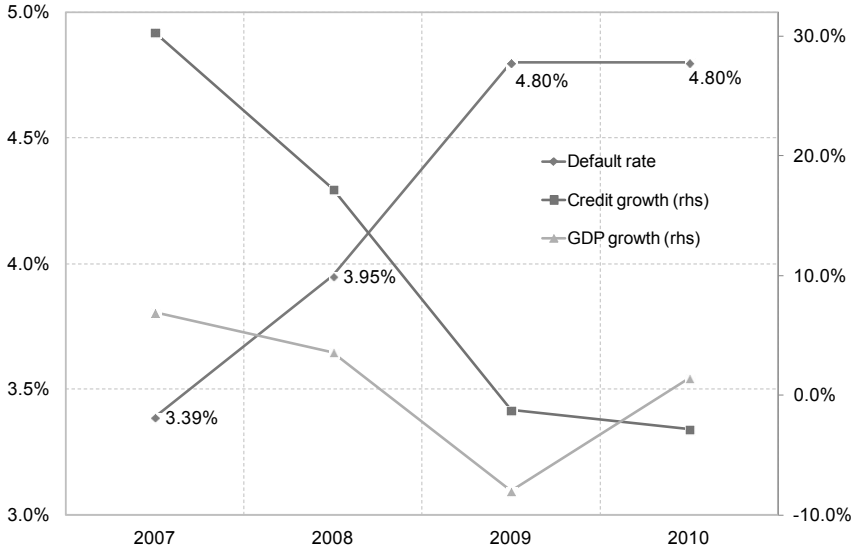
	Firms with no default at t		Firms in default at t	
	Mean	St. dev.	Mean	St. dev.
Total sales (EUR million)	2.21	13.54	1.11	3.73
Firm age (in years)	13.38	6.61	12.00	6.65
Quick ratio	1.34	1.57	0.85	1.06
Debt-to-assets	0.66	0.33	0.94	0.47
Cash flow	0.05	0.22	-0.11	0.50
Asset turnover ratio	1.54	1.88	0.80	1.01
Interest coverage*	4.62	11.20	-0.30	7.27
Blocked account (in days)	5.90	32.57	105.83	127.54
Total credit (EUR million)	0.40	1.07	0.65	1.38
No. of bank-borrower relationships	1.36	0.70	1.78	1.04
No. of observations	65557		2887	

Source: AJPES, Bank of Slovenia, own calculations
**statistics computed on reduced sample of 45236 observations due to the missing values.*
Notes: Firms without credit obligation or without information about credit overdue are excluded. Quick ratio is defined as the ratio of current assets (minus inventories) to current liabilities, Debt-to-assets is ratio of total debt and total assets, Cash flow is ratio of operating cash flow in revenues, Asset turnover ratio is ratio of total sales to total assets, Interest coverage is ratio of EBIT and interest expenses, Blocked account is number of days a firm has blocked bank account, No. of bank-borrower relationships measures to how many banks a particular firm is related to.

According to the relationship banking theory banks and borrowers can benefit from a close relationship (Boot, 2000). Especially small banks tend to have comparative advantage in using soft information technologies (Berger & Udell, 2002). Nevertheless, in a recent study, Berger and Black (2011) show that bank will generally choose a hard information technology over a soft information technology if a sufficient hard information is available. The results of Jimenez & Saurina (2004) indicate that when borrower's loans are spread across several banks there is less of an incentive to finance riskier borrowers. Banks are willing to finance higher risk borrowers if they have a close relationship with them. This seems not to hold in the case of Slovenia since firms in default have on average higher number of bank-borrower relationships. One explanation might be that risky firms seek for credit in other banks because current creditors don't want to lend them any more if they are not paying off the loan regularly. The borrower's credit history is in general not available to new creditors, thus they can only assess firms' creditworthiness through their financial ratios.

Jacobson et. al (2011) argue that firm-specific variables account for the cross-section of the default distribution, while macroeconomic variables play the role of shifting the mean of the default distribution in each period. Finally, care is taken to include business cycle effects in the model. Figure 1 illustrates the movement of default rate for a given sample against the two indicators of the business cycle. The default rate appears to be highly countercyclical and it seems more tightly related to credit growth than to GDP growth. As shown by Bonfim (2009), Jimenez and Saurina (2006) and others, most of the credit risk is built up during periods of strong credit growth when banks apply looser credit standards. This risk materializes when the economy hits a downturn. With looser credit standards banks attract more risky borrowers which deteriorate their average assets quality. Marcucci and Quagliariello (2009) find that banks with lower asset quality are much more vulnerable in recessions. The increase in default rates due to one percentage point decrease in output gap is almost four times higher for those banks than the effect on banks with better portfolios.

Figure1: Default rate, credit growth and GDP growth, in percentage



Source: Bank of Slovenia, SURS, own calculations
Note: Default rate is calculated as a percentage of firms that are in default in year t and were not in default in year t-1.

2.2. Data used in the comparison of the estimated PDs to the banks' rating classification

While data for modeling probability of default are at borrower level, analysis of credit rating classification is done at bank-borrower level. Each such relationship is taken into account. Similar as in the PD estimation part, the analysis is restricted to the period 2007-2010.

The credit ratings exhibit banks' assessment of the debtors' ability to discharge the liabilities to the bank. As opposed to credit overdue, credit ratings are more subjective measure of firms' riskiness. Crouhy et al. (2001) argue that rating systems are usually based on general considerations and experience and not on mathematical modeling. Although financial health of the firm is a key factor of rating classification, analysts must also take into account managerial and other qualitative information like feature of the industry. Debtors' credit ratings are in larger part independent of the quality of the posted collateral. As Crouhy et al. (2001) point out, obligor credit ratings exhibit the probability of default by a borrower in repaying its obligation in the normal course of the business.

According to the Article 13 of the *Regulation on the assessment of credit risk losses of banks and savings banks* (hereinafter referred to as *Regulation*) Slovenian banks classify borrowers into five credit grades, from A to E. The two main criteria that they should consider in classification are the financial health and credit overdue of a firm. Collateral can be used in the assessment only if it is best-quality. All the firms which pledged best-quality collateral can be classified in grade A, but only until they are less than 30 days overdue. Borrowers with credit ratings D or E are non-performing. All firms for whom there is a substantial likelihood of the loss of part of the financial asset or bank assesses that it will not be paid, are more than 90 days overdue, are insolvent or are in bankruptcy should be classified in one of these two classes.

Credit ratings are pro-cyclical (Amato & Furfine, 2004), thus it is expected to find deteriorating rating structure in economic downturn. This is confirmed in Table 2, which shows that there is a decreasing trend of borrowers with grade A, whose share has dropped by 6.5 percentage points since 2008, whereas the share of non-performing firms has increased by two thirds. A similar shift is also noted from credit overdue in Table 3, where the share of borrowers who are more than 90 days overdue increased by 3 percentage points since its lowest value in 2007. Thus the proportion of firms who are more than 90 days overdue is much lower on bank-borrower level than on firm level, where this proportion increased by 6 percentage points (2.5-times) in the same period. Once a firm is in overdue in one bank, there is a substantial likelihood that in the following periods it becomes a delinquent also in other banks to which

it has liabilities. Especially in economic downturns when firms struggle to repay the debt, significantly increased credit overdue in one bank clearly indicates that the firm has financial problems and thus exhibits a higher credit risk to all banks to which it has liabilities.

Table 2: Credit rating structure, in percentage

	Year			
Credit rating	2007	2008	2009	2010
A	57.35	57.93	53.65	51.44
B	32.72	31.68	32.97	33.94
C	5.23	6.06	7.52	7.50
D	3.40	3.15	4.36	4.64
E	1.30	1.18	1.50	2.48
No. of bank-borrower relationships	28318	29876	30633	31524

Source: Bank of Slovenia, own calculations

Table 3: Credit overdue, in percentage

	Year			
Credit overdue	2007	2008	2009	2010
0 days	93.14	90.88	89.34	88.11
1-90 days	3.42	4.99	5.05	5.41
more than 90 days	3.44	4.13	5.61	6.48
No. of bank-borrower relationships	27118	28598	29472	30447

Source: Bank of Slovenia, own calculations
Note: All the observations with no data for credit overdue are excluded.

Table 4 shows the distribution of firms according to their credit rating and credit overdue in particular bank in the period 2007-2010. It shows that these two measures exhibit a quite different assessment of firms' riskiness. Although according to the Regulation credit grade D should include borrowers that are in relatively bad condition or are more than 90 days overdue, around 50% of D borrowers is repaying its obligations without overdue. On the other hand, among borrowers who are more than 90 days overdue, around 5% are classified as A borrowers and 38% are classified in grades A, B or C.

Table 4: Credit ratings versus credit overdue for the period 2007-2010

Overdue in days		Credit rating					
		A	B	C	D	E	Total
0	Frequency	60200	35767	5786	2327	284	104409
	Row percentage	57.66	34.26	5.54	2.27	0.27	100
	Column percentage	96.90	91.63	73.62	50.81	14.59	90.29
1-90	Frequency	1667	2498	914	368	44	5491
	Row percentage	30.36	45.49	16.65	6.70	0.80	100
	Column percentage	2.68	6.40	11.63	7.88	2.26	4.75
>90	Frequency	261	768	1159	1928	1619	5735
	Row percentage	4.55	13.39	20.21	33.62	28.23	100
	Column percentage	0.42	1.97	14.75	41.30	83.15	4.96
Total	Frequency	62128	39033	7859	4668	1947	115635
	Row percentage	53.73	33.76	6.80	4.04	1.68	100
	Column percentage	100	100	100	100	100	100

Source: Bank of Slovenia, own calculations

Banks probably use also internal soft information in determining firms' credit rating. Credit overdue is not the only measure for classifying borrowers into credit grades. Close relationship with firms can provide a more detailed information which can not be inferred from firms' financial accounts but adds

valuable information in assessing firms' creditworthiness. For this reason credit overdue and credit ratings exhibit quite different risk structure. However, the proportion of borrowers with more than 90 days overdue in high credit grades still seems quite high. Firms with best-quality collateral can be kept in credit grade A only until they are less than 30 days overdue, so once they exceed this treshold, they should also be reclassified into lower grades.

Table 5 displays credit rating transitions which are computed on one-year horizons. In 2009 when macroeconomic conditions deteriorated significantly, banks downgraded larger share of borrowers than in the pre-crises period. Comparing to 2009 only downgrades from credit grades C and D increased in 2010, whereas those form A and B decreased. There was also larger proportion of credit rating improvements in 2010. Despite the first signs of slowdown in the second half of 2008, banks upgraded higher proportion of borrowers in 2008 than a year before when GDP grew by 6.9%. In the following sections we check what would be the change in rating structure according to the model-estimated PDs.

Table 5: Proportions of increases, decreases and no changes in credit ratings, in percentage

	Rating increased				Rating did not change				Rating decreased			
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
A					89.93	91.37	87.09	87.60	10.07	8.63	12.91	12.40
B	9.59	10.06	3.83	7.28	82.96	79.17	81.90	81.16	7.45	10.77	14.27	11.56
C	20.99	21.72	11.03	15.88	68.23	65.71	71.07	63.79	10.77	12.57	17.89	20.33
D	16.47	22.77	10.84	10.06	78.74	69.64	79.24	62.45	4.79	7.59	9.92	27.49
E	8.51	12.08	2.94	3.63	91.49	87.92	97.06	96.37				

Source: Bank of Slovenia, own calculations
Note: Percentages of credit rating transitions are calculated on one-year horizons.

3. Empirical model

Credit losses are typically measured with expected loss, which is a product of probability of default, loss given default and exposure at default ($EL=PD*LGD*EAD$). While PD is countercyclical, recovery rates are usually pro-cyclical since the value of collateral usually falls in economic downturn. Bruche and Gonzalez-Aguado (2010) find that macroeconomic variables are in general significant determinants of default probabilities but not so for recovery rates. They show that although variation in recovery rate distributions over time has an impact on systemic risk, this impact is small relative to the importance of the time variation in default probabilities. Hence, we focus on modeling PD, which also enable us to compare estimated PDs with credit rating classification by banks.

Many different approaches for modeling default probability are proposed in the literature. Altman (1968) proposes a model which relies on firm-specific variables, like asset turnover ratio, EBIT/total assets, working capital/total assets, etc. With some modifications this approach is widely used nowadays. Instead of discriminant analysis modeling technique researchers now use logit or probit models. Since the defaults are correlated aggregate time varying factors (like GDP growth, unemployment rate, etc.) have to be included in the models. These factors are common to all obligors and drive their credit risk into the same direction. In this respect we follow previous work by Bangia et al. (2002), Jimenez and Saurina (2004), Carling et al. (2007), Bonfim (2009) and others. Some authors, such as Jimenez and Saurina (2006), Foss et al. (2010) and Festić et al. (2011) stress another important aspect of macro effects on credit risk, arguing that strong GDP or credit growth before the crisis may have increased the share of defaulted firms or deteriorate NPL dynamics. The reason for this is that banks apply looser credit standards in expansions and thus attract more risky borrowers, which shows up during recessions when default rates rise.

Merton (1974) introduces a structural credit risk model where defaults are endogenously generated within the model. It is assumed that the default happens if the value of assets falls short of the value of liabilities. One of the model's major drawbacks is the availability of market prices for the asset value. Such data are usually not available for small and medium sized enterprises. As shown by Hamerle et. al (2003), Rosch (2003) and Hamerle et. al (2004) it is possible to overcome this problem with latent vari-

able approach. They model the default event as a random variable Y_{it} which takes value 1 if firm i defaults in time t and 0 otherwise. The default event happens when borrower's return on assets, R_{it}, falls short of some threshold c_{it}. The probability that a firm i will default in time t, given the survival until time t-1 is described by the threshold model:

$$\lambda_{it} = P(R_{it} < c_{it} | R_{it-1} \geq c_{it-1}). \quad (1)$$

Equivalently this probability can be described with discrete time hazard rate model which gives the probability that firm i defaults in time t under the condition that it did not default before time t:

$$\lambda_{it} = P(T_i = t | T_i > t - 1). \quad (2)$$

As discussed by Hamerle et al. (2003) it can always be assumed that the default event, Y_{it}, is observable. On the other hand the observability of the return on firm's assets, R_{it}, depends on the available data. If R_{it} is observable then the model is linear. Otherwise a nonlinear model, such as logit or probit, is estimated which treats the return on assets as a latent variable.

We estimate the probability that firm i defaults in year t given that it did not default in previous year $P(T_i = t | T_i > t - 1)$ using different specifications of the model:

$$P(Y_{it} = 1 | X_{it}, Z_t) = F(\alpha + \beta X_{it} + \gamma Z_t) \quad (3)$$

where Y_{it} is a binary variable which takes value 1 if firm i defaults in time t and 0 otherwise, α is constant term, X_{it} is a vector of firm specific variables including also time invariant factors like sector dummies and Z_t is a vector of time varying explenatory variables, such as time dummies and macroeconomic effects. $F(\bullet)$ is cumulative distribution function which is standard normal distribution function $\Phi(\bullet)$ in the case of probit model and logistic distribution function $\Lambda(\bullet)$ in the case of logit model.

The estimated PDs are used in comparison to credit rating classification by banks. Banks can observe firms' riskiness in time t through monitoring process and can also observe the state of the economy. Moreover, the main criterion that banks consider in classifying borrowers in credit grades is credit overdue, which is available to banks regularly in time t. This means that in time t banks have a large set of information to decide about firms' creditworthiness. To ensure that we are using the same set of information as available to banks in time t we include all the variables in the model at their values in time t, with few exceptions.

To estimate $P(Y_{it} = 1 | X_{it}, Z_t)$ we apply random effects probit model. This estimator is most often used in other research and is the underlying model in Basel II risk assessment procedures. Hamerle et al. (2003) show that when only defaults are observable, an appropriate threshold model leads to random effects probit or logit model.

We use the measures of goodness of fit described by BCBS (2005) and Medema et. al (2009). The most often used method for determining the discrimination power of binary models is Receiver Operating Characteristics (ROC) curve. It is obtained by plotting hit rate (HR) against false alarm rate (FAR) for different cut-off points. HR is percentage of defaulters that are correctly classified as defaulters and FAR is percentage of non-defaulters incorrectly classified as defaulters. The area under this curve indicates that the model is noninformative if it is close to 0.5 and the closer it is to 1, the better the discriminating power of the model.

The Brier Score is defined as $BS = \frac{1}{N}\sum_{i=1}^{N}\left(\widehat{PD}_i - Y_i\right)^2$ where $\widehat{PD}_i$ is estimated probability of default. As explained by Medema et. al (2009) it can be interpreted as the mean of the sum of squares of the residuals. The better the model, the closer BS is to zero.

Finally, pseudo R^2 is based on log-likelihood values of estimated model (L_1) and a model which contains only constant as explanatory variable (L_0): $Pseudo\ R^2 = 1 - \frac{1}{1+2(logL_1 - logL_0)/N}$. We also use Likelihood Ratio (LR) test which enables to compare two models of which one is nested into the other. It is defined as $LR = 2\left[logL(\hat{\theta}) - logL(\tilde{\theta})\right]$, where $L(\hat{\theta})$ and $L(\tilde{\theta})$ are log-likelihoods of unrestricted and restricted models, respectively.

4. Results

In the first part of this section, we present the estimation results of different credit risk model specifications. Estimated PDs from the two model specifications that best fit the data are then used in the second part in the comparison of estimated PDs to credit rating classification by banks. In the third part we check the robustness of the obtained results by excluding a variable that measures number of days a firm has blocked bank account from the model.

4.1. Estimation results

Table 6 shows the results of random effects probit models with various firm specific variables, sector dummies and time effects. In all the estimates, robust standard errors are used.

The basic model is given in first column of Table 6. It includes only firm specific variables. All coefficients are different from zero at 1% probability and display the expected sign. Total sales displays a negative coefficient, suggesting that larger firms have lower probability of default. Size of a firm is in many researches found as one of the most important ingredient of credit risk models, since smaller firms are in principle less diversified, have lower net worth and are more financially constrained. Similar result is also found for firm age, which indicates that younger firms who are usually more sensitive to shocks default more often.

Quick ratio, which is an indicator of liquidity, measures the ability of firm to use its quick assets (current assets minus inventories) to meet its current liabilities. As expected, firms with higher liquidity ratios have lower default probabilities. Defaulted firms are generally expected to have more debt in their capital structure. The negative sign on the coefficient for debt-to-assets ratio in the model clearly indicates that firms with higher leverage defaults more often. Cash flow, which is a ratio between operating cash flow and revenues, displays a negative coefficient. It is expected that stable, mature and profitable firms generate sufficient cash flows to pay off the owners and creditors. Asset turnover ratio measures firm's efficiency in generating sales revenues with assets. The estimated coefficient indicates that firms that are more efficient default less often. Number of days a firm has blocked bank account also seems to offer an important contribution in explaining firm's credit default. The longer the firms have blocked bank account in a given year, the higher the probability of default.

Number of bank-borrower relationships displays highly statistically significant coefficient with positive sign, which is contrary to the findings of Jimenez and Saurina (2004) and indicates that those firms with more credit relationships have on average higher default probability. This result suggests that less creditworthy firms seek for credit in more banks, possibly because current creditors don't want to lend them anymore or are only prepared to grant smaller amount of credit due to their riskiness.

We now extend the model with aggregate variables, i.e. the sectoral and time dummies. Many authors like Crouhy et al. (2001) and Antao and Lacerda (2011) suggest taking into account the features of the industry when modeling credit risk. In our sample defaulters and non-defaulters are similarly distributed across sectors, with the highest representativeness of Commerce (28%), Manufacturing (18%), Professional activities (17%) and Construction (11%). By includnig sectoral dummies in model (2), the dummy variable for manufacturing firms is omitted, so that the coefficients for other sectors indicate the relative riskiness of a particular sector in relation to manufacturing one. Year dummies (omitting the dummy variable for 2007) are capturing the time effects. It is wider category than macroeconomic variables, which will be added in further specifications, since it also captures institutional, regulatory or any other systematic factors that affect all firms. Although some of the sector dummies are insignificant, it is clear that there are some differences in credit risk across sectors. Sectors like electricity, gas and water supply, information and communication, professional activities and public services are less risky than manufacturing, whereas only accommodation and food service has on average higher statistically significant default probability. By adding both sector and time dummies coefficients of firm specific variables are changed only slightly, which indicates that these two set of aggregate variables are close to independent from firm specific effects. According to likelihood ratio test, sector and time dummies improve the fit considerably comparing to model (1).

Table 6: Estimated PD models (dependent variable is indicator for credit overdue

	Model 1 RE Probit	Model 2 RE Probit	Model 3 RE Probit	Model 4 RE Probit	Model 5 RE Probit	Model 6 RE Probit	Model 7 RE Probit
Firm variables							
Total sales	-0.017***	-0.019***	-0.018***	-0.018***	-0.018***	-0.018***	-0.019***
Firm age	-0.014***	-0.013***	-0.014***	-0.013***	-0.014***	-0.013***	-0.013***
Quick ratio	-0.042***	-0.036***	-0.041***	-0.036***	-0.035***	-0.034***	-0.036***
Debt-to-assets	0.540***	0.560***	0.540***	0.554***	0.542***	0.547***	0.559***
Cash flow	-0.138***	-0.137***	-0.137***	-0.135***	-0.138***	-0.140***	-0.136***
Asset turnover r.	-0.268***	-0.278***	-0.270***	-0.274***	-0.271***	-0.274***	-0.277***
Blocked account	0.007***	0.008***	0.007***	0.008***	0.007***	0.008***	0.008***
No. of bank-borr. r.	0.363***	0.379***	0.369***	0.375***	0.368***	0.371***	0.378***
Sector dummies							
Agric., For., Fish. & Mining		0.070	0.067	0.068	0.067	0.063	0.068
Electricity, gas & water supply		-0.404***	-0.391***	-0.395***	-0.391***	-0.393***	-0.399***
Construction		-0.001	-0.000	-0.001	-0.000	0.002	-0.000
Commerce		-0.045	-0.045	-0.045	-0.045	-0.043	-0.044
Tran. & storage		0.071	0.068	0.071	0.067	0.070	0.072
Accommodation & food service		0.168***	0.156***	0.166***	0.157***	0.161***	0.169***
Inf.& commun.		-0.246***	-0.241***	-0.246***	-0.238***	-0.241***	-0.248***
Fin. & insurance		-0.304*	-0.301*	-0.299*	-0.303*	-0.298*	-0.298*
Real estate		0.087	0.077	0.084	0.080	0.083	0.086
Professional act.		-0.169***	-0.164***	-0.168***	-0.164***	-0.164***	-0.169***
Public services		-0.206***	-0.201***	-0.203***	-0.198***	-0.201***	-0.206***
Time effects							
2008		0.212***					
2009		0.173***					
2010		0.209***					
GDP growth			-0.011***				
Quick r.*GDP gr.			0.006***			-0.001	
NFC loan growth				-0.005***			-0.007***
GDP growth (t-1)						-0.038***	
NFC loan g. (t-1)						0.018***	
Interest rate					0.024***		0.046***
Constant	-2.426***	-2.635***	-2.403***	-2.414***	-2.401***	-2.654***	-2.381***
Observations	68444	68444	68444	68444	68444	68444	68444
Pseudo R2	0.094	0.096	0.095	0.095	0.095	0.095	0.096
Log. lik.	-8382.7	-8313.6	-8331.2	-8326.7	-8332.5	-8328.9	-8321.1
LR test	-	138.4	103.1	112.1	100.4	107.6	123.3
AUC	0.888	0.890	0.889	0.889	0.890	0.890	0.889
Brier score	0.030	0.029	0.030	0.029	0.030	0.030	0.029

Source: AJPES, SURS, Bank of Slovenia and own calculations.
** p<0.10, ** p<0.05, *** p<0.01; Robust standard errors are used.*
Notes: Blocked account is a number of days a firm has blocked bank account, No. of bank-borr. r. measures to how many banks a particular firm is related to. GDP growth is in real terms. NFC credit growth is real growth of loans to non-financial corporations, Interest rate is long-term interest rate on loans to non-financial corporations, AUC is area under ROC curve.

Since the default rate is highly related to the business cycle - increasing in economic downturns - a set of macroeconomic and financial variables is included in models (3) to (7). GDP growth as the main indicator of economic activity is added in model (3). The estimated coefficient suggests that higher economic activity lowers the probability of default, because better macroeconomic situation enables a better performance of all

firms. The only significant interaction effect between GDP growth and firm specific variables is the one with the quick ratio, which shows how the effect of liquidity changes with one percentage point increase in GPD growth and vice versa. Similar result is also found in model (4) where growth of credits to non-financial corporations is used as an alternative indicator of business cycle. According to the likelihood ratio test, credit growth actually seems to be more a powerful business cycle variable for explaining default probability than GDP growth. The interest rate on bank loans is also expected to have an important influence on the borrowers' ability to repay loans. As suggested by the coefficient on interest rate in model (5), a higher interest rate leads to a higher probability of default, which also make sense, since it increases borrowers' credit burden.

Among macroeconomic variables, the credit growth seems to have the highest explanatory power in turns of default probabilities. When credit growth and interest rates are put together, as in model (7), it further improves the fit as can be seen from the likelihood ratio test statistic. We also estimate models with different combinations of business cycle indicators, but many of them were found insignificant or with unexpected sign. Short time series does not allow us to include many variables that vary in time and are constant for all firms.

Model (6) includes GDP and credit growth lagged one year. Lagged GDP growth exerts a negative effect on probability of default, as in contemporaneous case, although the displayed coefficient is now higher in absolute terms. On the other hand, lagged credit growth displays a positive coefficient, which suggests that high past credit growth increases probability of default, as expected. When economic situation turns around, as it did in 2009-2010, and risk premium starts rising due to the tightening credit standards, these borrowers quickly get into trouble and may default on their credit obligations.

4.2. The comparison of estimated PDs to credit rating classification by banks

As the estimated PD exhibit a measure of risk conditional on a large set of available information, it is interesting to compare it to the credit ratings by banks. Credit ratings indeed exhibit the banks' assessment of debtors' ability to repay the debt. For the purpose of comparison, we link firms' probabilities of default with all credit ratings by banks. Since PDs are estimated at firm level a particular firm represents the same level of risk to all banks that have exposure to this firm.

To select the model specification for this analysis we use root-mean-square error, which is defined as $RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(DR_{Pt} - DR_{At})^2}$, where DR_{Pt} and DR_{At} are predicted and actual default rate in time t, respectively. Table 7 shows that the in-sample predicted default rate from model (2), which includes year dummies as time effects, is the most unbiased. This result might be expected since time dummies do not only capture the macroeconomic dynamics but also other institutional, systematic or regulatory changes. Among models with macroeconomic variables, model (7), which includes credit growth and interest rate as business cycle effects, is the most accurate. Since these two models give the most unbiased in-sample predictions for the default rate and have high overall classification accuracy rate (96.3%) we use them in the comparison to the banks' risk grades.

Table 7: Actual vs. in-sample predicted default rate

	2007	2008	2009	2010	RMSE
Actual default rate	3.39	3.95	4.80	4.80	
In-sample predicted default rate					
Model 1	4.07	3.56	4.58	4.36	0.46
Model 2	3.38	3.92	4.71	4.67	0.08
Model 3	3.89	3.46	4.94	4.31	0.43
Model 4	3.66	3.40	4.90	4.68	0.32
Model 5	3.80	3.65	4.98	4.18	0.41
Model 6	3.80	3.82	4.29	4.73	0.34
Model 7	3.58	3.57	4.59	4.92	0.24

Source: Bank of Slovenia, own calculations
Note: In-sample predicted default rate is calculated as average of firms' PDs. It also takes into account individual specific effects, i.e. random effects, which are part of the estimated random effects probit model.

Table 8 shows the distribution of firms according to their credit ratings and the level of estimated PD in the period 2007-2010. In all credit grades, except E, the majority of firms have PD between 1 and 5 percent. Although we would expect borrowers in credit grade D to have high PDs on average, 43% have PD below 5%. Among high-risk borrowers with PD above 50%, around 13% are classified as A borrowers and approximately 57% are classified in grades A, B or C. This results are similar as those in Table 4 where instead of PD, the distribution is done according to credit overdue.

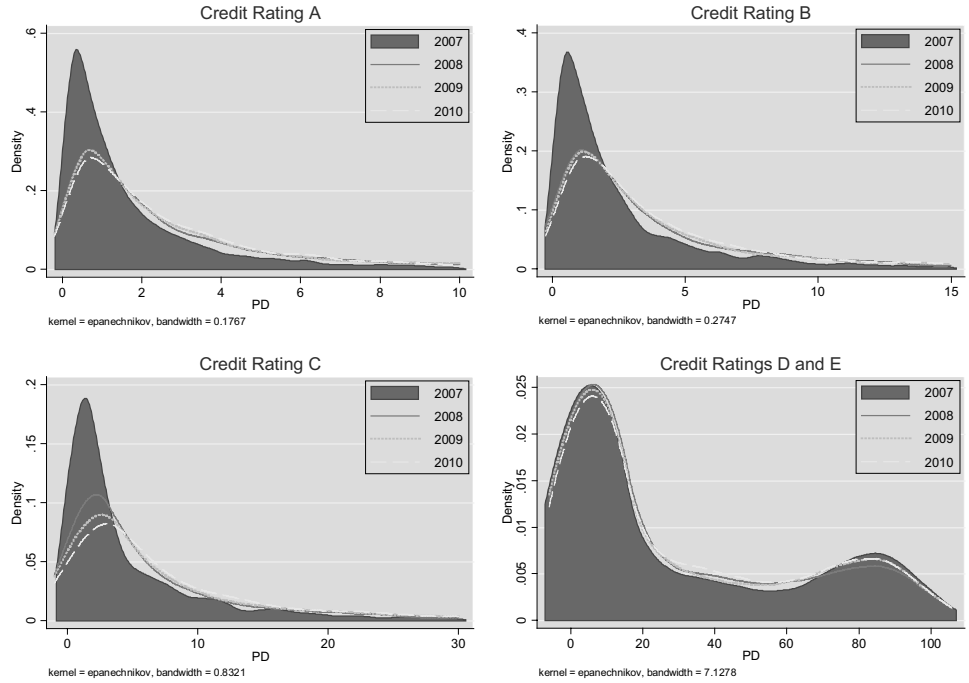
Estimated PDs allow us to test whether banks' rating criteria were constant in time. If banks use unique criteria to assess borrowers riskiness, the risk structure in terms of PDs of firms in each credit grade should be stable in time. Figure 2, Figure 3 and Table 9 indicate that the risk structure was changing in time, particularly in credit grades A, B and C. This can be best seen from the changing shapes in distributions of the estimated PDs in different credit grades. This holds for model (2) estimates (Figure 2) as well as for model (7) estimates (Figure 3), with the largest change in distribution between years 2007 and 2008. In Table 9, average default probability in credit grades A, B and C rose by 1.3, 1.5 and 1.5 percentage point, respectively, as estimated with model (2) and by 0.7, 0.7 and 0.5 percentage point, respectively, as estimated with model (7). This trend continued also in 2009 and 2010 where especially for credit grades A and B model (7) gives more pronounced results. Risk structure deteriorated the most in credit grade C, where the average default probability estimated with models (2) and (7) increased by 4.4 and 4.6 percentage point, respectively, from 2007 to 2010. Somehow surprisingly, in credit grades D and E the average estimated PD actually decreased in 2008. It is possible that this result is driven by small number of borrowers in credit grades D and E.

Table 8: Number of firms according to the estimated PDs with Model 2 and 7, by credit rating

PD	A	B	C	D	E	Total
Model 2						
PD≤1	18641	7596	868	399	16	27590
1<PD≤5	24621	15815	2296	808	57	43597
5<PD≤10	5669	4727	1062	406	58	11922
10<PD≤25	2992	2944	933	383	63	7315
25<PD≤50	748	838	395	285	68	2334
PD>50	202	368	334	504	178	1586
Model 7						
PD≤1	18519	7488	855	396	13	27271
1<PD≤5	24776	15899	2317	815	62	43869
5<PD≤10	5711	4784	1070	386	53	12004
10<PD≤25	2949	2938	924	398	66	7275
25<PD≤50	710	759	398	280	70	2253
PD>50	208	384	324	510	176	1602
Total	52873	32288	5888	2785	440	94274

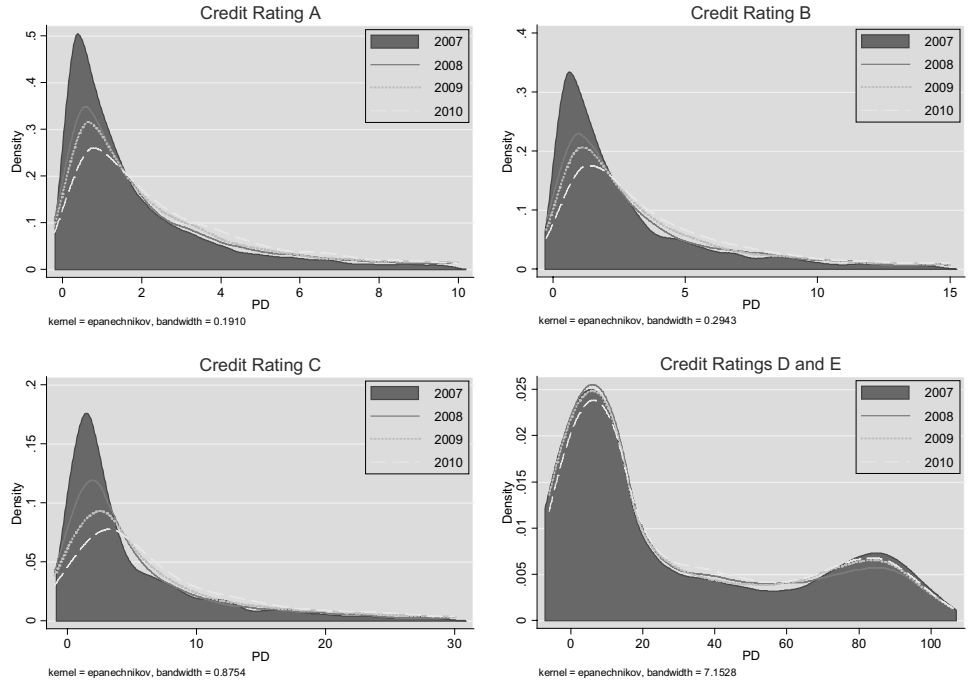
Source: Bank of Slovenia, own calculations

Figure 2: Kernel densities of PDs estimated with Model 2, by credit rating



Source: Bank of Slovenia, own calculations

Figure 3: Kernel densities of PDs estimated with Model 7, by credit rating



Source: Bank of Slovenia, own calculations

Table 9: Summary statistics for PDs estimated with Model 2 and 7, by credit rating

	Model 2						Model 7					
	Mean	St. dev	P50	P90	Skew.	Kurto.	Mean	St. dev	P50	P90	Skew.	Kurto.
Credit Rating A												
2007	2.6	5.8	1.1	5.8	7.8	91.1	2.8	5.9	1.2	6.2	7.4	88.3
2008	3.9	6.7	1.8	9.0	5.0	39.8	3.5	6.3	1.6	8.1	5.3	44.5
2009	4.0	7.3	1.8	9.0	5.3	41.4	3.9	7.2	1.8	8.7	5.4	42.6
2010	3.9	6.6	2.0	8.5	5.4	46.2	4.2	6.8	2.1	9.1	5.2	42.7
Credit Rating B												
2007	4.1	8.9	1.6	8.7	5.7	44.0	4.4	9.1	1.8	9.3	5.6	41.6
2008	5.6	8.9	2.6	12.8	4.2	26.4	5.1	8.5	2.3	11.7	4.4	29.6
2009	6.1	10.4	2.7	14.1	4.2	25.8	5.9	10.3	2.6	13.7	4.3	26.6
2010	5.9	9.7	2.9	13.3	4.5	28.6	6.2	9.9	3.1	14.1	4.3	27.1
Credit Rating C												
2007	8.7	15.9	2.7	22.6	3.4	15.4	9.0	16.2	2.9	23.7	3.3	14.8
2008	10.2	15.6	4.1	26.6	2.7	10.9	9.5	15.1	3.7	24.8	2.9	11.6
2009	12.7	19.1	5.0	38.4	2.4	8.4	12.4	18.9	4.8	37.4	2.4	8.6
2010	13.1	18.8	5.7	37.6	2.4	8.7	13.6	19.0	6.1	38.8	2.4	8.5
Credit Rating D												
2007	22.2	29.9	5.8	79.1	1.3	3.2	22.7	30.1	6.3	80.0	1.3	3.1
2008	16.9	22.8	6.4	55.9	1.7	4.7	16.0	22.2	5.7	53.6	1.7	5.0
2009	21.2	27.6	6.2	72.5	1.3	3.4	20.9	27.4	6.0	71.6	1.4	3.5
2010	23.2	28.0	8.9	74.2	1.2	3.1	23.8	28.2	9.4	75.2	1.2	3.0
Credit Rating E												
2007	42.9	36.0	34.1	92.7	0.2	1.4	43.5	36.1	35.2	93.1	0.2	1.4
2008	30.9	27.9	18.5	75.1	0.7	2.2	29.4	27.4	17.0	73.1	0.8	2.3
2009	47.0	35.1	40.3	91.6	0.1	1.3	46.5	35.0	39.6	91.2	0.1	1.3
2010	42.5	33.1	33.5	92.6	0.4	1.7	43.2	33.1	34.4	92.7	0.3	1.7

Source: Bank of Slovenia, own calculations
Notes: P50 and P90 are 50th and 90th percentile, respectively. St. dev., Skew. and Kurto. are abbreviations for standard deviation, skewness and kurtosis.

To get a more clear insight in comparing risk evaluations we check what would be the model-predicted rating structure if banks would keep constant rating criteria in time. To be able to do this we need to predict credit ratings by setting threshold PDs between each credit grade. Since there is a lot of overlapping in default probability between credit ratings, perfect discrimination is not possible. Hence, we set the cut-off PDs so as to ensure that the predicted rating structure in a particular date is equal to actual one. We use as a point of reference first 2007 and then 2008. Thus for 2007, we classify the top 56.22% in terms of PDs of firms as A borrowers, next 34.14% as B and so on. In this way, rating structure does not change, but the actual and predicted structure of borrowers in each credit grade is quite different. We repeat this in predicting credit ratings based on rating structure in 2008.

Table 10 shows the actual and predicted rating structures based on estimates with models (2) and (7). We focus on the crises years 2009 and 2010. Based on the estimated default probabilities with model (2), the proportion of A borrowers should have been lower for 15.8 pp in 2009 and 17.4 pp in 2010 if banks would apply the same rating criteria as in 2007. Similar results are also found with model (7), although with slightly better predicted rating structure in 2009. Using thresholds from 2008, predicted rating structures based on model (2) are almost equal to actual ones. On the other hand, based on model (7), the proportion of A borrowers should have been 6.6 pp lower in 2010.

Table 10: Actual vs. predicted rating structure, in percentage

			Model 2				Model 7			
	Actual		Cut-off 2007		Cut-off 2008		Cut-off 2007		Cut-off 2008	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
A	55.39	54.28	39.54	36.87	56.41	54.67	43.88	37.37	53.79	47.64
B	34.25	35.88	45.33	48.39	33.28	35.40	42.81	48.00	35.23	40.53
C	7.07	6.39	8.83	8.75	6.58	6.53	7.64	8.70	7.06	7.92
D	3.03	3.17	5.55	5.33	2.96	2.73	4.99	5.26	3.10	3.07
E	0.27	0.28	0.76	0.66	0.76	0.67	0.68	0.67	0.82	0.85

Source: Bank of Slovenia, own calculations
Notes: Only firms included in the model are taken into account.

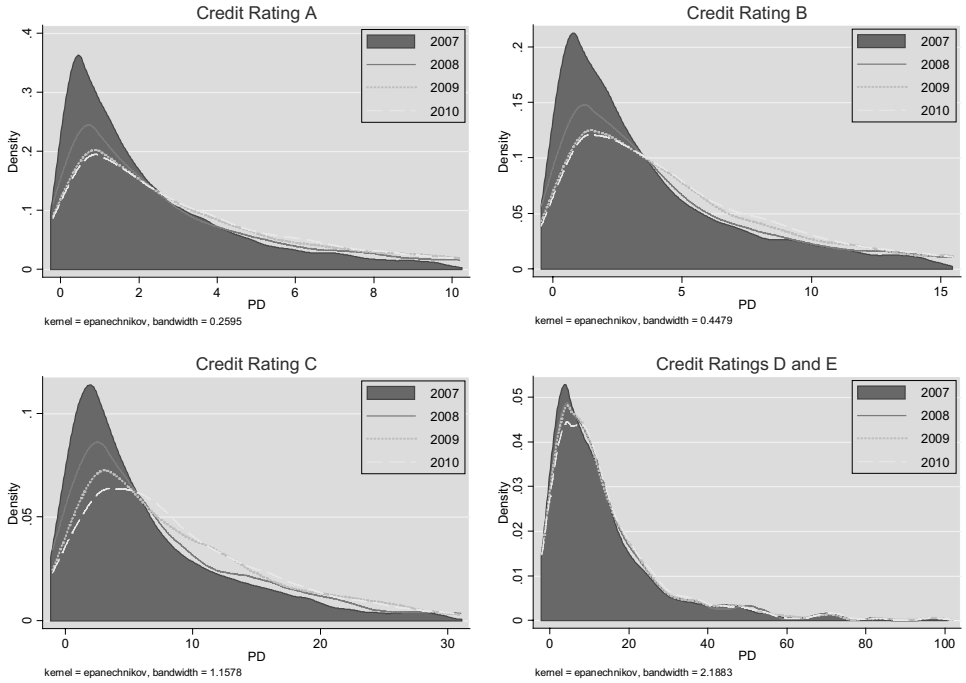
Besides the indication, that the risk assessment strategy by banks might have significantly changed over time, one could interpret these results in two ways. On the one hand, the banks risk classification might underestimate the underlying risk structure, with the risk grades attributed being too high. This could be due to a possible underestimation of the underlying risk. In particular, systemic risk factors might be more accurately captured in the model, which includes the macroeconomic factors, that drive average default probability over the business cycle. On the other hand, this could also be due to banks taking into account additional borrower-related information, e.g. the information gathered through bank-borrower relation, or to the lags in reclassification process.

4.3. Robustness check

To test the validity of the obtained results we exclude the variable that measures the number of days a firm has blocked bank account from the model. This variable could be a source of endogeneity bias since both, the dependent variable, which is based on credit overdue, and Blocked account are measures of default.

We reestimate model (2) by excluding Blocked account. All the estimated coefficients are highly statistically significant and display the expected sign. Discriminating power of the model, measured with area under ROC curve, is slightly lower and is equal to 0.83. As before, we use the estimated PDs in the comparison to credit rating classification by banks. As shown in Figure 4, the results are similar as before and indicate that in the crisis the risk structure of borrowers in credit grades A, B and C deteriorated. The largest change in the distribution is between years 2007 and 2008, when average default probability in credit grades A, B and C rose by 0.8, 1.0 and 0.9 percentage point, respectively. Although there are some differences in the shapes of distributions of estimated PDs, the results seems to be robust also when Blocked account is excluded from the model.

Figure 4: Kernel densities of PDs estimated with Model 2, excluding Blocked account, by credit rating



Source: Bank of Slovenia, own calculations

5. Conclusions

This paper uses the data on the characteristics of non-financial firms which have credit obligations to Slovenian banks. In the first part, we estimate several credit risk models, which suggest that probability of default can be explained with firm specific factors as well as macroeconomic or time effects. We find that model that includes year dummies as time effects performs slightly better than models with macroeconomic variables. This result is expected, since time dummies are much broader category that also capture institutional, regulatory or other systematic changes in time.

Estimated PDs from the two models that fit the best are used in the comparison to credit rating classification. We link estimated firms' PDs with all their relations to banks and analyze banks' classification of borrowers into credit grades. We find that PDs and credit ratings often imply a quite different measure of debtors' creditworthiness. Similar result is also found by using credit overdue instead of estimated PDs. By looking at PD densities for each credit rating, we find that in the crisis banks allow for higher risk borrowers in credit grades A, B and C. This could be due to banks taking into account additional borrower-related information, to the lags in reclassification process or a possible underestimation of systemic risk factors by banks.

One of the shortcomings of the estimated models is short time series. Problematic can be especially coefficients of macro variables, which are based on only four observations. Nevertheless, a supportive argument for the validity of the estimated PDs is that they remain very similar when time dummies are used instead. Also the coefficients on firm-specific determinants of PD all exhibit expected signs, are highly statistically significant and are very stable across different model specifications.

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BRIDGING THE BANKING SECTOR WITH THE REAL ECONOMY: A FINANCIAL STABILITY PERSPECTIVE[1]

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Abstract

The paper builds a macroprudential tool to assess whether a banking sector is adequately prepared to orderly withstand losses resulting from normal or stressed macro and microeconomic scenarios. The link between the banking sector and the real sector is performed through the corporate sector channel. The macroprudential tool consists in a two-step approach. The first one is building a probability of default model for the corporate sector to quantify the 1-year ahead developments in the banks' corporate loans quality. The framework is constructed using micro data and following a bottom-up approach. The second step is to bridge the PD model with a macroeconomic module, in order to capture the feedback effects from the macro stance into the banking sector, through the corporate sector channel. The usage of the macroprudential tool is exemplified on the Romanian economy.

JEL Classification: G32, G21, E17

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1. Introduction and literature review

There are at least two important lessons the crisis has taught about evaluating systemic credit risk. The first one is that the current instruments used to assess the overall banking sector level of risk witnessed important flaws in times of high distress. Probability of default is one of these key instruments. It is used by both banks and the micro and macroprudential authorities (to compute expected and unexpected losses, for stress testing exercises, etc.), but it proved to be procyclical and not very responding to material shocks that occur quite frequently in the real life[4]. The second lesson is that financial stability analysis should look into a deeper macro-prudential perspective, with more emphasis on the link between the real economy and the financial system. Corporate and household sectors, as well as macroeconomic developments, should be more closely integrated into the banking sector credit risk assessments.

The paper builds a macroprudential tool to assess whether a banking sector is adequately prepared to orderly withstand losses[5] resulting from normal or stressed macro and microeconomic scenario. The tool is developed into two steps. In the first step, we build a probability of default (PD) model for the corporate sector. Such models help financial stability evaluation in three avenues: (i) show the main micro factors that best explain companies' behavior in servicing their bank debts, (ii) indicate the level and direction of credit risk that lay in the banks' portfolio within a specific time horizon (1-year ahead PD is the most common tenor) and (iii) point out if the expected loss from the credit portfolio is adequately covered by provisions. The framework is constructed using micro data, following a bottom-up approach and highlighting the main factors that deter firms from servicing their bank loans. We use Basel definition for default (90-days past due default) and firm-level data for all non-financial companies with bank loans. Using financial data reported by all companies, we overcome some of the limitations of other models that are biased towards large firms or small samples. This approach also enables us to draw conclusions for the entire corporate portfolio of a banking sector.

The second step is to bridge the PD corporate model with a macroeconomic module, in order to capture the feedback effects from the macro stance into the banking sector, through the corporate sector channel. We compute how the main macroeconomic variables (annual GDP growth, real effective exchange rate, inflation rate, etc.) may impact corporate PD outcomes. The tool also allows us to use different macro scenarios for both normal or stress times in order to evaluate the ability of the corporate sector to withstand shocks and the degree these shocks are translated to the banking sector.

Forecasting aggregate default rates for the corporate sector based on macroeconomic conditions has gained steam in the literature on financial stability. Viroleinen (2004) shows that, in case of Finland, the evolution of the default rate can be explained by the GDP growth and the level of indebtedness of the corporate sector. Fong and Wong (2008) use a vector autoregressive model to link the default rates with macroeconomic environment for stress-testing purposes. Simmons and Rolwes (2008) embark on finding the determinants of default for Holland, showing that GDP growth and the oil price are representative determinants of default, while the exchange rate and the interest rate seem to weigh less. Band et. al (2008) model the impact of macroeconomic factors on the equilibrium in the corporate debt market and reveal that, on the supply side, this equilibrium depends on the change in the default rate. Jakubík (2007, 2011) applies to the Czech corporate and household sectors a one-factor Merton type model with default barrier depending on the macroeconomic environment.

Finally, we estimate the risks to financial stability via the direct channel. We take into consideration the probability of default (both at individual and aggregate levels) and the exposures to which firms could potentially default. We quantify the risks to financial stability by using the expected loss measure. This figure is compared with the outstanding buffers banks have already built to cover the expected losses.

[4] Kindleberger and Aliber (2005) show that large shocks (as panics or crashes) are quite usual. Standard models for assessing risk consider such material shocks as once-in-a-lifetime events, while they take place every 5 to 10 years.

[5] This tool primarily focuses on loan losses from the corporate sector and thus it provides a partial analysis of the ability of the banking system to withstand shocks (for instance, the banks' exposures to the household sector are not taken into account). Another caveat is that some elements remain insensitive in the macroeconomic scenario (e.g. impact of interest rate changes in banks' profitability), because the main purpose of this tool is to assess whether the banking sector has adequate buffers to withstand expected losses stemming from credit risk. The methodology proposed here might provide a starting-point for a broader macro stress-testing approach with results on profitability or solvability.

The literature discloses three main types of methodologies employed in modeling credit risk for non-financial companies.

1. Linear models split the firms into two groups (defaulters and non-defaulters), using a linear function of the financial ratios. The aim is to maximize the distance between the two groups. These models were first used in credit risk assessment by Beaver (1966) and Altman (1968). *Banque de France* is using a multivariate discriminant analysis technique to estimate a scoring model (WGRA, 2007);

2. Non-linear models (logit and probit) assume the probability of default follows a logistic or normal cumulative distribution function. One of the main developers of the logit model in credit risk assessment is Ohlson (1980). *Banco de España, Banque Nationale de Belgique or Banca Naţională a României* are amongst the central banks using such methodology to quantify the credit risk stemming from the corporate sector (WGRA, 2007; Vivet, 2011);

3. Non-parametric, non-linear models (such as neural networks or support vector machines - SVM) carry the advantage of not being restricted to a certain functional form and are able to better uncover the relationship between the dependent and independent variables. Their main disadvantages are the opaqueness (because is hard to describe the link between each variable and default) and the high number of regressors reflected in a lower precision of the estimated coefficients. *Deutsche Bundesbank* is using an SVM model for assessing credit risk for non-financial companies (WGRA, 2007).

In this paper we use a logistic regression since this type of models deliver better results compared to linear models. Furthermore, Bunn and Redwood (2003), and Chi and Tang (2006) point out to the non-linearity relationship between default and explanatory variables. Malhotra et al. (1999) test the performance of non-parametric models (neural networks and k-nearest neighbor) and find the latter have superior in-sample performance, but lower out-of-sample performance, compared to the logit regression.

Logit models require a large proportion of defaulters in order to produce accurate results. This is an important drawback of such models. In practice, researchers use artificial samples built up with all defaulters and a number of randomly chosen non-defaulters (most often, the sample composition is 50:50) in order to better capture the characteristics of rare events than a low default sample. Hence, the level of PDs will reflect the estimation sample composition and not the true population. King and Zeng (2001) propose a methodology for recalibrating the model to reflect the true default rate by adjusting the intercept in the logit formula and shifting the distribution of the PDs.

The remaining of the paper is organized as follows. Section 2 describes the methodology and the input data for the probability of default model and the macroeconomic module, section 3 applies the macroprudential tool to the Romanian economy, while the last section concludes the main ideas of the paper.

2. Methodology

2.1. Probability of default model: development and calibration

The corporate PD model development is the first step in building our macroprudential tool. We use a logit approach:

$$PD = \frac{1}{1 + e^{\alpha + \beta X}} \tag{1}$$

where PD is the calculated probability of default and X are the explanatory variables.

We winsorize[6] the explanatory variables in the training sample in order to exclude extreme values. From empirical simulations, we find a threshold of 15% being appropriate for a large amount of variables.

[6] Transformation process that limits extreme data values in order to remove outliers. This step is necessary in order to obtain unbiased estimates, especially when the initial values of the variables have very wide distributions. In order to exclude extreme values, we made tail-analysis for each distribution of the balance- sheet variables.

However, for the variables qualified in the final model, we take an in-depth study of the relationship between the natural logarithm of the odds of default and the variable values, modifying the winsorize thresholds according to this function's linearity.

The variables in the forecast sample are winsorized using the same values as in the training sample. When applying the model, we use this technique rather than the same quantiles, because we notice large shifts in the tails of the distributions of some variables over the past few years, resulting in unrealistic shifts in calculated PD due to extreme values. The logic behind winsorizing at the same values as the training sample is that the coefficients are estimated on the same interval of the variable's values.

In order to derive the final default model, additional filters and discriminatory power tests are employed on a pool of candidate explanatory variables and intermediary default models[7].

In the first step, the Kolmogorov-Smirnov (KS) test is applied. The purpose of this filter is to exclude ratios that are independent from default events. A one tail hypothesis test is carried out in order to compare the distributions of the values of defaulters and non- defaulters for each candidate variable. The null hypothesis for this test is that the two groups are drawn from the same continuous distribution. In the next step, we test the presence of a monotone, linear relationship between logarithm of the odds of default and the candidate variables. First, we divide the estimation sample into several sub-groups that contain the same number of observations. For each group, the historical default rate (the empirical logarithm of the odds of default) is established. We run a linear regression between the historical default rate and mean value of the variables and exclude those variables for which the linear regression assumptions are not accepted.

We run univariate logit models for the remaining candidate variables, to check their in and out-of-the-sample discriminatory power. We exclude variables with a univariate ROC less than 55%[8]. The univariate analysis is an important step due to the following reasons: (i) robustness checks of the coefficients and (ii) individual discriminatory power (in this stage we are not interested in the univariate PD estimate, but only in the capacity of the variable to select "good" from "bad' companies).

We test the lasting variables for multicolinearity. We compute their correlation matrix. The selection is based on the ROC levels achieved a9t the previous step. Variables are dropped if the correlation coefficient is higher than 0.7[9].

After filtering the candidate variables we proceed to derive a multivariate model of default. We use a backward selection method where we initially estimate the full model - including all the variables which passed the selection filters - and then eliminating the worst covariates based on their significance (calculated with likelihood ratio test).

The process of estimation of the multivariate model of default is split into two steps. First, we run a bootstrapping exercise by conducting 100 simulations. In each simulation we derive a multivariate model using the backward selection method and a proportion of 50:50 of defaulted to non-defaulted companies. For this purpose, we use all defaulted firms and we draw a random sample out of the non-defaulted firms of same size as the defaulted ones. In this way, we ensure that the model is able to better capture the characteristics of defaulting entities. Finally, we count how often a certain model specification is obtained, as well as how often each explanatory variable is observed during the simulations. In order to avoid sample biases, we use another similar bootstrapping procedure where we compute the coefficients by using only the variables of the model with the highest occurrence.

This un-calibrated model bears a number of drawbacks which may result in an underestimation of the PD in times of high stress. These drawbacks mainly relate to: (i) a certain pro-cyclicality degree of the PD outcome, (ii) low frequency of companies' financial data (semiannual) and (iii) the considerable delay between the end of reporting date of the financial statements and the date when these figures are

[7] A comprehensive approach for the methodology used to run these tests is provided by Mircea (2007).

[8] The main purpose of this threshold is to indicate that a candidate variable shows evidence of discriminatory power. Our findings indicate that a higher threshold would not have a major impact on the number of variables to be considered for the multicolinearity test.

[9] The idea is to set the threshold high enough in order to exclude high correlated variables.

effectively available for analysis. In such conditions, the latest explanatory variables might not incorporate the most recent economic developments, which might lead to an over/under estimation of the true PD. In order to alleviate these drawbacks, we use King and Zeng (2001) methodology for recalibrating the model to reflect the true default rate by adjusting the intercept in the logit formula with a coefficient dependent on the two rates:

$$\log(\frac{PD}{1-PD}) = \alpha + X\beta + \log(\frac{\pi_d}{1-\pi_d} / \frac{p}{1-p}) + \varepsilon \quad (2)$$

where PD is the calculated probability of default, π_d is the default rate at which we calibrate the PD, *p* is the average unadjusted computed probability of default for the forecast sample and X is the explanatory variables vector. The advantage of using this correction method is that it changes only the intercept of the logit formula without affecting the discriminatory power of the model (basically it shifts the PD distribution so that the mean of the distribution of the PDs converges to π_d).

2.2. Macroeconomic credit risk module

The second step in building the macroprudential tool is to adjust the PDs with the forecasted default rate, based on the methodology proposed by Jakubík (2007) consisting in an one-factor Merton type model with default barrier depending on macroeconomic environment.

This type of model assumes a random variable with a standard normal distribution for the standardized logarithmic assets returns of economic agent i at time t:

$$R_{it} = \sqrt{\rho} F_t + \sqrt{1-\rho} U_{i,t} \quad (3)$$

where:

- R_{it} denotes the logarithmic asset return for economic agent *i* in economy at time *t*,
- F_t stands for the logarithmic asset return of the economy at time *t*, which is assumed to be a random variable with a standard normal distribution,
- U_{it} represents the economic agent-specific asset return, which is assumed to be random with a standard normal distribution,
- ρ_i is the correlation of the economic agent's asset return with the systematic factor F_t.

The variable Ft represents the part of the asset return which is not specific to the economic agent and might be attributed to the general macroeconomic conditions. Ft and Uit are assumed to be uncorrelated.

In order to model aggregate credit risk by incorporating different macroeconomic indicators, we assume that the value of the default threshold depends on the state of the economy. This is modeled by taking a linear combination of macroeconomic variables (x_{it}) to represent the value of the default threshold .

The final representation of the macroeconomic one-factor credit risk model used in this model is given in equation (4), where ψ denotes the cumulative distribution function of the standard normal distribution that represents the impact of a change in the macroeconomic indicators, β_0 is a constant and β_j are the coefficients of the macroeconomic variables x_{jt} :

$$p_{it} = P(R_{it} < T) = P(\sqrt{q} F_t + \sqrt{1-\rho} U_{it} < \beta_0 + \sum_{j=1}^{N} \beta_j x_{jt}) = \Psi(\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt}) \quad (4)$$

The default probability conditional on the realization Ft (noted as ft) of a random unobservable factor representing the state of the economy at time t corresponding to the default probability (4) is given by formula (5).

$$p_i(f_t) = P(U_{it} < \frac{\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}}) = \Psi(\frac{\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}}) \quad (5)$$

If we assume a homogeneous portfolio of non-financial companies in the economy whose asset returns follow process (3), the default rate in the economy will converge - based on the law of large numbers - to the companies default probabilities. The specification of the model obtained from equation (4) is:

$$p_t = \Psi(\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt}) \quad (6)$$

where pt represents the default rate of the corporate sector, β_0 is a constant, x jt is the vector of macroeconomic variables and β is the coefficient vector.

In order to estimate model (4) we assume that, at each point in time, the conditional number of defaults dt is a binomial distribution with conditional probability given by equation (5) and the number of economic agents nt . Then the macroeconomic model is calibrated by maximizing the following likelihood function:

$$l(\beta_0,...,\beta_N,\rho) = \sum_{t=1}^{T} \ln\left\{ \int_{-\infty}^{\infty} \binom{n_t}{d_t} \Psi\left(\frac{\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}} \right)^{d_t} \left[1 - \left(\frac{\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}} \right) \right]^{n_t - d_t} \phi(f_t) df_t \right\}$$

where $\phi(f_t)$ is the density function of the standard normal distribution.

The role of the macroeconomic module is to estimate the future default rate, based on the developments in the macro variables (GDP, exchange rate, interest rate, etc.). The link with the PD model is made through the calibration method (King correction formula), which shifts the distribution of the PDs in order to reflect the developments in the macroeconomic context (represented by the annually forecasted default rate - π_d in equation [2]). This methodology also helps to avoid cases where GDP growth, exchange rate, etc. prove to be statistically insignificant or display a wrong sign in the logit formula, since their coefficients have been estimated point-in-time, based on past/non- crisis information.

2.3. Measuring the risk to financial stability

The main aim of this macroprudential tool is to assess whether a banking sector holds adequate volume of prudential buffers in order to withstand expected losses from normal or adverse developments in the macroeconomic stance. There are three additional uses of this tool for the financial stability purposes: (i) to evaluate the overall and sectorial distribution of risk in the real economy, (ii) to gauge the trend of the overall default rate for the corporate sector, highlighting the most likely direction in the banks' non- performing loan ratio and (iii) to complement the macroprudential approach with a micro perspective, in order to compute the portfolio at risk of those banks that might put pressure on the financial stability (e.g. systemically important institutions).

Total expected loss (EL) is computed using the following equation:

$$EL = \sum_i PD_i \cdot E_i \cdot LGD \quad (7)$$

where PDi is the probability of default for obligor i, Ei is the total loans of obligor i and LGD is loss given default (due to lack of information, LGD is assumed to be constant across all obligors, at 45%, as stipulated in the Basel II).

3. Empirical results

3.1. Results from the probability of default model

We compute the PD model (Table 1) for the corporate sector of the Romanian economy, using the methodology presented in section 2.1. The explanatory variables consist of 47 financial ratios and 9 additional dummy variables (8 for the sectors in the economy and one size dummy). The data used for building the PD model was obtained from:

a) the financial statements reported by companies to the authorities (e.g. Ministry of Public Finance, Trade Register, etc.). The database used in the model development stage consists of approximately 610,000 companies (December 2009). We exclude companies with invalid financial statements (such as negative turnover or total assets);

b) the defaults booked in the credit registers. In the case of Romania, this register is a database where all banks report exposures exceeding around EUR 5,000, at the obligor level. This credit register consists of around 220,000 credits and 90,000 individual debtors. The intersection of the above-mentioned databases delivers more than 90% of all credit to non-financial companies sector.

An out-of time analysis of the PD model is employed on a sample consisting of the 2010 financial statements and the observed defaults during January 2010 - December 2011. After validating the model, the PDs for 2012 are forecasted based on the 2011 semiannual financial statements.

Table 1: Logit model for 1-year default horizon using 2009-2010 data

-Number of observations in the dataset used for building the model: 68,463 out of which 6,903 defaults

-Number of observations in the bootstrapping exercise: 13,806 out of which 6,903 defaults

-In sample ROC: 84,2%

-Out of time ROC (2010-2011): 85,5%

-Neutral cost policy function:

o Optimal cut-off (2010): 9.5% implying a Hit rate: 72% and False alarm rate: 17% in 2011

Variables	**Coefficient**	**Standard error**
Adjusted intercept	-1.2395	n.a
Debt to equity	0.0496	0.0045
Debt to value added	0.0630	0.0101
Interest cover ratio	-0.0424	0.0083
Receivables cash conversion days	0.0045	0.0003
Sales growth	-0.6223	0.0622
<15 days past due dummy	1.6419	0.0728
15-30 days past due dummy	2.2398	0.1064
30-60 days past due dummy	2.8703	0.0944
60-90 days past due dummy	3.6170	0.1341

n.a. – not applicable

The variables used in the model, their individual performance and the descriptive statistics on the data structure are detailed in the Appendix (Tables 1, 2, 3 and 4). The samples consists of all companies having bank loans and not being in default at the beginning of the period (i.e. no overdue payment of more than 90 days past due in the last 12 months prior to the compilation of the sample). The performance of the model and other results are presented in the Appendix.

We find that the main factors explaining firms' ability to service the bank debts in our empirical case are: (i) debt to equity, (ii) debt to value added, (iii) interest cover ratio, (iv) receivables cash conversion days and (v) sales growth. A higher leverage indicates that the company might bear debt higher than its capacity to service the obligations pertaining to commercial clients and financial creditors. Debt to value added measures the ability of the firm to efficiently use its debt resources to generate profit: lower values

for this variable are associated with smaller chances of default. Interest burden is a measure of the cost of indebtedness relative to the volume of activity: as the variable goes up, higher probabilities of defaults emerge. The period of time for the account receivables to be converted into cash has a direct implication on default: a delay of cash-inflows from customers will be ultimately transmitted into a delay of debt service payment, which may cause a firm to default. Sales growth has also an important impact on credit risk assessment indicating the evolution of the firm's activity.

In order to assess the model robustness, we perform an out-of-time analysis to check the discriminatory power and the calibration performance of the model. The model calibrated to the registered annual default rate of year 2010 (using equation [1]) has the same discriminatory power as the model calibrated using the actual default rate. For both these models, in- and out-of-sample ROCs show a very good discriminatory power (84.2% and 85.5% respectively, Chart 1, Appendix). Furthermore, the optimal cut-off point that can be used to make binary predictions in 2010 is 9.5% (Chart 2, Appendix), implying a 72% hit rate and a false alarm rate of 17% in 2011. The only important difference between the models is given by the levels of PDs, which are overestimated in the first case (Charts 3 and 4, Appendix). We calibrate the PDs aiming at converging to the "true" annual default rate. The results in Table 1 represent the calibrated model with the actual default rate of 2011. The binomial test reveals that, in some cases, the model underestimates the PDs for the construction and the trading sectors (Table 5, Appendix). This can be explained by the use of the same default rate for calibration purposes, instead of multiple default rates (e.g. default rate for each economic sector, for rating classes, etc.).

Finally, in order to extract the estimated 1-year ahead PDs starting with the date the analysis is performed, we run a calibration using the default rate registered in 2011. Since the actual default information for the period is unknown, we use a forecasted default rate stemming from the macroeconomic credit risk module described in part 2.2. The results are presented in the next section.

3.2. Results from the macroeconomic credit risk module

The data used for building the macroeconomic credit risk module are selected from 36 quarterly macroeconomic time series (between 2003 Q1 and 2011 Q4). All the figures are collected from the central bank macroeconomic forecasting model in order to have consistency between the last-mentioned instrument used for price stability purposes and the tool we present in the paper, used for financial stability purposes. The dependent variable is the quarterly registered default rate.

The macro variables that proved to be representative for explaining the corporate default rate are: (i) annual GDP growth (GDP growth), (ii) change in the real effective exchange rate (REER), (iii) CORE1 annual inflation rate (CORE1) and (iv) the FX interest rate spread (spread), computed as the difference between real interest rate for lending and 3M EURIBOR in real terms. The coefficients for these variables comply with the sign restrictions and are statistically significant. The model specification that includes these variables is characterized by the smallest root mean square error (RMSE). The errors have been tested for both autocorrelation and heteroskedasticity.

We re-write the equation (5) in the following form:

$$p_t = \Psi(\beta_0 + \beta_1 gdp\,growth_t + \beta_2 reer_{t-1} + \beta_3 CORE1_{t-2} + \beta_4 spread_{t-2}) \quad (8)$$

where the values for the coefficients are presented in Table 2.

Methodology	Jakubík (2007)		
Time interval	**March 2003 – December 2011**		
Number of observations	**34**		
Number of variables	**6**		
Variables	**Lag**	**Coefficient**	**Standard error**
Constant	-	-2.0450	0.0790
GDP growth (yoy)	0	-0.0215	0.0061
REER (qoq)	1	0.0921	0.0151
CORE1 (yoy)	2	-0.0295	0.0089
spread	2	0.0222	0.0088
ρ	-	0.0001	0.0055
R-squared	83.95		
LR - test	94.98		
RMSE	0.020		

Since almost all of the time series are lagged[10], we use the forecasted values from the central bank macroeconomic baseline scenario, which had the following key assumptions for the 2012 euro area[11] developments: (i) annual growth of 0.5%, (ii) annual inflation rate of 1.7% and (iii) 3M EURIBOR interest rate of 1.06%. Based on the 2012 forecasted quarterly default rates, we obtain an annual forecasted default rate of 10.98%, which is used to calibrate the level of the corporate PDs using equation (2).

3.3. The ability of the banking sector to withstand losses

We compute expected losses for the banking sector for year 2012, using the methodology described in section 2.3 and the baseline scenario described in section 3.2. Companies that defaulted during July 2011-December 2011 are excluded from the updated sample and are considered to be in default. We use a constant LGD of 45%[12] across all companies' exposures, in line with the Basel II requirements for internal rating based approach modeling. The macroprudential tool highlights three main conclusions. The monitored banking sector is in a relatively good shape to withstand developments that would manifest in the corporate sector portfolio and in the considered macroeconomic scenario. This is the first conclusion. The gap of provisions is less than 0.11% of the total assets of the banking sector (in December 2011). Such an amount should be covered relatively easy and in an orderly manner. *In extremis*, the level of core Tier 1 capital ratio is sufficient to shelter expected losses stemming from the corporate sector, if the additional costs with provisions would finally translate in capital damages for some particular banks.

The second conclusion is that the gap between the expected losses stemming from the macro scenario and the already uploaded provisions does not display a risk pattern for the financial stability. Moreover, large banks (most likely systemically important entities) do not exhibit material gaps in provisioning. Also, banks that should increase their coverage with provisions are not the drivers in the corporate lending market.

The third conclusion is that the annual default rates remain below their peak (Chart 5, Appendix). Such trend would reflect a decrease in the non-performing loans ratio pace of increase, if new lending gets more steam and the macroeconomic picture does not deteriorate compared with the considered scenario.

[10] Lagged macroeconomic variables can be explained by the fact that a company must have at least 90 days past due payments in order to be in default.

[11] National Bank of Romania - Inflation Report, Inflation Outlook Section, November 2011.

[12] It is true that theory suggests that LGD should fluctuate across an economic cycle. In reality, at least for the emerging European economies, such a behavior is difficult to capture, due to (i) low history with LGD databases and (ii) the credit institutions' policies of not running material collateral liquidations due to actual improper market conditions (price, liquidity, etc.).

4. Conclusions

We build a macroprudential tool to assess whether a banking sector is prepared to orderly withstand losses from the corporate sector developments, in a given macroeconomic scenario. The tool is constructed in two steps. First, we model a logit 1-year ahead probability of default model for the corporate sector using micro data, with Basel II definition of default and following a bottom-up approach. Second, we bridge the PD model with a macroeconomic module, in order to capture the feedback effects from the macro stance into the banking sector, through the corporate sector channel. The tool is also able to (i) evaluate corporate risk at the sectorial and aggregate economy levels, (ii) gauge the trend of the overall default rate for the corporate sector, highlighting the most likely direction in the banks' non-performing loan ratio and (iii) complement the macroprudential approach with a micro perspective, in order to compute the portfolio at risk of those entities that might put pressure on the financial stability (e.g. systemically important institutions).

We test the tool for the Romanian economy. The conclusions highlight the investigated banking sector is in a relatively good shape to withstand developments that would manifest in the corporate sector portfolio and in the macroeconomic explored scenario. The up-trending level of provisioning is rather easy to be accommodated in an orderly fashion. The main micro factors identified to impair companies from servicing their bank debt are: deterioration in the receivables turnover ratio, sales to total assets ratio, short- term bank debt to total assets and debt to equity, while the macroeconomic factors affecting the corporate default rate are annual GDP growth, change in the real effective exchange rate, CORE1 annual inflation rate and the FX interest rate spread.

The tool proposed in the paper helps the macroprudential policy makers mainly in the following directions: (i) to signal whether the level of some macroprudential instruments (such as solvency ratio or provisions for credit risk) might reach critical benchmarks in the near future, (ii) to give a flavor of the trend and the speed of the corporate sector non- performing loans, or (iii) to flag the need for adjustments in some macroprudential measures (change in the LTV ratio, better credit risk management to avoid unsustainable credit growth, etc.).

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Appendix

Table 1: Financial ratios and filter results

Ratio name/description	Monotony and linearity test	Univariate logit
	R2	ROC
Debt to equity	81%	75%
Short-term bank debt to total assets	38%	50%
Receivables turnover ratio	84%	64%
Sales to total assets	88%	63%
Gross profit to sales	12%	50%
Operational profit margin	56%	63%
Net profit margin	79%	67%
Return on equity	55%	68%
Return on assets	9%	50%
Sales to equity	26%	50%
Sales to receivables	44%	50%
Cost of goods sold to inventories	0%	50%
Debt to value added	84%	67%
Debt to total assets	89%	70%
Debt to equity (one year prior)	11%	50%
Long-term debt to equity	46%	50%
Short-term debt to equity	50%	70%
Credit line utilization ratio	0%	50%
Inventories to cost of goods sold	42%	50%
Inventories to cost of goods sold (one year prior)	27%	50%
Payables turnover ratio (estimation) = short-term non-bank debt / cost of goods sold * 360	52%	62%
Short-term bank debt to total bank debt	0%	50%
Short-term bank debt to equity	0%	50%
Financing mismatch = (short-term debt – current assets) / total assets	65%	60%
Financing mismatch cover ratio = sales / (short-term debt – current assets)	0%	50%
Bank debt growth ratio	0%	50%
Foreign exposure (internal foreign exchange denominated debt + long-and medium-term external debt) / equity	0%	50%
Operational leverage = (Sales – cost of goods sold) / operating profit	50%	50%
Operational leverage (one year prior)	11%	50%
Sales growth rate	56%	64%
Total assets growth rate	43%	50%
Fixed assets growth rate	38%	50%
Investment in fixed assets = (fixed assets at t + depreciation) / fixed assets at t-1	0%	50%
Short-term assets growth rate	34%	50%
Net profit growth rate	42%	50%
Operational leverage change ratio	46%	50%
Inventories change ratio	23%	50%
Liquidity	68%	58%
Acid test	41%	50%
Cash ratio	35%	50%
Operational cash flow to net profit	11%	50%
Operational cash flow to equity	31%	50%
Interest coverage ratio	75%	67%
Interest to total assets	0%	50%
Inventories to total assets	17%	50%
Cash to total assets	22%	50%
Fixed assets to total assets	23%	50%

Table 2: Population statistics: number of companies with bank loans.

	December 2009	December 2010	June 2011
Number of observations	68,463	59,311	48,783
Defaulters (in year T+1)	6,903	4,110	
Default rate	10.08%	6.92%	

Table 3: Population statistics: structure of companies with bank loans by sector of activity:

	December 2009		December 2010		June 2011	
	Obs.	Defaults	Obs.	Defaults	Obs.	Defaults
Agriculture	5.1%	4.4%	5.7%	4.0%	6.3%	-
Mining	0.3%	0.5%	0.3%	0.3%	0.3%	-
Manufacturing	16.2%	15.6%	16.3%	15.1%	17.7%	-
Energy	0.8%	0.6%	0.8%	0.7%	1.0%	-
Construction	9.4%	14.5%	8.9%	13.6%	9.2%	-
Trade	39.6%	36.4%	39.5%	39.5%	40.6%	-
Services	25.7%	25.3%	25.5%	22.8%	22.7%	-
Real estate	2.9%	2.7%	3.0%	4.1%	2.2%	-

Table 4: Descriptive statistics for the variables included in the final model for 2009 and 2010 validation sample:

	December 2009				December 2010			
	Defaulters		Non-defaulters		Defaulters		Non-defaulters	
	Mean	St.dev	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
Debt to equity	10.28	5.71	7.31	6.08	10.25	5.77	7.16	6.12
Debt to value added	3.99	2.35	2.86	2.14	4.31	2.42	3.03	2.25
Interest cover ratio	0.36	2.87	1.87	3.30	0.18	2.91	2.09	3.45
Receivables cash conversion days	104.56	73.95	74.04	66.48	107.53	76.54	77.91	68.07
Sales growth	0.72	0.39	0.88	0.33	0.75	0.40	0.95	0.32

Table 5: Binomial test*

deciles			1	2	3	4	5	6	7	8	9	10
Sectors of activity	Agriculture	PD	1%	1%	1%	2%	2%	3%	4%	5%	8%	37%
		Default rate	0%	0%	1%	1%	2%	2%	3%	5%	7%	28%
		p-value	N/A	N/A	0.7117	0.9319	0.7287	0.8102	0.7479	0.4541	0.8310	0.9997
	Mining	PD	1%	2%	2%	3%	3%	5%	7%	10%	21%	57%
		Default rate	0%	0%	0%	0%	11%	0%	0%	11%	22%	28%
		p-value	N/A	N/A	N/A	N/A	0.1351	N/A	N/A	0.5607	0.5286	0.9971
	Manufacturing	PD	1%	1%	2%	2%	2%	3%	3%	5%	9%	41%
		Default rate	1%	0.2%	1%	1%	1%	2%	4%	5%	10%	39%
		p-value	0.9657	0.9999	0.9964	0.9545	0.9839	0.8276	0.3364	0.2344	0.2297	0.8640
	Energy	PD	1%	1%	1%	1%	2%	2%	3%	4%	9%	30%
		Default rate	0%	0%	0%	2%	2%	4%	0%	6%	8%	33%
		p-value	N/A	N/A	N/A	0.5009	0.5722	0.2855	N/A	0.3600	0.5914	0.3809
	Construction	PD	1%	1%	2%	2%	3%	4%	5%	7%	15%	52%
		Default rate	1%	2%	2%	4%	4%	6%	9%	12%	19%	46%
		p-value	0.5063	0.0967	0.1800	0.0188	0.0433	0.0017	0.0001	0.0001	0.0027	0.9971
	Trade	PD	1%	1%	2%	2%	2%	3%	4%	5%	9%	40%
		Default rate	1%	1%	1%	2%	2%	3%	4%	7%	11%	39%
		p-value	0.9910	0.9994	0.9956	0.7789	0.9323	0.7003	0.5647	0.0000	0.0004	0.8708
	Services	PD	1%	1%	2%	2%	3%	3%	4%	6%	12%	46%
		Default rate	0%	1%	1%	2%	3%	2%	3%	6%	11%	32%
		p-value	0.9945	0.9662	0.9496	0.7693	0.5279	0.9974	0.9751	0.6795	0.8597	1.0000
	Real estate	PD	1%	2%	2%	3%	4%	5%	8%	11%	17%	57%
		Default rate	1%	1%	2%	3%	2%	5%	10%	7%	23%	40%
		p-value	0.5905	0.7936	0.7793	0.4372	0.9216	0.5949	0.1091	0.9605	0.0218	0.9998
	Economy	PD	1%	1%	2%	2%	2%	3%	4%	5%	10%	43%
		Default rate	1%	1%	1%	2%	2%	3%	4%	7%	11%	38%
		p-value	0.9998	0.9999	0.9986	0.9379	0.8218	0.7520	0.1928	0.0001	0.0052	0.9999

**null hypothesis H0: the PD of a category is correct*
alternative hypothesis H1: the PD of a category is underestimated
green - p-value greater than 0.05
yellow - p-value between 0.01 and 0.05
red - p-value less than 0.01

Chart 1: Discriminatory power

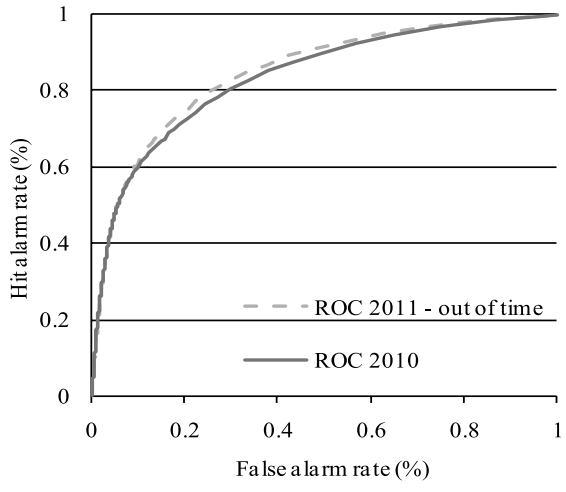


Chart 2: Out of time - performance measure

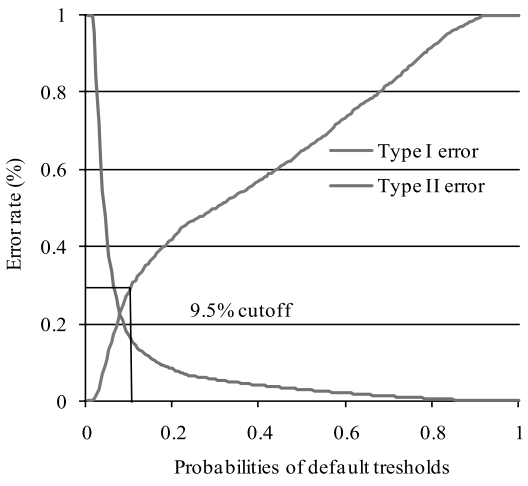


Chart 3:Calibration comparison - economy

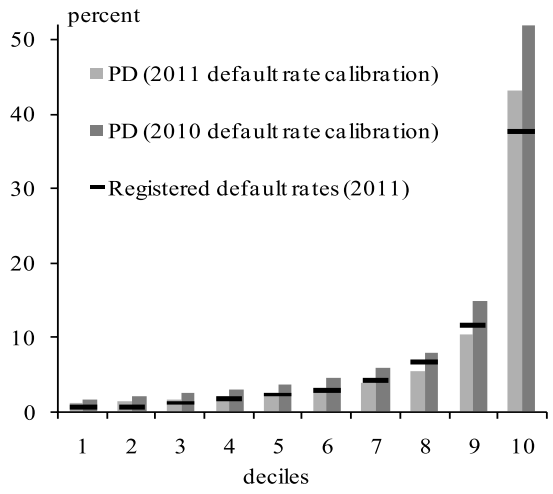


Chart 4:Calibration comparison - sector level

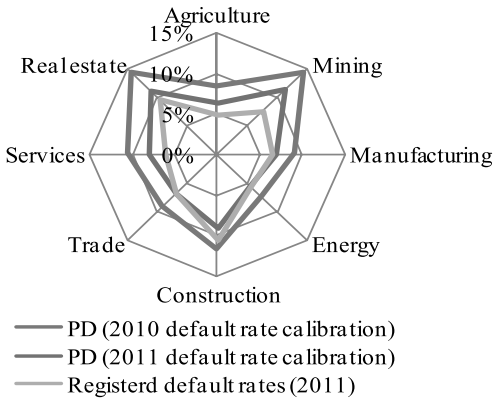
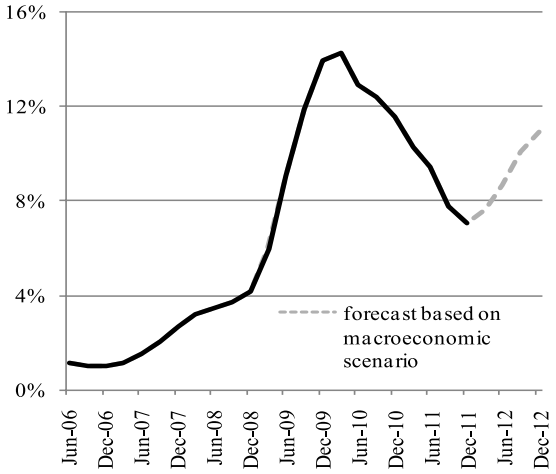


Chart 5: Annual default rates



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IDENTIFYING SYSTEMICALLY IMPORTANT BANKS IN KOSOVO

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Abstract

This article elaborates the concept of the systemic risk in the financial sector, giving emphasis on a relatively new concept in the finance literature, that of systemically important financial institutions (SIFIs). The importance of the debate on SIFIs lies in the fact that these institutions are essential for the smooth functioning of the financial sector, but also their breakdown or bankruptcy poses serious threat to the financial and macroeconomic stability. In order to provide a more comprehensive overview, this article includes a model for identifying systemically important banks (SIB) in the financial sector of Kosovo, which bases on the three criteria, namely, size, substitutability and interconnectedness. The main findings of this analysis are that the three largest banks in Kosovo clearly have systemic importance in all of the considered criteria; three biggest banks, two other smaller banks are also considered as systemically important in the substitutability criterion; whereas, besides having a negligible level of inter-bank correlations, three largest banks in Kosovo results as systemically important.

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1. Introduction

During the financial crises, financial institutions are more fragile to shocks and crises (Bernanke and Gertler, 1989) and may easily cause severe implications in the whole economy. The financial crisis that commenced in 2007/2008 serves as an example where the failure of the individual institutions helped spreading the shocks across the financial system and proclaimed the crisis into the real sector. Therefore, a key policy lesson from the recent financial crisis has been the need to put a greater emphasis on securing financial market stability, by paying special attention to the systemic risk (Tarashev et al., 2010). In effect, the global financial crisis induced a large amount of the rethinking of the previous financial regulatory frameworks (such as Basel II) and motivated reforms in regulating financial institutions, particularly the large and interconnected institutions. This is because, these particular financial institutions are significantly important for the well- functioning of the financial sector as well as other sectors in the economy, and likewise may pose serious consequences for the system and the economy. An emerging literature names these institutions as systemically important financial institutions (SIFIs).

The original idea on the systemic risk is relatively old in the literature, dating back more than twenty years ago. However, in terms of policymaking, the concept of SIFIs is relatively new, and to the best of our knowledge, it emerged no earlier than in 2009.

The purpose of this paper is to analyse the systemic importance in the banking system of Kosovo and to draw attention on the financial and economic costs inferred if the well- functioning of these institutions is disturbed. We will also present an analytical framework and the criteria used as instruments to identify SIFIs in the banking system of Kosovo. The analytical framework is based on the guidelines proposed in the joint report of Financial Stability Board (FSB), International Monetary Fund (IMF) and Bank for International Settlements (BIS) in 2009, which represents the initial initiative/guidance on measures to identify and address SIFIs. This framework has been adopted in a more simplified version in order to accommodate the characteristics of the Kosovo's banking system.

The structure of this paper is organized as follows. The first part of the paper is devoted to the definition of the SIFIs concept, together with a literature review on this field. The second part introduces the criteria to identify SIFIs in the banking system of Kosovo, followed by the analysis of the results.

2. What is systemic risk?

The European Systemic Risk Board (2010) defines the systemic risk as a disruptive event in the financial system that has the potential to promulgate the adverse effects to the internal market, as well as the real economy. Acharya et al. (2009) define the systemic risk as a risk with potential to cause a crisis that spreads throughout the economy; the financial crisis of 2007/2008 may be an example. Thus, systemic events in the financial system become a macroeconomic problem and hence the costs inferred are system wide. IMF, FSB and BIS (2009) provide a definition of the systemic events, together with a set of distortions which may have a system-wide impact:

'**...An impairment or disruption to the flow of financial services** would include situations where certain financial services are temporarily unavailable, as well as situations where the cost of obtaining the financial services is sharply increased. It would include disruptions due to shocks originating outside the financial system that impact on it, as well as shocks originating from within the financial system. A systemic event should be contrasted with more general wealth effects that may have severe macroeconomic consequences but are not associated with the impairment of the financial system...'

The case where one financial institution experiences difficulties in performing its daily tasks due to a risky investment, or a particular bank suffers depositors run, is not considered a systemic risk. This represents a case of the idiosyncratic risk, since the costs inferred from the financial disruption of that bank are equivalent to the value of the transactions between the parties involved (e.g. lenders and borrowers of that bank), thus the costs and risks are of microeconomic significance.

The systemic risk may be defined in terms of the two dimensions, i.e. cross-sectional and time-series dimension. The cross-sectional dimension addresses the issue of the distribution of risk in the financial system or from financial sector into other sectors, e.g. through common exposures or inter-linkages of the banks. Whereas, the time-series dimension refers to the dynamics of the systemic risk during a period, i.e. cyclicality of systemic risk. For example, in more steady-state economies, bank lending is usually highly correlated with the real economic growth rate, giving rise to a procyclical systemic risk. For example, during the booming periods, financial industry usually realizes profits and extends lending via cheaper loans and lower screening criteria; meanwhile the risk perceptions associated with the loan repayment is fairly low. The borrowers on the other side prefer the cheaper loans so they tend to increase the demand for credit. Given that the economy is experiencing a period of growth, the policymakers may also encourage the expansionary lending by banks. This way, by accumulating from one period to another, the systemic risk catches a time-series dimension and becomes procyclical.

3. What are the systemically important financial institutions (SIFIs)?

The definition of the systemically important financial institutions (SIFIs) is not straightforward. This is because different countries have different set of regulatory frameworks and respective institutions for this matter, as well as different level of banking system development. Primarily, SIFIs can be defined from the microprudential and macroprudential supervision perspective. From the microprudential point of view, an institution may be qualified as a SIFI if its failure causes losses to its depositors, lenders and other involved stakeholders, but the adverse effects are isolated to the value of the transactions between the parties involved. On the other side, the macroprudential point of view defines SIFIs as institutions that have important role on the economy, and their failure would trigger repercussions into the overall financial system and impose costs in the whole economy.

To determine whether a financial institution is may be considered as a SIFI, Weistroffer (2011) provides two views. The first view considers SIFIs as relevant and indispensable institutions for the wellbeing of the financial system and the economy. The second view considers as SIFIs those financial institutions, whose malfunction has the potential to infer high costs in the financial sector and transfer them into the real sector.

The concepts of systemic risk and SIFIs are closely related to the concept of contagion effect. The contagion effect in the financial sector represents a propagation process which may drag a simultaneous failure of several institutions or markets at the same time (De Bandt and Hartman, 2000). For example, a failure of a relatively large bank with high exposure on other banks may cause losses on assets and liabilities connected in the interbank market. In effect, a default of a bank may cause the default of other banks through interbank losses or liquidity losses which then may spread throughout the entire financial sector (Iazzetta and Manna, 2009). Thus, if contagion happens, otherwise known as the 'domino effect', it may simultaneously cause confidence loss in the financial markets, consequently causing a bank run, interbank placement losses, drop in crediting the economy etc. Hence, a breakdown of a substantial part of the banking system may follow, consequently imposing high costs in the economy (Upper, 2010).

4. Why SIFIs are important?

Because the magnitude of the costs related with SIFIs in times of financial distress is considered to be enormously high, as we have seen in the case of the global financial crisis, governments and international institutions may interfere by bailing them out, in order to prevent them from failing. However, since these institutions (e.g. banks) are may be aware of their systemic importance in the economy, they may pose moral hazard problems. By relying in the Given the probability that the government is likely to not let SIFIs fail, they may engage in even riskier activities, thus contributing in increasing systemic risks even more.

Understanding the nature and causes of systemic risk, as well as the role and impact of the SIFIs in the economy is crucial with respect to creating appropriate regulations, supervisory policies, and instruments that will help to avoid or at least mitigate the periods with financial distress. Being able to identify SIFIs in real time, evaluating their potential contribution into a systemic event and addressing them

efficiently by taking a priory corrective measures, may help to mitigate the potential risks generated by a system-wide crisis, which may possibly be caused by them. Measures that may diminish the importance of the SIFIs, as proposed by ESRB, are mainly counter-cyclical. For example, higher capital requirements for banks during the booming times, less capital requirements in times of recession, preventing maturity mismatch, limiting expectations of bail out, limiting the exposure concentration (e.g. large exposure concentration), risk-based deposit insurance schemes, etc. These, in turn, may serve as precautionary measures against potential crisis and contribute to strengthen the resilience of financial infrastructure to potential shocks (Thomson, 2009).

To be able to limiting the adverse effects that may come from the SIFIs in case of a systemic event, such institutions should be firstly identified. A set of criteria that can be used to identify SIFIs in the banking system are presented in the following section.

5. Measuring systemic importance

Conversely to the reporting systems where bank level data are being collected for the micro-prudential supervision purposes, creating a model for identifying SIFIs in the economy may be particularly helpful as it takes into consideration a bigger picture, where individual bank data are connected to the overall economy, reassuring the macroeconomic nature of the SIFIs. An emerging literature proposes two approaches that may be useful in identifying SIFIs in a financial sector (Weistroffer, 2011; Bramer and Gishche, 2012). The first approach is a market-based technique, which mainly relies on financial models and financial markets' data to estimate the systemic importance of the financial institutions. These models are usually complex and difficult to implement in practice, and also more difficult to communicate to the public (Drehmann and Tarashev, 2011). The second approach is an indicator-based technique which incorporates bank-level data to evaluate SIFIs in the financial system. Indicator-based approaches usually require bank level balance sheet data to assess the systemic relevance (IMF, FSB, BIS, 2009). An advantage of this method is that it relies on less volatile indicators, compared with the market-based approach. However, a drawback of this approach is that it requires an arbitrary division of the composition of indicators (Weistroffer, 2011).

In July 2011, the Basel Committee on Banking Supervision (BCBS), acting under the umbrella of the BIS, has released a preliminary version of the criteria to be used for the identification of the SIFIs. The report lists five relevant criteria: size, interconnectedness, substitutability, complexity and cross-jurisdictional activity (BCBS, 2011). The BCSB assigns equal weight to each criterion e.g. 20% weighs each of the five criteria.

This study elaborates the first three criteria proposed by the FSB, IMF, BIS (2009), namely size, interconnectedness and substitutability, which are usually more appropriate in the countries with less developed financial sectors.

The size of the financial institutions usually represents one of the most important determinants of systemic importance. The importance of a financial institution, e.g. a bank, increases, depending on the amount or volume of financial services that the bank generates relative to other financial institutions. Based on this criterion, the larger a bank is, the more important it may be for the system as the dependence of the clients, lenders and stakeholders is larger. Thus, the costs inferred in case the large banks fail to perform their tasks are larger than the collapse of the smaller banks (Upper, 2010).

The inter-connectedness risk of the financial institutions, where contagion risk mostly takes place, usually represents the most important risk that can increase the adverse effects of SIFIs, especially in countries with developed financial systems (ECB, 2011). Strong and complex inter-connection of the financial institutions with each other and other sectors of the economy is also an indicator of the systemic importance. This is because strong inter- linkages in share (value of a transaction with a bank to total transactions realised) and complexity (inter-linkages with many other financial institutions) may trigger accumulated idiosyncratic risks of the single financial institutions to transfer into other financial institutions, eventually leading into a simultaneous systemic event. Since interconnections of the financial institutions may increase the systemic importance, which is obviously costly in many levels, the question

that arises is why do financial institutions expose themselves to risky investments and debts in other institutions and jeopardize the whole system? First of all, interconnections enable financial institutions to diversify the risk of investments, and protect their investments from full losses (Battiston et al., 2009). However, the decision of each financial institution to invest is driven by individual incentives, which not necessarily diversify the macroeconomic risk. This does not necessarily represent an ideal situation for financial system or the economy, since individual financial institutions may fail to assess their participation/ contribution on the systemic risk in an appropriate manner. Second, financial institutions may not be aware about other financial institutions' exposures, or to what level these exposures reach.

Another important factor that is used to determine the systemic importance of financial institutions relates to the degree of substitutability of banking services provided by individual institutions. The systemic importance of a bank increases when in case of a bankruptcy, other banks cannot provide similar products to that bank. In other words, the concentration of a particular product or service to a single bank is less likely to make a bank systemically important if, other things being constant, these activities may easily be substituted by other financial institutions or new entrants in the market (Thomson, 2009).

The three criteria provide a useful analytical device to structure the assessment of systemic importance. The assessments tend to be more reliable when the three criteria are used jointly.

6. Identification of SIFIs in the banking system of Kosovo

6.1. The reference system

The reference system to identify and evaluate SIFIs can be classified as local, regional, national or international (FSB, IMF and BIS, 2009). As Kosovo has a banking system with a relatively simple structure, we will concentrate on identifying the SIFIs in the banking system by taking the national domestic market as a reference system.

6.2. Systemically Important Banks (SIB)

Provided that banking system in Kosovo comprises more than 70 percent of the overall financial sector, in this study we have concentrated in identifying SIFIs in the banking system only, i.e. we aim at identifying the Systemically Important Banks (SIB). In this study, we rely on the guidelines of the FSB, IMF and BIS (2009) report, by applying a simplified version to accommodate the banking system characteristics of Kosovo. Given that none of the banks operating in Kosovo are listed in the financial markets, we analyse the SIBs in the banking system of Kosovo using the indictor-based approach, which appears to be more practical in the sense of micro-prudential and macro- prudential supervision and generates more comprehensive results for decision making. Similar approaches, amongst others, are being used by the Czech Republic, Moldavian and Australian authorities (Komarkova et al., 2011; Moore and Zhou, 2012 or Bramer and Gischer, 2012). In order to measure the systemic importance of individual banks in Kosovo, this study uses three main criteria: size, interconnectedness and substitutability.

7. Methodology

The methodological approach used for identifying SIBs in Kosovo is indicator-based. The banking system of Kosovo currently consists of 8 commercial banks. The data used are balance sheet indicators of the year 2011. The weights for each criterion used were assigned as follows: size = 40%, substitutability = 40% and interconnectedness = 20%. Individual bank level data have been used for the all 8 banks operating in Kosovo. Overall, 18 banking indicators were used (Table 2). All indicators within one category (e.g. size), were assigned equal weights. For example, an indicator that belongs to the size or substitutability criterion group was assigned a weight of 5 percent (because size/substitutability criterion weights 40% divided by 8 indicators = 5%), whereas indicators in the interconnectedness criteria group were given a weight of 6.67 percent (20% divided by 3 indicators = 6.67%).

Table 2. Balance sheet indicators used to identify systemic importance of banks in Kosovo

Criteria	Indicators
Size = 40%	1. Cash and balances w ith CBK 2. Deposits 3. Participation share in banks' ow n resources 4. Bank placements from other banks 5. Securities 6. Retained profit 7. The share of the number of total depositors 8. The share of banking system liquid assets
Substitutability = 40%	9. The share of agricultural loans 10. The share of household loans 11. The share of trade loans 12. The share of industry loans 13. The share of Government banking sector deposits 14. The share of public enterprises' deposts 15. The share of total loans to total assets
Interconnectedness = 20%	16. Bank placements on other banks 17. Securities 18. Subordinated debt

In the following, we calculated the mean value of every indicator for the whole sector, which served as a reference point for individual banks' indicators. For example, if the weighted mean of an indicator (e.g. deposits) resulted to be higher than the mean of the sector, that bank was considered to have systemic importance regarding the respective indicator. Besides the separate indicators, we also calculated the systemic importance of the banks concerning the criteria's used in a similar fashion. For example, if the weighted mean of a bank resulted to be higher than the sector average for a criterion (e.g. size), that bank was considered to have systemic importance in that criterion. If the weighted mean of the banks were lower than the sector mean, these banks were considered to not have systemic importance in the financial sector. This procedure was applied for each bank and indicator separately.

8. The results

The three largest banks resulted to be systemically important in all the indicators whereas also some of the smaller banks turned out to be systemically important in certain indicators.

More precisely, size criterion turned out as one of the most significant criteria, where the three largest banks also came out persistently as systemically important (Table 3). Within the size criterion, the sub-indicators (aggregated from all banks) that came out as systemically important are: deposits, share in own resources, bank placements, the share of the number of depositors and the retained profit.

Regarding the substitutability criterion, five banks turned out as systemically important, from which three of them large banks, and the other two represent relatively smaller banks. This means that concerning some indicators, smaller banks are also important and dominate in providing certain services in the market. Indicators that turned out as systemically important within the substitutability criterion are: share of agricultural loans, share of consumption loans, share of industry and trade loans, and the share of payments through the payment system.

Despite the fact that the inter-linkages of the banks operating in Kosovo are fairly low, three largest banks resulted with systemic importance regarding the interconnectedness criterion. This means that the three largest banks are more interconnected with other banks in the country; two smaller banks are less inter-connected, whereas other banks that resulted not to be systemically important are inter-connected with other banks at very low levels or have no inter-connections. Nevertheless, given the relatively low level of bank inter-connections, it should be noted that the potential systemic

importance rising from this factor should be relatively low for the whole system. Indicators with systemic importance within the interconnectedness criterion are bank placements on other banks and securities. The interconnectedness of the banks operating in Kosovo is more emphasised with the banks abroad, especially with the parent banks.

Table 2. Identification of SIFIs in the banking system of Kosovo

*Banks/Criteria	Size	Substitutability	Interconnectedness
Bank A			
Bank B		√	
Bank C		√	
Bank D			
Bank E	√	√	√
Bank F			
Bank G	√	√	√
Bank H	√	√	√

Note: the ordering of the banks is random.

9. Conclusions

Even though the importance of systemic risk has gained attention as a consequence of the several financial crises (e.g. Asian financial crisis during '90s), the concept of systemically important financial institutions (SIFIs) emerged only after the recent financial crisis that commenced in 2007/2008. In the core of the debate concerning SIFIs underlies the fact that supervisory institutions should pay attention and try to identify the financial institutions not only individually, but rather in a system-wide perspective, where the impact of the SIFIs is also related to the overall economy. This is because the malfunction of these institutions (SIFIs) may propagate serious financial and macroeconomic stability threat, leading to a crisis and imposing enormous costs on the economy, as was recently noticed in the global financial crisis.

In this study we have elaborated the concepts of systemic importance in general and identified the systemically important banks (SIB) in Kosovo. In order to identify the SIBs in the banking system of Kosovo, we have relied on three criteria, namely, size, substitutability and interconnectedness. With regard to the size criterion, the results unsurprisingly reveal that the three largest banks in Kosovo are clearly systemically important. Concerning the substitutability criterion, besides the three largest banks, two other relatively smaller banks also came out as systemically important. Besides the relatively low level of inter-connections between banks in Kosovo, three largest banks resulted with systemic importance.

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MEASURES OF FINANCIAL STABILITY IN MACEDONIA

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Abstract

This paper aims at reviewing the work done towards developing quantitative measures of financial stability in Macedonia. The approach to the development of these measures concerns a macro-prudential dimension of financial stability. Constructing a single indicator to indicate the level of stability of the financial system is a very difficult task given the complex nature of the financial system and the existence of numerous interactions between financial market participants, non-financial sectors and financial institutions. Our empirical work started with constructing an *aggregate banking stability indicator* as an attempt to assess the risks to financial stability by focusing on a set of key financial soundness indicators of the banks. But given the complex interactions of different elements of the financial system among themselves and with the real economy, from the analysis of an early warning indicator to monitor the state of the banking system, the analytical focus has been shifted towards a broader system-wide assessment of risks to the financial markets, institutions and infrastructure. In other words, we developed a *financial conditions index* which provides a signal of financial stress and broad coverage of the areas that could indicate it. Both composite measures of financial stability can be used to gauge the build-up of imbalances in the system even in the absence of extreme events. In addition, we also demonstrate that it is possible to use our financial measures to improve, although only marginally, upon forecasts of measure of economic activity over short horizon.

JEL: E5, E17, E44

Key words: Banking Stability Index; Banking Sector's Financial Strength; Financial Conditions Index; Financial Stability; Principal Component Analysis

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1. Introduction

In the last decade, financial stability has become one of the objectives of the central banks, in addition to price stability as their primary objective. In this field of the literature, but also in practice there are many definitions of financial stability. In the first Financial Stability Report for 2006, prepared by the National Bank of the Republic Macedonia (Financial Stability and Banking Regulation Department), financial stability is defined as the condition of smooth operation of all segments of the financial system, with each of them providing the highest possible level of flexibility to absorb possible shocks.

In order to minimize future crises, financial market participants and regulators need to effectively determine the potential stress in the financial system. Therefore, the construction of indicators which will provide timely warning of potential risks, composed of a set of economic and financial indicators, is very important for the prevention (minimizing) of the financial crises.

Our empirical work started with construction of an aggregate banking stability index for Macedonia. Given the dominance of the banking system in the entire financial system this index refers only to the banking system. But given the complex interactions of different elements of the financial system among themselves and with the real economy, from the analysis of an early warning indicator to monitor the state of the banking system, the analytical focus has been shifted towards a broader system-wide assessment of risks to the financial markets, institutions and infrastructure. In other words, we developed a financial conditions index which provides a signal of financial stress and broad coverage of the areas that could indicate it.

One of the key observations to come out of the recent financial crisis is that financial innovations have made it difficult to capture broad financial conditions in a small number of variables covering just a few traditional financial markets. Monitoring financial stability, thus, now explicitly requires an understanding of both how traditional and evolving financial markets relate to each other and how they relate to economic conditions. Indicies of financial conditions are an attempt to quantify these relationships (Brave and Butters, 2011).

Thus, when policymakers decide upon the appropriate stance of monetary policy, they must take account of the possible macroeconomic implications of developments in the financial sector. To do so, they must monitor not only risk-free interest rates and equity prices, but also risk spreads on various instruments, the financial health of businesses and households, the financial health of intermediaries, and the operation of financial markets. With this information in hand, they then need to assess the likely implications of the financial developments for the economic activity (English et al., 2005).

In what follows, we first describe the methodology employed for constructing our banking stability index. We review how we combine the key variables into this composite indicator for the purposes of monitoring the banking sector stability in Macedonia. In this research paper we also review the work done towards developing of financial conditions index for Macedonia. We further concentrate our analysis on highlighting the contribution of different sectors of the financial system to our financial conditions index, as well as the systemically important indicators among them. Next, we show that both composite measures of financial stability can be used to gauge the build-up of imbalances in the system even in the absence of extreme events. Given the interdependence of financial and economic conditions we also demonstrate that it is possible to use our measures to improve, although only marginally, upon forecasts of measure of economic activity over short-term horizon.

2. Measures of financial stability - a brief literature review

Some central bank publications have recently attempted to construct a single indicator to indicate the level of stability of the financial system in the country concerned. This is a very tough task given the complex nature of the financial system and the existence of numerous links between financial market participants, non-financial sectors and financial institutions. Most of the attempts focus on constructing an aggregate indicator for the banking sector, which is the most important part of the financial system

with respect to financial stability. A relatively simple aggregate indicator of banking sector stability can be constructed as a weighted average of partial indicators of the financial soundness of banks. Such an index is used, for example, by the Turkish central bank (CBRT, 2006). Its financial strength index consists of six sub-indices covering asset quality, liquidity, foreign exchange risk, interest rate risk, profitability and capital adequacy. Before aggregation the individual sub-indices are normalized in order to achieve the same variance (variance-equal weighting scheme) (Geršl and Heřmánek, Czech National Bank).

An alternative approach is to construct an aggregate indicator of financial stability by using daily data from the financial markets (such as stock prices of banks and other financial assets). These data can signal any problems in the financial sector in advance as indicated by market perceptions about their probability Financial fragility indicator presented by experts from the U.S. Federal Reserve System (Nelson and Perli 2005) and the financial stress index calculated by the experts from the Central Bank of Canada (Illing and Liu 2003) are practical examples of this approach (Geršl and Heřmánek, Czech National Bank).

In addition, financial market information can be combined with data from the financial statements of banks. This approach has been accepted by the Central Bank of Switzerland in the construction of stress index for the banking sector (Swiss National Bank, 2006). In parallel with the use of indicators calculated on the basis of the financial statements of banks (e.g., changes in profitability, capital, asset quality, number of branches, etc.) market indicators (change in prices of bank stocks and bonds) and other information are used such as the amounts of interbank exposure and additional supervisory information (share of assets of banks under enhanced supervision) (Geršl and Heřmánek, Czech National Bank).

Central Bank of the Netherlands calculates the so-called Financial Stability Conditions Index (Van den End 2006), which is constructed by extending the so-called monetary conditions index with the so-called index of financial conditions. Monetary conditions index is based on the interest rates and the effective exchange rate, while real estate and stock prices, the solvency of financial institutions and the volatility of the stock market index of financial institutions are covered by the index of financial conditions. Certain acceptable levels of the index (lower and upper limit) have been set. Too low an index value means increased instability, whereas too high a value may result in the accumulation of financial imbalances, since very positive developments and minimal market volatility may lead to distortion of relative prices, inefficient fund allocation and lower prudence and risk limits. Therefore, the ideal evolution of the index is one within a particular financial stability band (Geršl and Heřmánek, Czech National Bank).

A new approach to the construction of an aggregate financial stability indicator consists in calculating default risk at the level of the entire financial system, or its main sectors, for instance using the Merton model (Van den End and Tabbae, 2005). A similar systemic risk indicator based on the stochastic default risk distribution of individual institutions as an operational financial stability indicator is proposed, for example, by Čihák (2007). The advantage of these indicators lies in their close linkage with problems in the financial sector (default of major financial institutions or a sector) and with the business cycle. The disadvantages include, however, demanding analysis and in some cases also the existence of a liquid stock market with a good representative sample of individual sectors (Geršl and Heřmánek, Czech National Bank).

When it comes to the financial conditions indices (FCIs), "springing out from the literature on monetary conditions indexes (MCIs), intended to capture the overall stance of monetary policy, the more comprehensive FCIs are created to provide information about the broader financial conditions and their impact on economic activity. As methods and financial variables differ between FCIs, the exact focus, use and interpretation varies across indicators. In some cases FCIs measure the tightness/ accommodativeness of financial factors relative to their historical average, while other indexes illustrate financial conditions' contribution to growth. Some indexes are closely related to policy making in as much as index values can be interpreted in terms of interest rate equivalents (see e.g. Beaton, Lalonde and Luu (2009)). Other indicies are more oriented towards forecasting and may be used as leading indicators as they can provide timely information about economic activity. Whether an FCI mainly captures financial variables' response to economic activity, or if it is more of an indicator of financial

conditions' impact on real activity, depends on how it is constructed, although this distinction is not always made clear. However, in both instances an FCI can provide early and leading information as financial data typically are available well in advance of quarterly national statistics", (Vonen, 2011, p.2).

In the literature, a variety of methodologies for constructing FCIs have been developed, but there are two prominent approaches: a weighted-sum approach and a principal-components approach. In the weighted-sum approach, each financial variable in the index is assigned a weight that reflects an estimate of its impacts on real GDP. These estimates are obtained through simulations of large-scale macroeconomic models, or through the estimation of reduced-form demand equations or vector autoregression (VAR) models. Examples of FCIs using a weighted-sum approach are the indexes estimated by Macroeconomic Advisors, the OECD, Goldman Sachs, Bloomberg FCI, and Citigroup. The second approach is based on the principal component analysis, whereby a common factor is estimated from a group of several financial variables and interpreted as the unobserved common variable underlying the variation of all the financial variables included in the index. Examples of this type of FCIs include the indexes estimated by the Deutsche Bank and the Federal Reserve Bank of Kansas City (Osorio et al. 2011).

3. Banking stability index for Macedonia

In this section we review the work done towards developing an aggregate index for the stability of the Macedonian banking system, i.e. the banking stability index. The banking stability index for Macedonia uses selected quantitative indicators of the set of basic FSI (Appendix 1), with its calculation being tested for the period from December 31, 2005 to December 31, 2012, on a quarterly basis. Indicators that are included in the index are selected on the basis of their relevance to the stability of the banking system, given its nature and size. Also, the choice of individual indicators was based on international practice. The index does not include macroeconomic variables or some qualitative indicators (such as the regulatory framework).

Banking stability index includes only banks. It is constructed as a weighted sum of indicators that represent the following bank risks: insolvency risk, credit risk, profitability, liquidity risk and currency risk.

Banks' capital adequacy and profitability show the banks' capacity to deal with potential risks. Capital adequacy measures banks' capital cushion size to address expected or unexpected losses. Excessively low levels of this ratio points to potential defaults and can be a forerunner of a banking crisis.

Return on equity is a bank profitability indicator and is intended to measure deposit takers' efficiency in using their capital. In addition, noninterest expenses to gross income ratio measures the size of administrative expenses within gross income—that is, it measures the efficiency of deposit takers' use of resources.

Asset quality is assessed through two indicators related to the credit risk as well as the liquidity risk of the banks. The rate of non-performing loans is the key indicator to measure the level of credit risk and it identifies problems with the loan portfolio quality, while the annual growth rate of non-performing loans is an indicator of the credit risk trend.

Liquidity ratios measure banks' readily available short-term resources that can be used to meet short-term obligations.

Currency risk is measured by the ratio calculated as a share of net open position in foreign exchange position in banks' own funds. It shows banks' exposure to exchange rate risk compared with capital and it measures the mismatch of assets and liabilities in foreign currency and its vulnerability to exchange rate movements.

Table 1
Employed key financial variables

Risk	Indicator	Weight
Insolvency	Capital adequacy ratio	0.25
Credit risk	Nonperforming loans / Total loans	0.25
	Annual growth rate of non-performing loans	
Profitability	Return on equity	0.20
	Non-interest expenses / Gross income	
Liquidity risk	Liquid assets / Total assets	0.25
	Liquid assets / Short-term liabilities	
Currency risk	Net open position in foreign exchange / Own funds	0.05

3.1. Adjustment of data

In order to place the values of the indicators to a scale, the data, before the final aggregation, passed through a process of adjustment.

First, indicators (non-performing loans / total loans; net open position in foreign exchange / own funds; non-interest expenses / gross income) which in opposite directions show improvement / deterioration in terms of the direction of other indicators, their reciprocal value is taken, while the annual growth rate of nonperforming loans is multiplied by (-1).

In the second phase, indicators were normalized through a process of so-called empirical normalization that placed all indicators in the same scale in the interval from 0 to 1.

Empirical normalization adjusts the indicators in the interval from 0 to 1. The formula that represents this method is as follows:

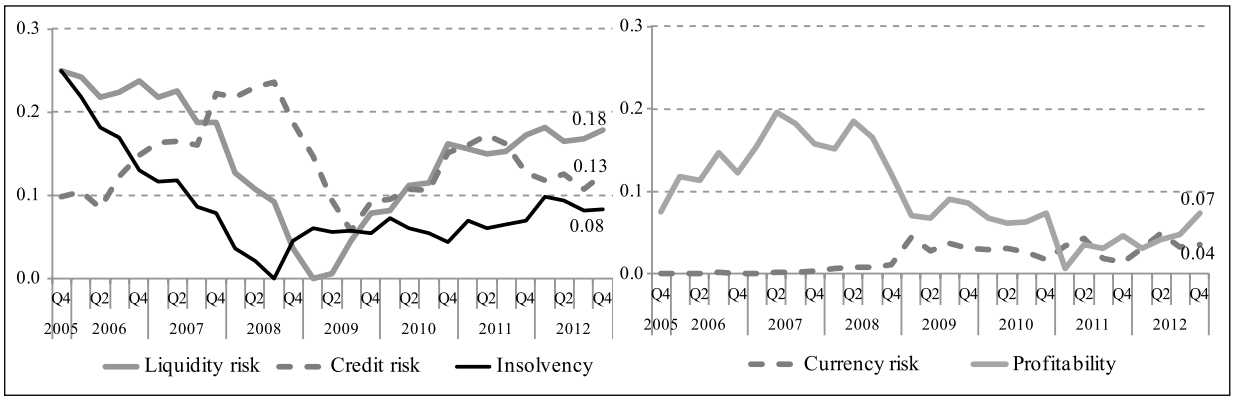
$$I_{it}^{n} = \frac{I_t - Min\,(I_i)}{Max\,(I_i) - Min\,(I_i)}$$

Where: I_{it} is the value of indicator i in period t; Min (I_i) and Max(I_i) are the minimum and maximum of the indicator in the analyzed period.

When constructing the banking stability index the so-called *empirical normalization*[3] *is being* applied, whereas data rating factor is the interval between the minimum and maximum. This means that each indicator is compared to its limit values (min-max) in the period, and its normalized value represents the deviation from the limit values. The lack of this kind of normalization is that it is based on minimum or maximum value of data within a specified period, which can be unreliable for the entire data series. The advantage is the effect it has in a series of data with minor changes from date to date, where any change has obvious effect on the value of the composite indicator.

[3] Despite empirical normalization, the indicators that make up the index for banking stability can be adjusted through the so-called statistical normalization. This normalization aligns indicators in the interval from -3 to +3, with an average value of 0 and standard deviation 1. The correlation between banking stability index calculated by empirical normalization and calculated by the method of statistical normalization is 1 which means that their movements overlap.

Figure 1
Movement of the components of the banking stability index



Source: NBRM and author's calculation

According to the empirical normalization, the approximation of the index value to 1 (Max), means lower risk, while the movement towards 0 (Min) means larger risk exposure.

In the following stage, the normalized values of the individual indicators are weighted in order to emphasize the significance that the individual risks have on the stability of the banking system. Thus the capital adequacy, the credit risk and the liquidity risk, as the most important risks, register higher weights (by 25%). The currency risk has been reduced to a minimal level in conditions of Denar fixed exchange rate policy, while the profitability weight equals 20%.

The calculation of the aggregate banking stability index is a sum of the weighted, normalized indicators for individual risks (Appendix 2).

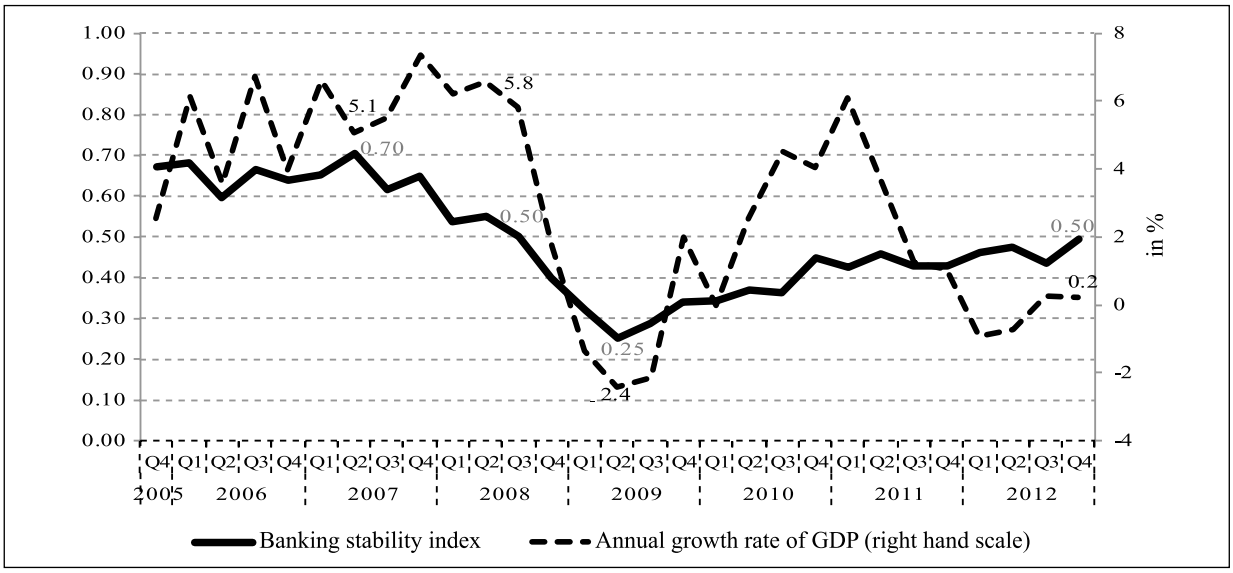
3.2. Results obtained for the banking stability index for Macedonia

According to this procedure, the increase in the index means improved banking stability, while the decrease denotes stability worsening.

In the analysis, banking stability index for Macedonia for December 31, 2005 - December 31, 2012 period, on a quarterly basis, was created. The average weighted value of the index for the entire analyzed period is 0.49, while as of the last date (the data on December 31, 2012), the index continues its upward trend and it equals 0.50.

The analyzed period can be divided in two stages. The first stage covers the period from the end of 2005 until the third quarter of 2008, when the average index value is higher by 0.13 relative to its average for the entire period.

Figure 2
Banking stability index for Macedonia

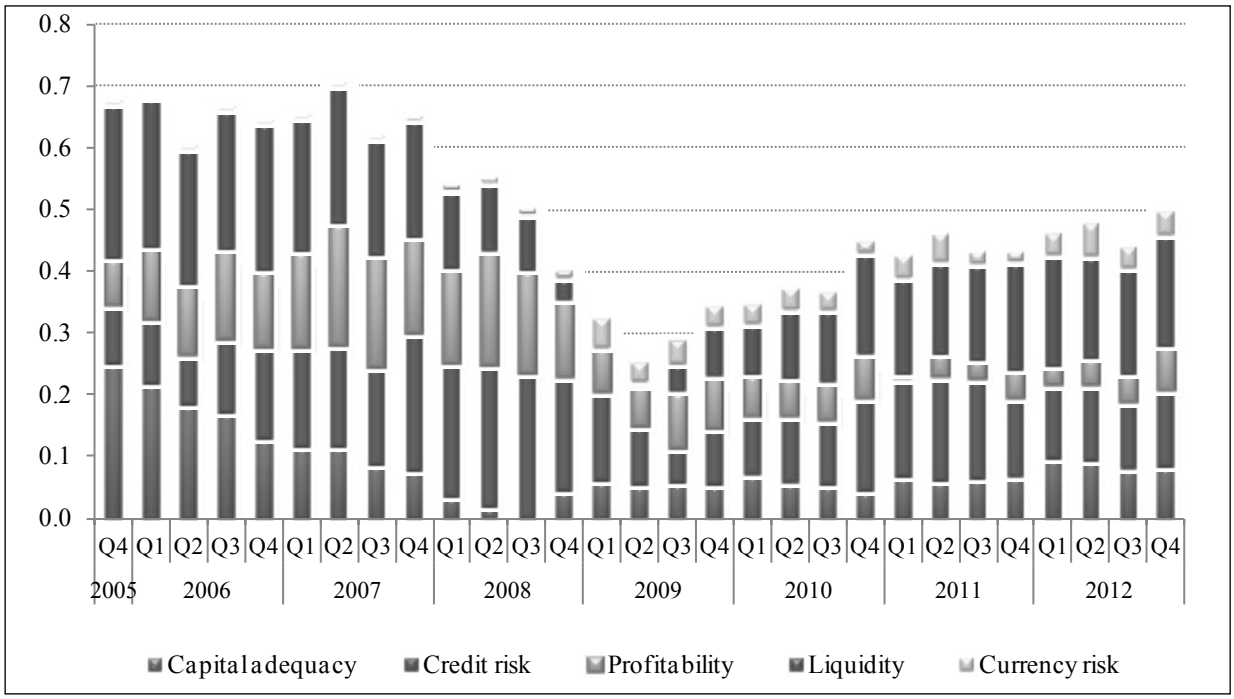


Source: NBRM and author's calculation

The second stage covers the period from the third quarter of 2008 until end of 2012, when the average index value is by 0.09 lower compared to the average for the entire period. The lower value of the index mirrors the negative effects of the financial crisis spill-over on the banks. During the analyzed period, the banking stability index plunged to the lowest level in the second quarter of 2009, when the negative effects of the global economic and financial crisis on both the domestic economy and the domestic financial system were most evident.

However, the second stage is the period of recovery evident through the index rising tendency. The figure 2 also presents the correlation between the movement of the banking stability index and the annual growth rate of GDP.

Figure 3
Contributions of the individual components of the banking stability index



Source: NBRM and author's calculation

Figure 3 displays the contributions of the individual components to the banking stability index over the analyzed period.

The individual components of the banking stability index show different trajectories. In the most recent period, the liquidity risk, credit risk, loss risk and the banks' currency risk have been reducing, thus contributing towards a permanent improvement of the banking stability. In parallel, the banks' solvency ratio remained stable at high level (Appendix 2) and had a relatively constant share in the composite index.

4. Financial conditions index for Macedonia

For constructing our FCI we follow the second strand in the literature, i.e. our index is constructed as a weighted average of a number of indicators of the financial system's health. We used a principal component analysis, or PCA, to estimate the weight given each indicator. The benefit of PCA is its ability to determine the individual importance of a large number of indicators so that the weight each receives is consistent with its historical importance to fluctuations in the broader financial system. Indexes of this sort have the advantage of capturing the interconnectedness of financial markets - a desirable feature allowing for an interpretation of the systemic importance of each indicator. The more correlated an indicator is with its peers, the higher the weight it receives. This allows for the possibility that a small deterioration in a heavily weighted indicator may mean more for financial stability than a large deterioration in an indicator of little weight (Brave and Butters, 2011).

Following Hatzius et al. (2010), we also consider adjusting the financial variables for current and past economic activity and inflation prior to construction of the index. Therefore we develop an index that separates the influence of economic conditions from financial conditions. Using quarterly series of the financial variables, each series is regressed on current and two lags of quarterly GDP growth and inflation.

$$x_{it} = \beta_0 + \beta_1 \Delta y_t + \beta_2 \Delta y_{t-1} + \beta_3 \Delta y_{t-2} + \beta_4 \Delta z_t + \beta_5 \Delta z_{t-1} + \beta_6 \Delta z_{t-2} + \vartheta_{it}$$

The residuals, ϑ_{it}, or rather, the estimates of these, $\widehat{\vartheta_{it}}$, are in turn used as measures of financial variables purged of the effect of the business cycle and inflation, and the calculation of the principal components is now based on these, $\widehat{\vartheta_{it}}s$.

Our adjusted FCI is motivated by the observation that financial and economic conditions are highly correlated. Removing the variation explained by the latter addresses potential asymmetries in the response of one to the other. For instance, a deterioration in financial conditions when economic growth is high and inflation low may have different effects on the real economy than deterioration in financial conditions when economic growth is low and inflation high. Our adjusted FCI is, thus, likely relevant for isolating the source of the shock to financial conditions. FCI index could serve as useful policy tool by providing a sense of how tight or loose financial markets are operating relative to historical norms. In this sense, for our adjusted FCI, a zero value indicates a financial system operating at the historical average levels of risk, liquidity, and leverage (Brave and Butters, 2011).

4.1. Empirical Approach

In this section, we explain the mathematics behind the PCA[4]. Namely, one may hypothesize that a few underlying factors govern the movement in a larger number of series. Assuming such a factor representation of the data is appropriate, factors are related to the observable variables (in this case a set of financial variables) in the following way: Let N be the number of variables x_i , $i = 1 \dots N$, and T be the number of time period observations included in the analysis, $t = 1 \dots T$. The time t observation of a given variable x_i can then be expressed as:

[4] For a more in-depth and technical derivation of factor models and the use of principal components, see e.g. Stock and Watson (2002a).

$$x_{it} = \lambda_i \mathrm{F}_t + \mathrm{e}_{it}$$
$$= C_{it} + e_{it}$$

where F is the underlying factor. The relationship between a given factor and an observable variable is given by the so called factor loadings λ_i. These loadings will in general differ between the variables, and for each variable there is one factor loading associated with each of the underlying factors. $C_{it} = \lambda_i \mathrm{F}_t$ is referred to as the common component of the model. e_{it} is the idiosyncratic or variable specific component reflecting the "uniqueness" in each variable, that is, the part of the variation in a series which is not common to all the included variables. The underlying factors are not observable themselves, and therefore they need to be estimated. Principal components are used for this purpose. The first principal component accounts for the largest share of total variance in the data set. The next principal components are labeled according to the declining share of variance accounted for. Note that all the principal components are orthogonal to each other, i.e. a given principal component is uncorrelated with all the other principal components. In total, the number of principal components is equal to the number of original variables in the dataset. However, a substantial share of the total variance can usually be accounted for by only a few principal components, and the method is thus an efficient way of reducing the data dimension. In order to make the variables comparable, they are standardized before being transformed to principal components. Standardization implies that the variance of each variable equals one, and therefore the total variance in the dataset is equal to the number of variables N (Vonen, 2001).

In deciding which factors to use in the construction of the Macedonian financial conditions index, the threshold for the share of total variance explained was taken to be at least 70%. By this measure, the first 5 principal components suffice to summarize the dataset. The financial conditions index is then constructed by summing the selected principal components weighted by the share of total variability explained by them. The resulting index is then further divided by the share of total variance explained. Therefore, the actual importance of each variable in the financial conditions index is equal to the weighted sum of the loadings on each variable across the 5 principal components (Angelopoulou et al., 2012).

In general, interest rates and risk measures receive positive weights in the index. Conversely, leverage has negative weight. This pattern of increasing interest rates and risk premiums and declining leverage is consistent with tightening financial conditions, and provides us a basis for interpreting the index.

4.2. Systemically important indicators

There are two ways to view the systemic relationship expressed in each indicator's weight: by its sign and by its magnitude. For instance, risk measures with their generally positive weights and leverage measure with its negative weight imply that increasingly positive values of the index capture periods of above-average risk and below-average leverage. Conversely, increasingly negative values of the index capture periods where risk is below average and leverage is above average (Brave and Butters, 2011).

In our adjusted FCI, the process of deleveraging appears as an indicator of deteriorating financial conditions given that this ratio determines the degree of robustness of financial institutions to withstand shocks to their balance sheets (FSIs, IMF).

Our index also includes NPLs net of provision / Own funds ratio. This capital adequacy ratio is an important indicator pointing out to the capacity of banks' capital to withstand losses from NPLs (FSIs, IMF).

The asset price categories included in our adjusted FCI (market capitalization of shares as well as the residential real estate prices) measure risk premiums in their various forms. Therefore, increasing risk premiums denotes tightening real estate and equity market conditions. With respect to the residential real estate prices, "the most recent subprime credits crisis revealed that a belief that house prices would continue to appreciate stimulates easy credits thus increasing the financial vulnerability. The decline in underwriting standards did not directly trigger the crisis, because the gradual changes in standards did

not statistically account for the large difference in default rates. In other words, the trend in worsening loan quality is harder to detect with rising housing prices, as more refinancing options are available, keeping the default rate lower (adaptation from Demyanyk and Hemert, 2007)".

Macedonian stock exchange index (MBI-10) return is also selected as a broader measure of financial conditions. MBI-10 return measures the "risk - reward relationship" associated with the stock market thus covering the general equity market risk premium with implications for monetary policy, financial stability and economic activity.

Real effective exchange rate is also included in our adjusted FCI. According to (Céspedes et al., 2000) an economy is classified as vulnerable if real exchange rate depreciations lead to increases in the risk premium faced by firms. This result is summarized in their dynamic equation for risk premium and crucially, depends on firms' debt burden, i.e. on the steady state ratio of debt to investment[5].

Another broader measure of financial conditions reflecting risk premia is the share of FX Deposits including foreign exchange-indexed to total deposits. This ratio refers to the degree of asset substitution (dollarization/euroization) in the economy. With dollarization/euroization, the domestic authorities lose the ability to respond to a sudden run on bank deposits by acting as a lender of last resort. In particular, the authorities are unable to inject an unlimited amount of liquidity into the payment system to prevent a default on deposits (Berg and Borensztein, 2000), as the amount available to purchase bank assets and to recapitalize distressed financial institutions is restricted to the country's stock of foreign reserves (Winkler et al., 2004).

Our index also includes measures of banks' profitability. Namely, noninterest expenses / gross income ratio is a profitability ratio, which measures the size of administrative expenses within gross income - that is, it measures the efficiency of deposit takers' use of resources. On the other hand, interest margin / gross income ratio is a profitability ratio, which measures the relative share of net interest earnings - interest earned less interest expenses - within gross income. Determinants of bank profitability can be split between those that are internal and those that are external. Internal determinants of bank profitability can be defined as those factors that are influenced by the bank's management decisions and policy objectives. Management effects are the results of differences in bank management objectives, policies, decisions, and actions reflected in differences in bank operating results, including profitability. Zimmerman (1996) found that management decisions, especially regarding loan portfolio concentration, were an important contributing factor in bank performance. However, the profitability of banks is influenced not only by factors related to their management decisions but also to changes in the external macroeconomic environment, as well as by factors related to market share changes (FSIs, IMF & Staikouras et al., 2004)

Loans to deposit ratio as well as the banking system exposure to subsidiaries and shareholders are used to detect liquidity problems - a high ratio might indicate potential liquidity stress in the banking system and perhaps a loss of depositor and investor confidence in the long-term viability of the sector (FSIs, IMF).

To this end, we include in our adjusted FCI, the interest rates as well as the FX interest spread. Increasing both, the interest rates and the spread[6] coincide with tighter banking system conditions.

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[5] When the steady state ratio of debt to investment is large, then the economy is more likely to be financially vulnerable. According to (Céspedes et al., 2000), adverse external shocks cause a larger impact real depreciation under flexible rates, but a larger expected real depreciation under fixed rates. Ceteris paribus, this causes domestic real interest rates to be higher under a peg, adversely affecting current investment and future output. Céspedes et al., 2000, build a model of a small open economy in which real exchange rates play a central role in the adjustment process, wages are sticky, liabilities are "dollarized," and the country risk premium is endogenously determined by the net worth of domestic entrepreneurs. Hence all the basic building blocks are there for unexpected real exchange rate movements to be financially dangerous, and for flexible exchange rates to be destabilizing. In other words, the authors have shown that if a sharp devaluation wreaks havoc with bank and corporate balance sheets, country risk premia will increase. This combination causes, in some cases, the domestic effects of external shocks to be magnified and made persistent. In others, the expectation of a large devaluation causes one to occur and damage financial health enough to justify the initially pessimistic expectations.

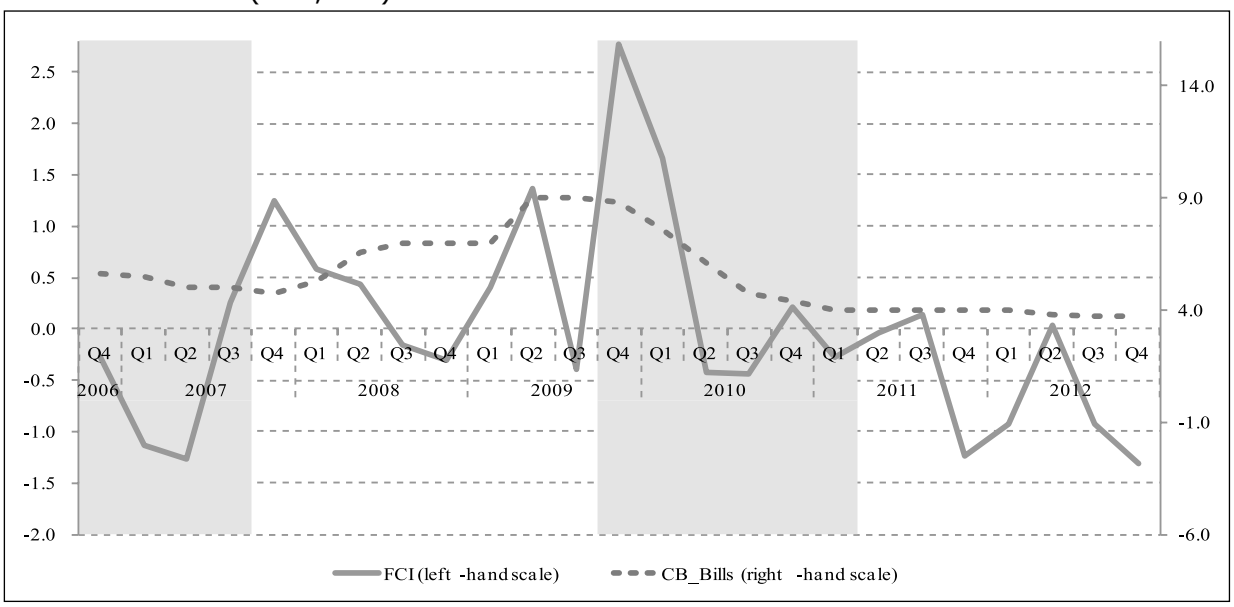
[6] Higher spread between the lending and deposit rate reflects higher perceived credit risk. The spread can also be used as a gauge of competitiveness within the sector, i.e. higher spread implies lower competitiveness (FSIs, IMF).

The rationale behind high deposit rates and tight banking system conditions lies in the fact that some banks might use high deposit interest rates to fund their risky lending strategies. And the high deposit interest rates of these banks might create a negative externality by forcing less risk-loving banks to raise their deposit rates to retain deposits, thus squeezing bank profits and creating a secondary impulse for less risky banks to actually increase the riskiness of their portfolio. Therefore, the first-best policy would be to use high deposit interest rates as a signal of increased risk (Kraft and Galac, 2007).

The high bank lending rates are closely associated with the high-risk premiums. When these premiums are far above those justified by the economic fundamentals, they could be called a "fear premiums". These premiums are usually driven by some country-specific macro/liquidity risks. In other words, high lending rates reflect a cautious attitude on the part of lenders - driven by growing uncertainty, elevated funding costs, and tighter financial regulations (Shirai, 2012).

In Figure 4, the movement of the adjusted FCI is plotted. In the first half of 2007 the adjusted FCI slipped well into a negative territory which suggests looser overall financial conditions that leaded to an acceleration in economic growth. The loose financial conditions in this period had been driven largely by favorable movements in equity markets (i.e. sharp increase of the market capitalization of shares) as well as by both, the restored capacity of the banks' capital to withstand losses from NPLs (i.e. decrease in NPLs net of provision / own funds), and the increased banks' profitability (that is decrease in noninterest expenses / gross income ratio). In parallel, 2007 coincides with NBRM policy easing cycle. From mid-2007 until mid-2008 a tight financial conditions had been prevailing. The unfavorable financial conditions in this period are primarily induced by the sharp increase in interest rates on denar deposits as well as by decrease in banks' leverage. In the second half of 2008 financial conditions begin to loosen (the FCI turns downward). Loosening deepens until a trough at the end of 2008 after which a new cycle of tightening financial conditions begins (the FCI turns upward). The favorable financial conditions in the second half of 2008 are driven largely by the decline in short and long term interest rates on foreign currency loans, as well as by further improvement of the capacity of banks' capital to withstand losses from NPLs (i.e. decrease in NPLs net of provision / own funds). In addition, in this period a significant shrinkage in the general equity market risk (i.e. decline in MBI-10 returns) is observed. Tight financial conditions generally persist during 2009 and 2010 reflecting primarily the adverse movements in credit conditions (most notably surge in banks' denar deposit and lending rates, as well as the increase in banking system exposure to subsidiaries and shareholders (i.e. increased liquidity risk). The period 2008-2009Q3 reflects NBRM's remarkable tightening cycle, as well as deceleration in economic growth. Loose financial conditions that started at the beginning of 2011 and are still persisting are mainly induced by: improved credit conditions (decrease in both, the lending and the deposit interest rates); decrease in liquidity stress in the banking system (i.e. decline in total loans / customer deposits ratio); increase in leverage, as well as in capacity of banks' capital to withstand losses from NPLs; a reduction in banking system exposure to subsidiaries and shareholders is also observed in this period reflecting reduced liquidity risk. On the monetary side, starting from end-2009 a pronounced monetary easing cycle is observed. Namely, in light of recovering international reserves and in order to encourage economic activity, the central bank gradually lowered its key policy rate to 4 percent in December 2010.

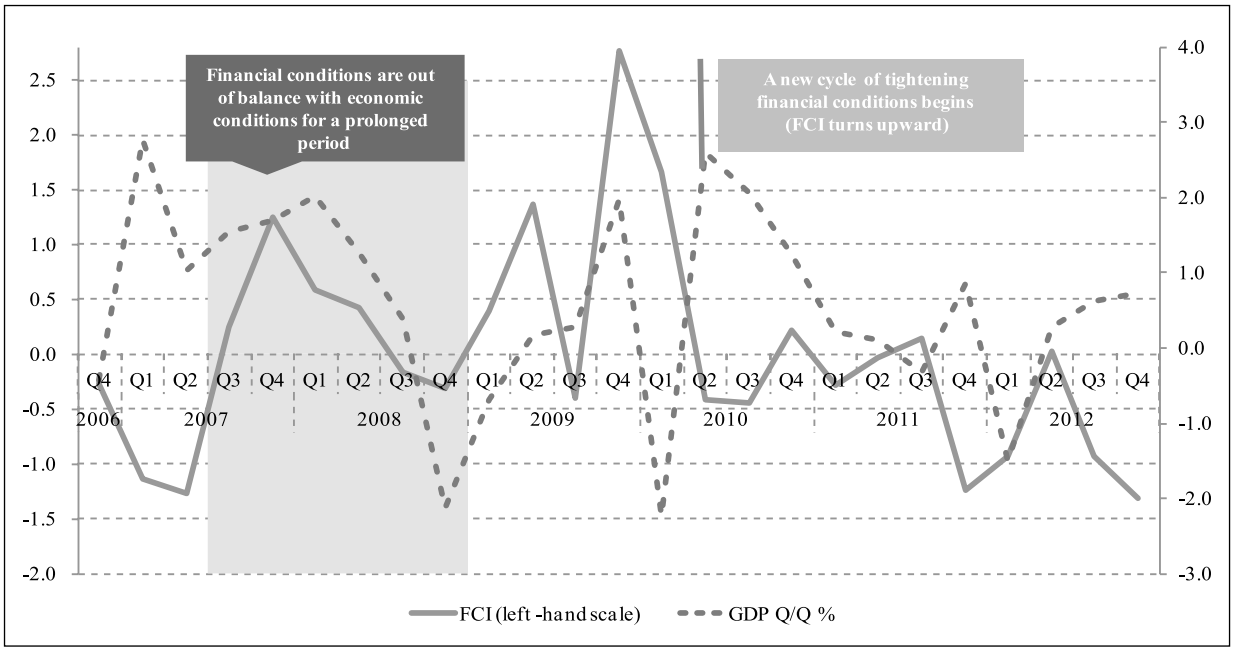
Figure 4
Adjusted FCI (measured in terms of number of standard deviations away from historical mean, LHS), and CB bills interest rate (in %, RHS)



Source: NBRM and author's calculation; Shaded areas are NBRM policy easing cycles

Loose financial conditions on average in 2007–2008 are associated with the upturn in the global economic activity and the high GDP growth in Macedonia. Prior to this period, Macedonia's international economic standing also improved as shown by better credit ratings. In 2009-2010 the FCI is generally well into positive territory implying unfavorable financial conditions. This fast deterioration in financial conditions is to large extent associated with the global economic crisis and the period that followed. Still, in the subsequent quarters, we observe a fast improvement of the financial conditions in Macedonia. The most recent reading of FCI (last quarter of 2012) is a record-low level.

Figure 5
Adjusted FCI (measured in terms of number of standard deviations away from historical mean, LHS) and real GDP (Q/Q %, RHS)



Source: NBRM, SSO and author's calculations.

The Macedonian economy has been less affected by the global economic and financial crisis than some regional peers. GDP has recovered from a modest downturn in 2009 to 2.9 per cent growth in 2010, largely attributed to a substantial increase in exports and global demand for commodities. Net foreign direct investment (FDI) has resumed significantly in 2010. Economic performance continued to be relatively strong in the first half of 2011, though industrial production remained somewhat volatile. Inflation accelerated in the first half of 2011 to above 4 percent on an annual basis, but has begun moderating again very soon afterwards. The banking sector remains liquid, owing mostly to stable internal funding sources and conservative asset portfolios. Annual private sector credit growth has remained positive throughout the crisis and the level of non-performing loans (NPLs) remained at just below 10 per cent of total loans by the end of 2011. Still, provisions exceed NPLs, and the system remained free of pressures on liquidity or solvency. Moreover, the banking system remained profitable after provisioning, capital adequacy ratio exceeded 17 percent, thus being well-above the regulatory minimum, and bank liquidity was ample. Reliance on domestic deposits as the primary funding source, combined with minimal reliance on external funding and the lack of exposure to risky external assets, have helped shield the banking system from euro area developments. Both deposits and loans have continued to increase modestly. The NBRM left interest rates unchanged from December 2010 until April 2012, while modestly relaxing prudential requirements that had been tightened as a crisis response in 2008–09. In April, it introduced a set of measures aimed at easing credit conditions and furthering money market development, including a gradual reduction in the amount of outstanding 28-day central bank bills, the introduction of a 7 day and overnight deposit facility and a weekly repo auction. In early May 2012, it lowered the maximum rate on central bank bills by 25 bps to 3.75 percent (IMF Executive Board Conclusions, 2012).

Fiscal policy has been prudent throughout the crisis. Despite several anti-crisis measures implemented during the crisis, the government has maintained a budget deficit of 2.5 per cent in 2010 and 2011, relatively low by regional standards. In addition, spending on capital investments also has increased in the post crisis period (IMF Executive Board Conclusions, 2012).

4.3. Forecasting economic conditions

Another test of our index is its ability to predict the impact of changes in financial conditions on future economic activity. Therefore, in this section, we evaluate our adjusted FCI by first seeing how well it predicts the growth of economic activity on a one quarter horizon relative to the AR model. Table 2 summarizes the pseudo-out-of-sample forecasting results based on several OLS regression models. The data entries are the relative RMSEs using those for the AR model as the benchmark.

To construct forecasts, we began with data from 2006:Q4 through 2009:Q4. One quarter's worth of data was then added on a recursive basis and forecasts were made at a horizon of one quarter ahead until the end of our data in 2012:Q4. The advantage of this framework is that it mimics the production of forecasts in real time (minus the impact of data revisions).

Table 2
Relative pseudo-out-of sample root mean squared forecast errors*

List of employed regressors in each model specification	Relative RMSE
AR(1)	1.00
AR(1) adj_FCI(-1)	1.18
AR(1) adj_FCI(-1) adj_FCI(-2)	1.11
adj_FCI(-1)	1.00
adj_FCI(-1) adj_FCI(-2)	0.99

Source: author's calculations.
** AR is a referent model; Dependant variable in each model specification is first difference of the logarithm of the seasonally adjusted real GDP.*

For an evaluation criterion, we used the root mean squared forecast error (RMSE) statistics computed from our sample of forecasts from 2010:Q1 through 2012:Q4 expressed relative to the similar statistics based on forecasts computed using only AR(1) model. This ratio provides a test of model fit,

so that a value less than 1 indicates an improvement in forecast accuracy relative to an autoregressive baseline. As expected, the AR benchmark is generally hard to beat. Thus, the results suggest that the OLS regression containing only lagged values of the adjusted FCI term just marginally outperforms the alternative models examined.

5. Conclusion

The recent financial crisis have brought to the fore the importance of financial stability and how it may affect the overall economy.

This paper develops two quantitative measures of financial stability in Macedonia. Both composite measures can be used to gauge the build-up of imbalances in the system even in the absence of extreme events. The behavior of both aggregate measures reflect the financial system conditions well post facto. These quantitative composite measures of financial system stability are intuitively attractive as they could enable policy makers to better monitor the degree of financial stability of the system and to anticipate the sources and causes of financial stress to the system.

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Appendix 1

Financial Soundness Indicators of the Macedonian Banking System, 2006-2012

	2006Q4	2007Q4	2008Q4	2009Q4	2010Q4	2011Q4	2012Q1	2012Q2	2012Q3	2012Q4
Deposit takers										
Capital adequacy										
Regulatory capital/risk weighted assets	18.3	17.0	16.2	16.4	16.1	16.8	17.5	17.4	17.1	17.1
Regulatory Tier I capital/risk weighted assets [1/]	17.4	15.7	14.0	13.8	13.4	14.1	14.7	14.7	14.4	14.5
Equity and reserves to Assets	13.3	11.4	11.5	11.4	10.6	11.0	11.4	11.6	11.5	11.2
NPLs net of total provision / own funds [2/]	0.7	-5.0	-6.2	-0.6	-0.3	-0.9	-2.0	-2.3	-0.5	-3.7
NPLs net of total provision / own funds [3/]			-6.8	-0.8	-0.5	-1.1	-2.2	-2.4	-0.7	-3.8
NPLs net of provision for NPLs / own funds [3/]			33.4	13.5	11.9	10.8	10.7	11.5	12.9	10.7
Asset quality										
NPLs / gross loans [2/]	11.2	7.5	6.7	8.9	9.0	9.5	9.9	9.7	10.6	10.1
NPLs / gross loans [3/]	11.2	7.5	6.8	9.1	9.3	9.9	10.2	10.0	10.9	10.5
Total provisions to Non-Performing Loans [2/]	98.3	114.3	118.1	101.4	100.7	101.9	104.2	104.7	100.9	107.1
Total provisions to Non-Performing Loans [3/]	n/a	n/a	120.3	101.8	101.2	102.2	104.7	105.1	101.3	107.5
Provisions for NPLs to Non-performing Loans	n/a	n/a	0.0	70.0	74.0	77.4	77.6	75.7	75.5	79.0
Large exposures /own funds [6/]	194.7	181.4	118.0	213.3	200.4	189.6	183.8	188.7	181.3	205.1
Number of large exposures [7/]					30	20	19	25	22	24
Market share [8/]					23.2	24.2	24.0	1.5	1.5	1.5
Large exposures (%) [9/]					4.9	7.4	7.2	7.5	1.7	1.9
Net value of foreclosed assets/own funds					13.7	16.2	15.7	17.3	18.0	15.6
Banking system exposure to subsidiaries and shareholders / own funds	5.2	5.6	3.1	4.6	6.3	4.6	4.0	3.9	4.0	3.5
Banking system equity investments / own funds	6.3	4.9	3.9	1.5	1.5	1.6	1.7	1.7	1.7	1.8
Foreign-Currency -Denominated Loans/Total Loans	52.7	54.7	57.0	58.5	58.8	59.2	58.3	57.0	55.7	55.4
Foreign-Currency Loans/ Total Loans	26.3	24.6	22.9	22.6	25.8	28.2	28.0	27.1	26.0	25.5
Foreign-Currency Indexed Loans/Total Loans	26.4	30.1	34.1	35.9	33.0	31.0	30.3	29.8	29.7	29.8
Earnings and profitability										
ROAA [10/]	1.8	1.8	1.4	0.6	0.8	0.4	-0.3	0.4	0.3	0.4
ROAE [10/]	12.3	15.0	12.5	5.6	7.3	3.4	-2.5	3.2	2.3	3.8
Interest margin/gross income [11/]	57.1	57.0	58.9	62.6	61.8	60.0	64.2	64.0	64.3	60.7
Noninterest expenses/gross income [12/]	63.6	60.3	64.0	64.5	68.2	69.7	67.7	70.6	68.6	65.3
Trading income to total income					0.5	0.5	1.1	0.7	0.5	0.4
Personnel expenses/ noninterest expenses	41.1	38.4	36.5	36.9	36.1	34.1	34.6	32.9	33.5	33.1
Interest Rates										
Local currency spreads between reference lending and deposit rates	6.3	4.5	3.2	2.8	2.3	3.2	3.4	3.4	3.4	3.5
Foreign currency spreads between reference lending and deposit rates	6.7	6.5	4.2	4.2	4.4	4.8	4.8	4.8	4.7	4.6
Interbank market interest rate	4.9	3.1	5.3	6.2	2.7	2.2	2.1	2.4	2.2	2.1

	2006Q4	2007Q4	2008Q4	2009Q4	2010Q4	2011Q4	2012Q1	2012Q2	2012Q3	2012Q4
Liquidity										
Liquid assets/total assets [13/]	18.0	20.9	16.9	20.6	25.3	25.3	26.5	26.5	27.5	29.4
Liquid assets to total short-term liabilities (contractual maturity) [14/]	25.2	28.2	24.0	30.1	38.5	39.6	42.1	42.6	44.8	48.2
Liquid assets to short-term liabilities (residual maturity)[14/]					33.8	34.3	36.9	36.8	38.3	40.6
Customer Deposits/Total (Non-interbank) Loans	137.1	128.4	107.7	108.2	114.3	115.7	114.9	111.8	111.9	113.5
Foreign-Currency -Denominated Liabilities/ Total Liabilities [15/]	59.0	55.0	56.4	63.0	59.4	56.6	55.0	53.4	52.8	52.8
Foreign-Currency -Denominated Deposits/ Total Deposits	56.1	51.5	54.8	60.9	55.5	52.7	51.1	49.3	48.8	48.3
Foreign-Currency Deposits/ Total Deposits	51.8	44.5	48.1	56.2	53.5	50.8	49.1	48.6	48.0	47.3
Foreign-Currency Indexed Deposits/Total Deposits	4.3	7.0	6.7	4.7	2.0	1.9	2.0	0.6	0.8	1.0
Sensitivity to market risk										
Net open foreign exchange position / own funds	47.0	38.2	25.1	13.0	18.9	21.3	12.5	8.7	12.3	11.4

Sources: NBRM 's Financial Stability Unit.
1/ Since 31.03.2009, regulatory Tier 1 capital has been calculated after supervisory deductions
2/ The indicator refers to loans to the financial and nonfinancial sector.
3/ The indicator refers to loans to the nonfinancial sector.
6/ Sum of the large exposures (10% and above 10% from own funds) by individial bank for all banks in the banking system divided with the banking system's own funds.
7/ Number of large exposures within the bank with the highest number of large exposures at the cut-off date.
8/ Market share of the bank with the highest number of large exposures at cut-off date.
9/ Market share of the bank with the highest relative share of large exposures in own funds at cut-off date.
10/ Annualized and adjusted for unrecognized impairment. Since 31.03.2009 these items have been adjusted for unrecognized impairment.
11/ Interest margin is interest income less interest expense. Gross income includes net interest income, fees and commissions income (net) and other income excluding extraordinary income.
12/ Noninterest expenses include fees and commissions expenses, operating expenses and other exp enses excluding extraordinary expenses.
13/ Liquid assets are defined as cash and balance with the NBRM , treasury bills, NBRM bills, and correspondent accounts with foreign banks. Assets in domestic banks are excluded from total assets. According to the Methodology of NBRM these are highly liquid assets.
14/ Short-term liabilities are defined as deposits and other liabilities with a maturity of one year or less (without deposits and borrowings from domestic banks).
15/ Foreign currency denominated liabilities refer to liabilities with contractual maturity. Total liabilities refer to all liabilities excluding equity and reserves and current profit.

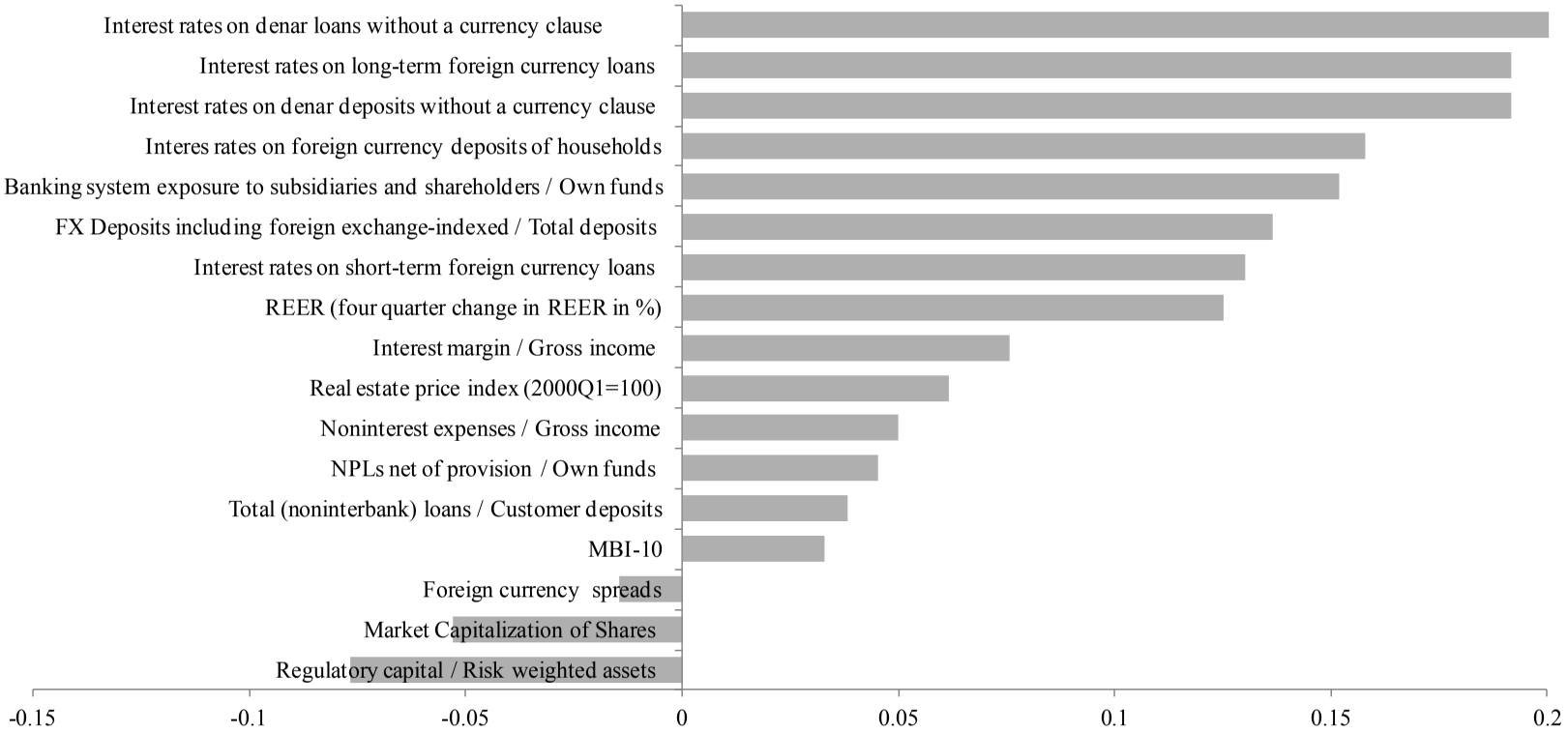
Appendix 2

Quarter	Capital adequacy	Credit risk	Profitability	Liquidity	Currency risk	**Banking stability index**
2005-Q4	0.25	0.10	0.07	0.25	0.00	**0.67**
2006-Q1	0.22	0.10	0.12	0.24	0.00	**0.68**
2006-Q2	0.18	0.08	0.11	0.22	0.00	**0.60**
2006-Q3	0.17	0.12	0.15	0.22	0.00	**0.66**
2006-Q4	0.13	0.15	0.12	0.24	0.00	**0.64**
2007-Q1	0.12	0.16	0.15	0.22	0.00	**0.65**
2007-Q2	0.12	0.16	0.20	0.22	0.00	**0.70**
2007-Q3	0.09	0.16	0.18	0.19	0.00	**0.62**
2007-Q4	0.08	0.22	0.16	0.19	0.00	**0.65**
2008-Q1	0.04	0.22	0.15	0.13	0.01	**0.54**
2008-Q2	0.02	0.23	0.18	0.11	0.01	**0.55**
2008-Q3	0.00	0.24	0.16	0.09	0.01	**0.50**
2008-Q4	0.04	0.19	0.12	0.04	0.01	**0.40**
2009-Q1	0.06	0.15	0.07	0.00	0.04	**0.32**
2009-Q2	0.06	0.09	0.07	0.01	0.03	**0.25**
2009-Q3	0.06	0.06	0.09	0.04	0.04	**0.29**
2009-Q4	0.05	0.09	0.09	0.08	0.03	**0.34**
2010-Q1	0.07	0.10	0.07	0.08	0.03	**0.34**
2010-Q2	0.06	0.11	0.06	0.11	0.03	**0.37**
2010-Q3	0.05	0.11	0.06	0.11	0.03	**0.36**
2010-Q4	0.04	0.15	0.07	0.16	0.02	**0.45**
2011-Q1	0.07	0.16	0.01	0.16	0.03	**0.42**
2011-Q2	0.06	0.17	0.04	0.15	0.04	**0.46**
2011-Q3	0.06	0.16	0.03	0.15	0.02	**0.43**
2011-Q4	0.07	0.13	0.05	0.17	0.01	**0.43**
2012-Q1	0.10	0.12	0.03	0.18	0.03	**0.46**
2012-Q2	0.09	0.13	0.04	0.16	0.05	**0.47**
2012-Q3	0.08	0.11	0.05	0.17	0.03	**0.44**
2012-Q4	0.08	0.13	0.07	0.18	0.04	**0.50**

Appendix 3

Selected variables:	Transformation:	Categories:	Selected variables cover:
Real estate price index (2000Q1=100)	First difference of logarithm	Risk premia	A sustained increase in prices tends to lower the underwritting standards
Market Capitalization of Shares	First difference of logarithm	Risk premia	Financial wealth of corporate sector
FX Deposits including foreign exchange-indexed / Total deposits	First difference of logarithm	Risk premia	Degree of asset substitution
MBI-10	First difference of logarithm	Risk premia	Measures the "risk-reward" relationship associated with the stock market
NPLs net of provision / Own funds	First difference of logarithm	Liquidity risk	Capacity of banks' capital to withstand losses from NPLs
Banking system exposure to subsidiaries and shareholders / Own funds	First difference of logarithm	Liquidity risk	Potential liquidity stress
Total (noninterbank) loans / Customer deposits	First difference of logarithm	Liquidity risk	Potential liquidity stress
Interest rates on denar loans without a currency clause	Level	Interest rate	Systemic implications of interest rate setting
Interest rates on long-term foreign currency loans	Level	Interest rate	Systemic implications of interest rate setting
Interes rates on foreign currency deposits of households	Level	Interest rate	Systemic implications of interest rate setting
Interest rates on short-term foreign currency loans	Level	Interest rate	Systemic implications of interest rate setting
Interest rates on denar deposits without a currency clause	Level	Interest rate	Systemic implications of interest rate setting
Foreign currency spreads	First difference of logarithm	Credit risk	Perceived credit risk
Regulatory capital / Risk weighted assets	First difference of logarithm	Leverage	Robustness of financial institutions to withstand shocks to their balance sheets
REER (four quarter change in REER in %)	Level	Price competitiveness	Risk premium faced by firms
Interest margin / Gross income	First difference of logarithm	Profitability	Profitability
Noninterest expenses / Gross income	First difference of logarithm	Profitability	Profitability

Figure 1
Ranking of variables by their actual importance in the adjusted FCI*



**The actual importance of each variable in the financial conditions index is equal to the weighted sum of the loadings on each variable across the 5 principal components; the variables are listed in this order - from those with the largest positive weights to those with the largest negative weights in our adjusted FCI.*

NATIONAL BANK OF THE REPUBLIC OF MACEDONIA

P R O G R A M
2nd Research Conference "Policy Nexus and the Global Environment: A New Consensus Emerging from the Crisis?"
26 April, 2013, Skopje

Venue: Holiday Inn Hotel

26 April 2013 (Friday)

Conference "Policy Nexus and the Global Environment: A New Consensus Emerging from the Crisis?"

9.00 Dimitar Bogov, Governor of the NBRM, Opening Speech

Session I: Effectiveness of Monetary Policy in the Midstream of Protracted Crisis: The Synergy of Conventional and Unconventional Monetary Approach

Moderator: Anita Angelovska Bežoska, Vice-Governor, NBRM

9.15 Turalay Kenç, Deputy Governor, Central Bank of the Republic of Turkey - keynote speaker

9.45 Giuseppe Ferrero, Bank of Italy - Unconventional Monetary Policy in Theory and in Practice

10.05 Yasin Mimir, Central Bank of the Republic of Turkey - Required Reserves as a Credit Policy Tool

10.25 Discussion

10.45 Announcement of the Annual Award of the NBRM for the Best Paper of a Young Researcher

10.50 Coffee break

Session II: Monetary and Fiscal Policy Interaction, Has the Crisis Provided New Insights?

Moderator: Maja Kadievska Vojnović, Vice-Governor, NBRM

11.20 Michal Franta, Czech National Bank - Tracking Monetary-Fiscal Interactions Across Time and Space

11.40 Mirjana Miletić, National Bank of Serbia - Efficiency of the Fiscal and Monetary Stimuli: The Case of Serbia

12.00 Viktor Iliev, Bulgarian National Bank - Fiscal Policy and Economic Growth in Bulgaria

12.20 Mirna Dumičić, Alan Bobetko, Josip Funda, National Bank of Croatia - Fiscal Determinants of Government Borrowing Costs – Do We Have Only Ourselves to Blame?

12.40 Discussion

13.00 Lunch

Session III: Macroprudential Tools and Policies for Measuring and Mitigating Financial System Risk and Interaction with the Monetary Policy

Moderator: Aneta Krstevska, Chief Economist, NBRM

14.15 Adam Geršl, Joint Vienna Institute - Credit Growth and Capital Buffers: Empirical Evidence from Central and Eastern European Countries

14.35 Júlia Király, Central Bank of Hungary - Foreign Currency Lending: The "Flow" and the "Stock" Problem

14.55 Matjaž Volk, Bank of Slovenia - Estimating Probability of Default and Comparing It to Credit Rating Classification by Banks

15.15 Discussion

15.30 Coffee break

15.45 Adrian Costeiu, National Bank of Romania - Bridging the Banking Sector with the Real Economy: A Financial Stability Perspective

16.05 Albulene Kastrati, Central Bank of the Republic of Kosovo - Identifying Systemically Important Banks in Kosovo

16.25 Magdalena Petrovska, Elena Mucheva, National Bank of the Republic of Macedonia - Measures of Financial Stability in Macedonia

16.45 Discussion

17.00 Wrap up and closing of the conference

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