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Journal of Central Banking Theory and Practice

Provided in Cooperation with:
Central Bank of Montenegro, Podgorica

Suggested Citation: Dumičić, Mirna (2016) : Financial Stability Indicators – The Case of Croatia, Journal of Central Banking Theory and Practice, ISSN 2336-9205, De Gruyter Open, Warsaw, Vol. 5, Iss. 1, pp. 113-140, https://doi.org/10.1515/jcbtp-2016-0006

This Version is available at:
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DE GRUYTER OPEN

UDK: 336.131(497.5)
DOI: 10.1515/jcbtp-2016-0006

Journal of Central Banking Theory and Practice, 2016, 1, pp. 113-140
Received: 8 November 2015; accepted: 20 December 2015

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Financial Stability Indicators – The Case of Croatia[1]

Abstract: This paper considers financial stability through the processes of accumulation and materialisation of systemic risks. To this end, the method of principal component analysis on the example of Croatia has been used to construct two composite indicators – a systemic risk accumulation index and an index reflecting the consequences of systemic risk materialisation. In the construction of the indices, the features and risks specific to small open economies were considered. Such an approach to systemic risk analysis facilitates the monitoring and understanding of the degree of financial stability and communication of macroprudential policy makers with the public.

JEL: E44, E50, E58

Keywords: financial stability, systemic risks, financial system resilience, principal component analysis, Croatia

1. Introduction

Successful implementation of macroprudential policy requires identification of all sources of risk that may threaten financial stability. Due to the complexity of relations between financial institutions and financial markets, and the risks related to financial market infrastructure and domestic and international macroeconomic developments, the number of factors that may influence financial stability and of potential sources of systemic risks is extremely high. The selection

[1] The views expressed in this paper are those of the author and do not necessarily reflect the views of the Croatian National Bank.

of indicators to enable timely recognition of the build-up of vulnerabilities and potential systemic risks is therefore one of the biggest challenges for macroprudential policy.

This paper considers financial stability through the process of accumulation of systemic risks that could, if materialised, prevent the efficient process of financial mediation through various channels and negatively affect developments in the real economy. Also analysed are the consequences of the materialisation of systemic shocks. The focus is on features and risks specific to small and open and highly euroised economies. The method of principal component analysis on the example of Croatia has been used to construct the composite indicators that describe the processes of systemic risk accumulation and materialisation, while their dynamics is linked to activities of the central bank in the period prior to and following the occurrence of the global financial crisis in the third quarter of 2008.

The contribution of this paper to the existing literature on the measurement of financial stability is in its adoption of a new approach to indicators which reflect the processes affecting financial stability and the identification of the main sources of systemic risks for small and open economies rather than reflecting the state of stability of individual sectors or the system. Such a division and presentation of indicators should facilitate the understanding of the process of creating buffers against systemic shocks, risk accumulation and materialisation of previously accumulated risks. Composite indicators that reflect the movement of systemic risks can make it easier for both economic policy makers and market participants to monitor and understand the degree of financial stability and to predict possible sources and triggers of crisis episodes. They can also be useful for explaining the introduction, modification or removal of macroprudential measures and instruments.

The paper is divided into four main sections. The introduction is followed by a short overview of published studies dealing with the measurement of financial stability, with the emphasis on papers calculating composite indicators. In the third section, systemic risk accumulation and materialisation indices are constructed using the method of principal component analysis, and their movement and main determinants are described, with special reference to the central bank's activities related to these developments. The final section summarises the main results of the research and highlights the benefits of indicators constructed in this manner.

2. Literature overview

There is still no universally accepted model for a comprehensive measurement of financial stability and systemic risks. Financial stability indicators published to date mostly reflect the degree of stability of individual sectors or financial market segments or are focused on individual sources of risks. Macroprudential indicators covering individual sectors may be useful, but have no capacity to describe the state of a system as a whole. For this reason, the literature often uses composite indices capturing information obtained on the basis of individual macroeconomic, financial and other indicators. Gadanecz and Jayaram (2009), who have presented the attempts of researchers and central banks to contribute, by the use of various indicators and the creation of composite indices, to better understanding of financial stability, show that in spite of problems associated with their construction, composite indices have more power to identify the degree of financial stability than individual indicators.

Composite indicators are calculated at various degrees of complexity and then aggregated. For this purpose, simple statistical methods may be used, such as arithmetic mean or median (Bank for International Settlements, 2012). The literature dealing with early warning systems for crisis episodes often assesses multivariate logit or probit models where the dependent variable takes the value of one in the period assessed as the crisis period, and zero in other periods (Reinhart, Goldstein and Kaminsky, 2000). Petrovska and Mucheva Mihajlovska (2013) emphasise the two most frequently used methods for calculating composite indices – a weighted sum approach where each variable is weighted by its estimated impact on real GDP and the method of principal component analysis.

A set of variables included in an index must reflect the structure of the financial system and the specific macroeconomic characteristics of a country. The selected set of indicators initially assessed as suitable for efficient monitoring of systemic risks should be continuously adapted to developments in the financial system and macroeconomic environment. Therefore, indicators describing developments in financial markets, financial infrastructure, performance of financial institutions and developments in the real and public sectors, which are the main debtors of financial institutions, are used for the analysis of financial stability (Geršl and Hermanek, 2006). Due to the importance of banks in the process of financial mediation, the focus of these indices is most often on the indicators of bank performance (Bank for International Settlements, 2012).

Some of the composite indices commonly used in the literature and practice to monitor financial market conditions are the monetary conditions index and the

financial conditions index. Monetary conditions indices usually comprise the exchange rate and reference interest rate, while financial conditions indices describe the conditions for borrowing in domestic and foreign markets and also include numerous other macroeconomic variables and indicators of financial markets (Mayes and Viren, 2001). However, although they have a wider coverage than similar indicators, financial conditions indices do not include data on the state and performance of financial institutions so that the set of variables used for calculating financial stability indices may be complemented by indicators of performance of banks, pension funds and insurers (Van den End, 2006). Indicators of financial stress, calculated on the basis of high-frequency data from financial markets, are often used in the analysis of short-term developments (Kliesen, Owyang and Vermann, 2012; Dumičić, 2015).

Before the escalation of the global financial crisis, aggregate financial stability indicators were available only for a small number of, mostly advanced, countries. Although this number has increased recently, it mostly relates to financial stress indicators (Kliesen et al., 2012), while indicators reflecting financial stability or processes associated with systemic risks are less common.

This section briefly describes selected financial stability indicators constructed for several emerging market economies. The Central Bank of Turkey (2006) calculates the financial strength index, which is a weighted average of sub-indices that reflect the stability of the banking sector, where each sub-index has the same weight (Appendix 1, Table 1). Geršl and Hermanek (2006) constructed a stability indicator for the Czech banking sector in which the weights assigned to the variables used in the calculation of the total index were based on expert judgement (Appendix 1, Table 2). Albulescu (2010) created an aggregate financial stability indicator for Romania divided into sub-indices for financial development, financial vulnerability, financial soundness and the world economic climate (Appendix 1, Table 3). Cheang and Choy (2011) constructed an aggregate financial stability index for Macao by using 19 individual indicators which, after normalisation, were grouped into three categories – the financial soundness index, the financial vulnerability index and the regional economic climate index (Appendix 1, Table 4). Variables were assigned the same weight in the aggregation of each sub-index, while in the calculation of the aggregate financial stability index, weights were assigned in line with the estimated importance of a given segment for the entire financial sector.

Petrovska and Mucheva Mihajlovska (2013) constructed for Macedonia two composite indices – the stability index for the entire banking system, which dominates the Macedonian financial system, and the financial conditions index. The

former covers quantitative indicators on banks' performance assessed to be capable of exerting a significant impact on the stability of the banking system. Based on expert judgement, each group of indicators is then given a weight in the total indicator (Appendix 1, Table 5). The financial conditions index is constructed by use of the principal component analysis method in such a way that the first five principal components are summed and weighted by the share of total variability explained by them. The resulting index is then further divided by the share of total variance explained. Arzamasov and Penikas (2014) constructed financial stability indicators for Israel by using 16 selected financial soundness indicators from the IMF's database and applying the principal component method and its modifications, regression models and hybrid methods (Appendix 1, Table 6).

3. Methodology

In order to avoid the use of arbitrary methods in selecting the variables for the analysis of systemic risks and to be able to obtain a single indicator, the principal component analysis method has been used. It is a multivariate statistics method that summarizes information from a large number of intercorrelated variables and avoids problems like omitted variables or those related to degrees of freedom.

Financial stability indicators for Croatia are divided into those that reflect the processes of the accumulation of systemic risks and of their materialisation, which usually occurs after a financial shock. The selection of variables has been influenced not only by the experience of other researchers but also by the specific macroeconomic, monetary and financial features of Croatia. The systemic risk accumulation index (SRAI) is composed of 14 variables while the systemic risk materialisation index (SRMI) consists of 15 variables. Quarterly data for the period from the first quarter of 2001 to the fourth quarter of 2014 have been used for the computation (Tables 1 and 3). Both indices are defined as the first principal component obtained by the principal component analysis method:

$$SRAI_t = x_t \alpha$$
$$SRMI_t = y_t \alpha,$$

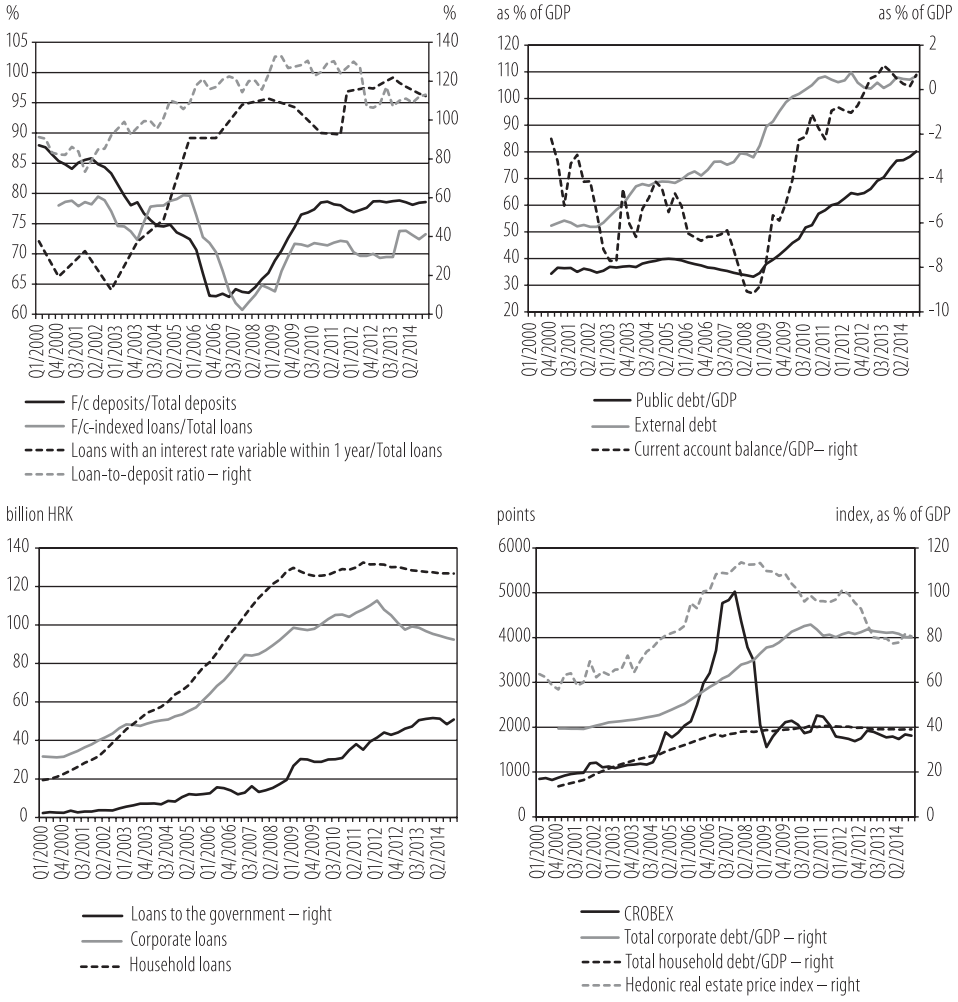
where α is a weight vector having the dimension 14x1 (15x1), and x_t (y_t) is the 1x14 (1x15) vector of the value of the indicators on the basis of which the indices are evaluated (Tables 1 and 2). The index calculated as a weighted average of the first five principal components has been presented as well. In that case, percentages of the common variance explained by an individual principal component have been used as weights (Petrovska and Mucheva Mihajlovska, 2013). Each index

has been computed in two versions – one based on quarterly and another based on annual changes in the individual indicators.

3.1. Accumulation of systemic risks

The systemic risk accumulation index captures those indicators available on quarterly basis over a longer period that have been assessed, based on theoreti-

Figure 1: Developments in components of the systemic risk accumulation index



Sources: CNB, HANFA, MoF, CBS and author's calculation.

cal assumptions and specific characteristics of the Croatian economic and financial system, as influencing the process of systemic risk accumulation in the system and/or in financial institutions and the sectors that are their main debtors – households, enterprises and the government. Namely, this process is closely related to the economic and financial characteristics of a country such as openness, degree of euroisation, share of foreign banks in total banking-sector assets, share of banks in the financial system, banks' policies with regard to price and non-price lending conditions, degree of domestic savings, and dependence on external sources of funding, and is influenced by stages of the economic and financial cycle (Table 1, Figure 1).

Banks have a share in the domestic financial system in excess of 70%, which makes them the most important factor of stability of the overall financial system. In view of banks' exposure to various types of risk, the index covers indicators that reflect credit risk, interest rate risk, currency risk and liquidity risk that may be of a systemic character (Ivaniš, 2012).

Credit risk is the risk that customers will default on their loan obligations. The share of loans with a floating interest rate in total loans approximates a part of interest rate risk, and, indirectly, credit risk as well, as the interest rate depends on factors beyond the debtor's control, which can, in the case of a significant rise in the interest rate, result in the debtor being unable to repay the loan.

The currency structure of loans and deposits reflects the degree of euroisation of the financial system. The greatest part of domestic loans is either denominated in a foreign currency or linked to it but they have been granted to customers who have no foreign exchange income. This means that due to the currency mismatch, a large part of the economy, including the government, is exposed to currency-induced credit risk, which increases debtor's insolvency risk and the likelihood of a rise in non-performing loans of banks, as well as the vulnerability of the economy as a whole in the case of a major weakening of the domestic currency.

Table 1: Impact of individual variables on the systemic risk accumulation index

Sources of systemic risk accumulation	Indicators	Loading parameters – SRAI_annual changes	Loading parameters – SRAI_quarterly changes
Balance sheets of banks	Loans with an interest rate variable within 1 year/Total loans	0,16	0,12
	Loans denominated in or indexed to foreign currency/Total loans	-0,10	-0,10
	Foreign currency deposits/Total deposits	-0,31	-0,31
	Loans/Deposits net of parent bank deposits	0,22	0,16
Corporates	Corporate debt/GDP	0,13	0,15
	Rate of change in corporate loans	0,36	0,41
Households	Household debt/GDP	0,38	0,40
	Rate of change in household loans	0,37	0,45
Government	Public debt/GDP	-0,36	-0,38
	Rate of change in government loans	0,08	0,07
Macroeconomic developments	External debt/GDP	0,05	0,07
	Current account balance/GDP*	0,26	0,20
Financial market developments	Hedonic real estate price index	0,36	0,27
	Share index CROBEX	0,22	0,15

Note: The indicators are organised in such a way that their increase denotes an accumulation of systemic risks, while the indicators which move in the opposite direction are marked with an asterisk and multiplied by minus one. The loading parameters reflect the contribution of a given variable to the explanation of the common trend of all the variables included into the calculation of the individual index constructed on the basis of the first principal component.

Source: Author's calculation.

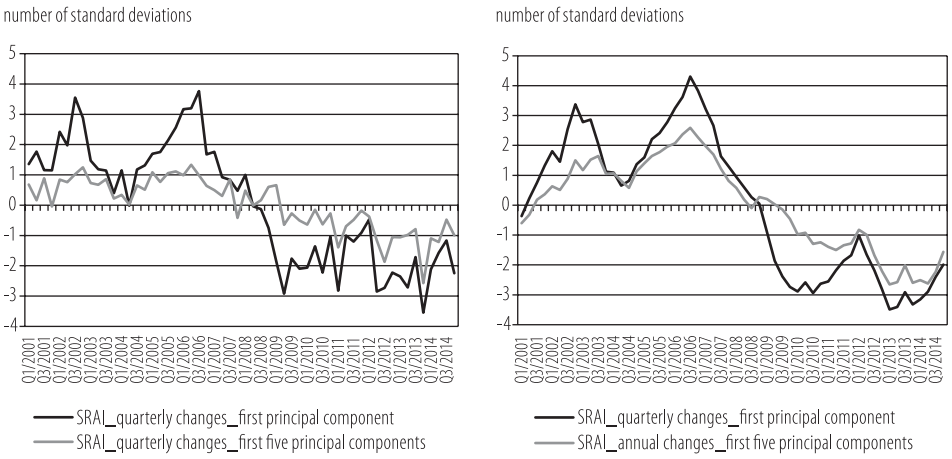
The loan-to-deposit ratio reflects the liquidity risk of banks and the degree of reliance on stable funding sources. A rise in this indicator indicates a heavier reliance on external sources of funding, which may raise the degree of systemic risks (Black, Correa, Huang and Zhou, 2012).

Numerous research papers have suggested that excessive lending activity is often associated with a rise in the vulnerability of the system as it implies a lower quality of approved loans and increased risk assumption, which can considerably exacerbate the effect of the transmission of the crisis from financial mediators to the real sector and vice-versa (International Monetary Fund, 2011), which is why the index also contains the rate of change in loans to enterprises, households and

the government. However, as strong loan activity is not necessarily linked to the accumulation of systemic risks, for example if it is a consequence of an expected future productivity growth, the index also contains macroeconomic variables that reflect the accumulation of macroeconomic imbalances on the system level and in individual sectors. The aim is to differentiate between sound loan growth and a growth accompanied by a permanent rise in asset prices and external imbalances or a rise in risks in banks' balance sheets amid the pronounced loosening of lending standards.

A high current account deficit contributes to the growth of risks related to a possible slowdown or stop in capital inflows and increases the vulnerability of the system (Blanchard and Milesi-Feretti, 2011). Something similar is true when foreign indebtedness grows, which intensifies the dangers related to financing and refinancing of liabilities due, particularly when unfavourable conditions occur in foreign financial markets or in case of a sudden stop (Alesina and Tabellini, 1988). Systemic risk associated with the government is measured as the public debt-to-GDP ratio. The level of this ratio largely affects the sustainability of public debt and the likelihood of a financial crisis (Hurlin, Popescu and Turcu, 2013; Ramsay and Sarlin, 2015). The index also includes prices of various forms of assets like real estate and shares. Stock market bubbles often precede, and can be taken as a reliable indicator of, crisis episodes. The same applies to real estate prices (Reinhart and Reinhart, 2008).

Figure 2: Systemic risk accumulation indicators



Source: Author's calculation.

Table 2: The percentage of explained common variance of variables included in the systemic risk accumulation index

	SRAI_annual changes	SRAI_quarterly changes
First principal component	39%	26%
First five principal components (weighted)	82%	66%

Source: Author's calculation.

Like most other Central and Eastern European countries, in the period up to the escalation of the global financial crisis in the third quarter of 2008, Croatia was exposed to strong foreign capital inflows. Liberalization of international capital flows, high global liquidity, and low global interest rates increased risk appetite, relatively low indebtedness of domestic sectors in comparison to the old EU members and the insufficient level of domestic savings for the funding of lending activity were a strong stimulus for investment in these countries. In the majority of them, the largest part of the banking system is in foreign ownership, so that a significant part of such financial flows were actually transfers of funds from parent banks to domestic banks. Capital inflows were mostly used for funding consumption and investment in the non-tradable sector, which resulted in strong appreciation pressures on the domestic currency and the growth in prices of other forms of financial assets. Demand for goods and services encouraged by loans exceeded short-term capacities of domestic supply, leading to increased imports and the current account deficit, while maintaining price stability at the same time (Rohatinski, 2009). The growth in the value of collaterals additionally encouraged credit expansion and increased risk assumption.

Developments in the systemic risk accumulation index indicate that the majority of systemic risks were accumulated in the period before the escalation of the global financial crisis (Figure 2). Loading parameters show that the greatest influence on the process of risk accumulation in Croatia was exerted by real estate prices, rates of changes in loans to the private sector, total indebtedness of the household sector, degree of euroisation and the movement of public debt and the current account balance (Table 1). It has to be pointed out that although public debt declined in the pre-crisis period, it started to grow very rapidly once the crisis had escalated. Developments in the degree of euroisation were similar; it had been falling up to the crisis onset but resumed an upward path as early as in late 2008 (Figure 1). During the entire period, the Croatian National Bank (CNB) employed various monetary and macroprudential measures and instruments which increased the resilience of the system to shocks on one hand, and mitigated the process of risk accumulation, which would have been even more pronounced without them, on the other hand (Dumičić and Šošić, 2014).

The central bank acted by tightening prudential and implementing administrative measures focused on decreasing the profitability of foreign sources of funds and discouraging the expansion of credit supply from such sources (Rohatinski, 2011; Figure 3).

The process of systemic risk accumulation started in 2002 and coincided with the beginning of strong credit expansion and deterioration of external vulnerability indicators (Figure 2). For these reasons, the CNB launched a series of measures to alleviate external and internal imbalances as early as in 2003, the most important being the following (Croatian National Bank, 2000 – 2012; Figure 3):

- the high level of general reserve requirements (23.5% in early 2000 and 13.5% in early 2013);
- an administrative limit on loan growth set at 16% per annum in 2003; and
- the decision on the obligation to maintain the coverage of short-term foreign currency liabilities by short-term foreign currency claims at a minimum of 53% was in 2003 replaced by the decision on the obligation to maintain the minimum amount of foreign currency claims at 35% of foreign currency sources, aimed at ensuring suitable foreign exchange liquidity of banks.

In the period from mid-2004 to mid-2006, the main generators of the risk accumulation process were the high growth rates of loans to the private sector, a strong increase in its total indebtedness as measured in terms of GDP and a significant rise in real estate prices. The high current account deficit also contributed to the growth of systemic risks, while the reduction of the degree of euroisation that marked a larger part of the pre-crisis period worked in the opposite direction.

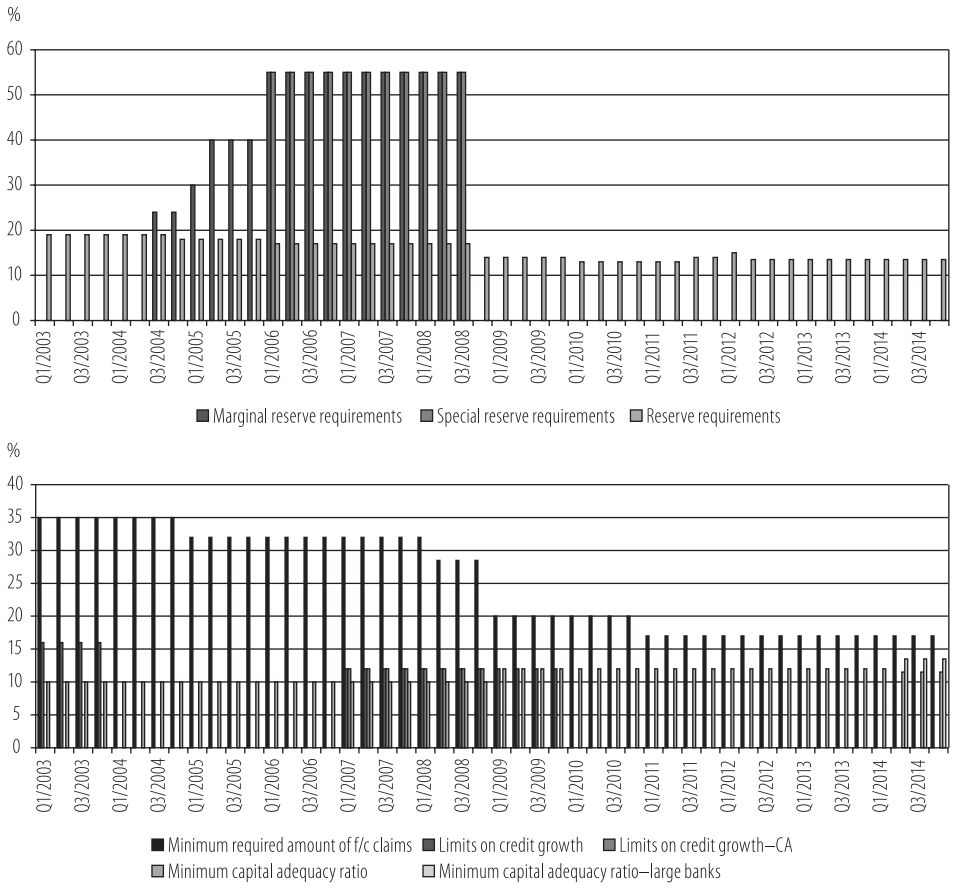
In this period, the CNB additionally tightened its monetary and macroprudential policy by (Figure 3):

- adopting the decision on the obligation to set aside marginal reserve requirements against increases in the foreign liabilities of banks aimed at making international borrowing more expensive and slowing down the growth of external imbalances and loans; the requirements were gradually increased from 24% to 55 %;
- introducing a special reserve requirement aimed at making it more expensive for banks to borrow by issuing domestic market debt securities that could afterwards be sold to non-residents, which actually meant that banks indirectly borrowed abroad and avoided other CNB measures;
- increasing capital requirements for currency-induced credit risk;

- increasing the prescribed minimum capital adequacy ratio (12%);
- conducting foreign exchange interventions primarily aimed at alleviating appreciation pressures on the domestic currency that resulted in an increase in international reserves;
- adopting the decision on the subscription of compulsory CNB bills allowing a non-penalised rate of credit growth of 12% per annum aimed at slowing down credit growth, which was in some periods several times faster than the growth of gross domestic product, and at contributing to the maintenance of macroeconomic and financial stability in the country; and
- increasing capital requirements for banks whose credit growth exceeds 12% per annum, which made it more expensive for banks to grant loans denominated in or indexed to a foreign currency in terms of capital and facilitated a gradual reduction of the degree of euroisation, making kuna loans more attractive, while an increase in the risk weight strengthened the stability of the banking system and, due to a strong growth in bank capital, decreased systemic risks associated with excessive lending activity.

The process of risk accumulation started to slow down in the second half of 2006. The trend continued in 2007 as a consequence of the introduction of the highest permissible rate of credit growth, but also of the first signs of the global financial crisis, which appeared in mid-2007 and escalated in the third quarter of 2008. When interpreting Figure 2, it is important to realise that the low level of the systemic risk accumulation index in the period after the escalation of the global financial crisis does not necessarily imply a significant reduction of the overall level of risk, but a deceleration of the process of risk accumulation. This becomes clearer when individual components of the index are considered (total indebtedness of corporate and household sectors, public debt, external debt) whose levels indicate a high total risk, which reduced slightly only in some segments, while the degree of euroisation actually increased. The only improvement can be observed in the current account balance.

Figure 3: Changes in the most important monetary policy measures from 2003 until end-2014



Sources: Financial stability, No. 3, Croatian National Bank, August 2009, Croatian National Bank (2000 – 2012) and complemented by the author.

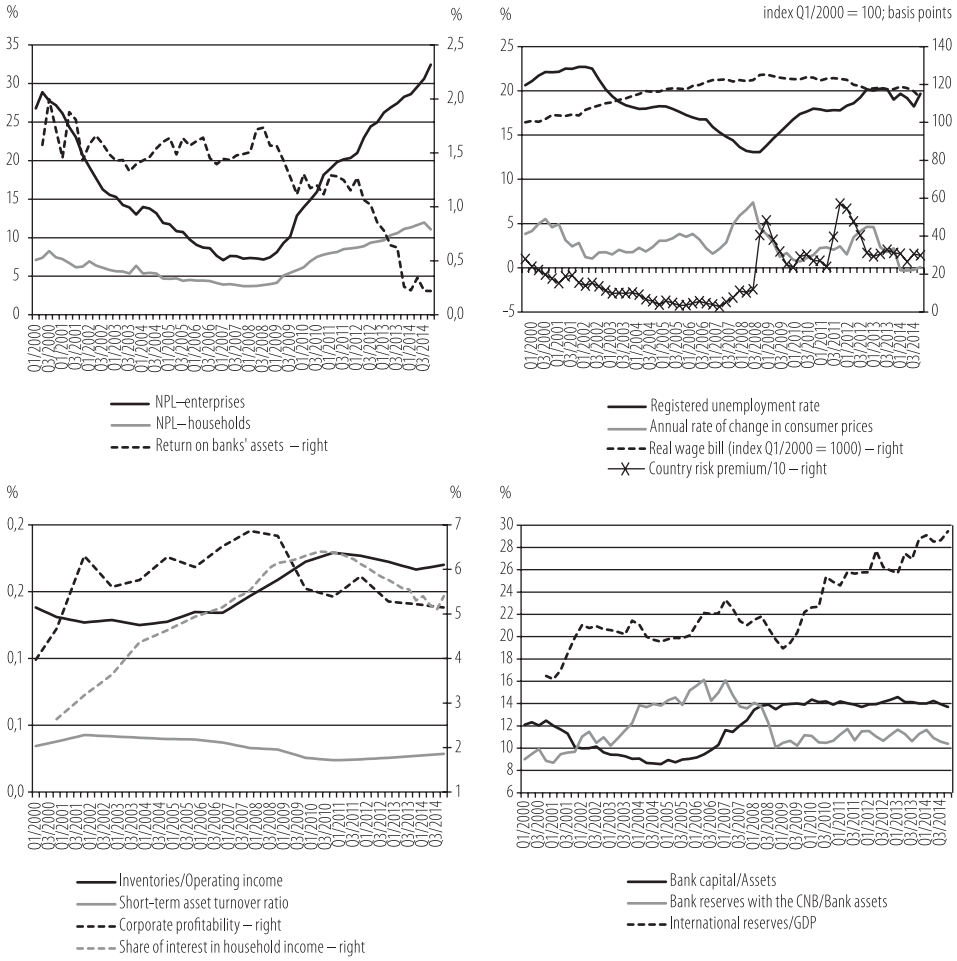
3.2. Materialisation of systemic risks

To obtain a more comprehensive insight into the financial stability of the system, it is necessary also to observe the consequences of the materialisation of previously accumulated risks. While such episodes are most often induced by various financial disturbances measured by high-frequency indicators, they can also be triggered by changes in the terms of trade, political instability and natural disasters, i.e. events which, when they occur, disclose previously accumulated unsustainable macroeconomic imbalances or risks accumulated in financial institutions. By then, it is usually too late to take measures and introduce instruments capable of strengthening the resilience of the system, which adds emphasis to the importance of timely implementation of macroprudential policies.

Consequences of systemic risk materialisation are proportional to the strength and type of shock that triggered the process, the quantity of previously accumulated risks and the structural characteristics of the economy, but they also depend on the phase of the cycle. Materialisation of these risks disrupts the financial indicators of both the government and the private sector, and diminishes their capacity to contribute to economic activity, which also reduces future potential GDP growth. This results in long-term negative consequences for the entire society.

The systemic risk materialisation index covers indicators that are available on quarterly basis, which are believed to reflect the consequences of materialisation of accumulated systemic risks at the level of the economy as a whole and in individual sectors: indicators of the quality of banks' assets and performance, available indicators of the financial position of households and enterprises, various macroeconomic variables and indicators of system resilience (Table 3, Figure 4).

Figure 4: Developments in the components of the systemic risk materialisation index



Sources: CNB, CBS, Bloomberg and author's calculation.

Table 3: Impact of individual variables on the systemic risk materialisation index

Consequences of systemic risk materialisation	Indicators	Loading parameters – SRMI_ annual changes	Loading parameters – SRMI_ quarterly changes
Banks	Share of non-performing corporate loans in total loans	0,42	0,40
	Share of non-performing household loans in total loans	0,42	0,31
	Return on bank assets (resilience)*	0,24	0,10
Corporates	Inventories/Operating income	0,12	0,32
	Short-term asset turnover ratio*	0,16	0,37
	Profitability*	0,33	0,45
Households	Share of interest expense in income	-0,34	-0,31
	Registered unemployment rate	0,29	0,19
	Real wage bill*	0,35	0,29
Government	Tax revenues*	0,29	0,14
Macroeconomic developments	Annual rate of change in consumer prices	-0,10	-0,03
	Country risk premium	0,01	0,05
System resilience	Capital/Assets*	-0,09	-0,20
	Bank reserves with the CNB/Bank assets*	0,14	0,09
	International reserves/GDP*	-0,04	-0,06

Note: The indicators are organised in such a way that their increase denotes a materialisation of systemic risks, while the indicators which move in the opposite direction are marked with an asterisk and multiplied by minus one.
The loading parameters reflect the contribution of a given variable to the explanation of the common trend of all the variables included into the calculation of the individual index constructed on the basis of the first principal component.

Source: Author's calculation.

Table 4: Percentage of explained common variance of variables included in the systemic risk materialisation index

	SRMI_annual changes	SRMI_quarterly changes
First principal component	36%	21%
First five principal components (weighted)	88%	77%

Source: Author's calculation.

The escalation of the global financial crisis manifested in a strong deceleration of capital inflows into Central and Eastern European countries, increased mistrust in global financial markets and the resulting growth of risk premiums, and higher costs of foreign capital due to the growth of country risk premiums, as well as

risk premiums for the parent banks of domestic commercial banks brought about by the sovereign debt crisis in peripheral euro area countries. Besides, the majority of the countries recorded a strong decline in real estate prices and various forms of financial assets. Such developments had a strong impact on the domestic real sector which, due to the systemic risks accumulated in the previous period, was burdened with a high level of indebtedness and a low investment potential at the time the crisis episode occurred.

The major part of the consequences of materialised systemic risks is directly or indirectly related to credit risk that has become evident in banks' balance sheets as a surge in non-performing loans. The ratio of corporate and household non-performing loans to total loans reflects the quality of bank assets, which is very sensitive to the movements in corporate and household income. An increase in the number of borrowers who are not able to repay their loans may lead to difficulties in banks' operations and have a negative impact on their profitability and capitalization. Although the kuna/euro exchange rate remained stable during the entire observed period, currency-induced credit risk still partly materialised due to the depreciation of the domestic currency against the Swiss franc, as 16% of total loans were indexed to the CHF at the end of 2008. A sharp decline in real estate prices additionally weakened the position of debtors.

Studies about Central and Eastern European countries show that there is a strong feedback loop between the quality of placements and the real economy, as the growth in non-performing loans negatively affects the speed and capacity of the economy to recover (Klein, 2013). It also reflects macroeconomic conditions, such as movements in GDP, unemployment and inflation, which result in a decline in the disposable income of households and diminish their ability to service their liabilities, while reducing corporate profitability. The interest expense burden on household income also affects debtors' ability to repay their loans, as does the movement of the wage bill, which depends not only on per-capita wages but also on the number of employees and is a form of systemic risk materialisation which reduces the capacity of households for consumption and restricts their access to loans. Growth in unsold inventories, extension of collection periods and a decline in recoverability, a deterioration of liquidity indicators and the resulting fall in earnings and capitalization of enterprises are also consequences of systemic events reflected not only in the capacity of enterprises to contribute to economic recovery, but also in banks' balance sheets in terms of an increase in non-performing loans.

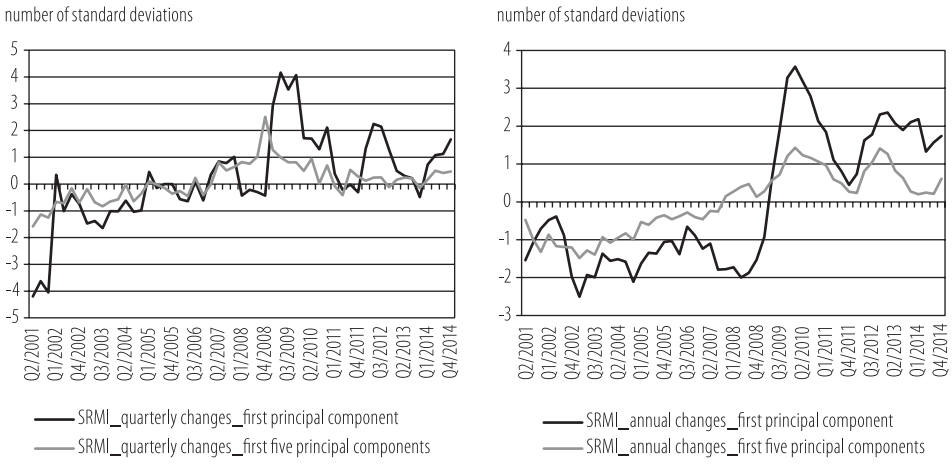
A country risk premium reflects expectations of market participants regarding macroeconomic and financial developments in a country. It is also one of the

most significant determinants of the borrowing costs for domestic sectors as it affects the availability of foreign capital and may therefore be used as a measure of the consequences of systemic risk materialisation to the government sector and, indirectly, to the private sector.

The system resilience indicators include banks' profitability and capitalization and their reserves with the CNB, as well as international reserves. A reduction of these indicators may be related to either the materialisation or the prevention of the materialisation of systemic risks (Johnston and Grey, 2011). The banking sector resilience is a major component of overall financial stability and it is measured by the ratio of capital to total assets of banks. Unlike the capital adequacy ratio, this indicator is not affected by changes in prescribed risk weights. Banks' return on assets reflects their profitability, which is closely linked to their resilience and capacity to absorb potential shocks (Pavković, 2004), while its decline may be associated with the materialisation of systemic risks. International reserves are insurance against the risk of a sudden stop in foreign capital inflows and against crisis episodes (Čeh and Krznar, 2009). If markets assess that their level is sufficient to absorb potential shocks, the reserves enable easier access to international capital markets. Their strong decline is assumed to be a consequence of the materialisation of systemic risks, for example, prevention of depreciation of the domestic currency exchange rate. The bulk of banks' reserves with the CNB includes funds set aside as reserve requirements which, in the part of the period under review, comprised immobilized funds of banks with faster than permitted credit growth. Although reserve requirements are primarily used to regulate system liquidity and increase the effectiveness of monetary policy, they are also an insurance against sudden liquidity shocks. For this reason, numerous central banks have used reserve requirements in a counter-cyclical manner in order to prevent and mitigate the consequences of systemic risks (Tovar, Garcia-Escribano and Martin, 2012).

The index shows that the consequences of the crisis episode started to reflect in early 2009 both in banks' balance sheets and in the real sector, while its movements were most influenced by the dynamics of banks' non-performing loans, labour market developments and corporate profitability (Figure 5, Table 3).

Figure 5: Systemic risk materialisation indicators



Note: An increase in the indicator denotes intensification of the process of the materialisation of systemic risk consequences.

Source: Author's calculation.

In the period up to 2008, most of the observed indicators had improved considerably (Figure 4). The non-performing loan ratio had been reduced for both corporate and household sectors, the unemployment rate was also continually falling, the wage bill was growing and inflation was relatively stable and low, while performance indicators of corporates and the financial position of households mainly improved. However, although this was an apparently stable period marked by an above-average economic growth, historically low levels of risk premium and strong capital inflows into the country, it was in this period that most of the imbalances and systemic risks were accumulated, the risks that would begin to materialise after the escalation of the global financial crisis (Figure 2). The majority of the CNB's monetary and macroprudential measures were tightened in this period, whereas international reserves increased due to numerous foreign exchange interventions primarily aimed at alleviating appreciation pressures on the exchange rate of the domestic currency against the euro, which increased the system's resilience (Figures 3 and 4). A gradual decline in the rates of reserve requirements ando the minimum required foreign currency claims ratio aimed at enabling the government to borrow in the domestic market worked in the opposite direction.

Although the first signs of the crisis in world financial markets appeared in mid-2007, they acquired prominence in Croatia only after the collapse of the Lehman Brothers investment bank in September 2008. At the end of the year, downward pressures on the domestic currency were triggered by the spillover of the global financial and real crisis to the domestic financial system and the real economy and the limited net inflow of foreign capital, and the CNB began gradually to release the system reserves accumulated in the preceding period and necessary to finance domestic sectors (Figure 3):

- in order to improve the foreign exchange liquidity of banks and ensure the payment of international liabilities, the marginal reserve requirement was removed in October 2008;
- in December 2008, the reserve requirement ratio was reduced from 17% to 14%, significantly improving the system liquidity and making it easier for the government to borrow in the domestic market, as foreign markets were actually frozen;
- in February 2009, in response to the freezing of world financial markets, the foreign exchange liquidity of the banking system was additionally increased when the minimum required foreign currency claims ratio was reduced from 28.5% to 25% and later to 20%;
- at the end of 2009, the decision restricting the growth in placements to 12% was abolished; and
- in March 2011, the minimum required foreign currency claims ratio was reduced to 17%, releasing an additional credit potential of banks and reducing the regulatory costs for banks.

By easing the previously introduced measures and instruments, the CNB released more than 6.1 billion euros, i.e. the equivalent of more than 14% of GDP by the end of 2012. These actions preserved the stability of the kuna/euro exchange rate and the overall financial stability of the system and ensured a smooth servicing of government liabilities to foreign creditors, while there were no fiscal expenditures for the resolution of financial institutions. However, the maintenance of financial system stability was not sufficient to stop negative developments in the real sector, as evident from the deterioration of the banks' asset quality indicators and performance indicators of enterprises and the financial position of households (Figure 4).

Conclusion

Analysis and understanding of systemic risks are a basis for making decisions on the use of macroprudential policies and for the creation of an efficient framework for the prevention and mitigation of crisis episodes and the strengthening of system resilience.

In this paper, systemic risks are observed through the processes of their accumulation and materialisation. Analysis of constructed composite indicators suggests that the process of risk accumulation in Croatia was to the greatest extent related to a strong lending activity. This is in line with the findings of most of the authors who deal with crisis episodes, as they identify excessive credit growth and exaggerated optimism in lending as the key characteristics of the financial and banking crises (Kaminsky and Reinhart, 1999). Materialisation of systemic risks was foremost manifested in banks' balance sheets as an increase in the non-performing loan ratio, which also reflected negative developments in the real sector. The central bank acted in a countercyclical manner during the whole period under review, partly alleviating the process of accumulation of systemic risks, while the release of the funds previously immobilised by macroprudential and monetary measures following the escalation of the global financial crisis helped to maintain the stability of the domestic financial system and ensure the country's international liquidity.

Such indicators draw attention to factors that affect the process of systemic risk accumulation and encourage preventive actions, and can also be useful for communication with the public. However, in spite of numerous possibilities for constructing quantitative indicators of financial stability and their effectiveness in identifying potential crisis episodes, processes related to movements of systemic risks and capturing of all variables relevant for financial system stability are still rather limited. In order to gain a comprehensive insight into financial stability, they should be combined in practice with a qualitative analysis and consultations among economic policy makers, relevant market players and academics.

Acknowledgment:

This work has been partially supported by Croatian Science Foundation under the project *STatistical Modelling for REspoNse to Crisis and Economic GrowTH in WeStern Balkan Countries -STRENGTHS (project no. 9402).*

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Appendix 1

Composite financial stability indices – literature overview

Table 1: Banking stability index for Turkey

Sub-indices	Banking stability index		
	Indicators	Weight	Impact
Capital adequacy	Capital adequacy ratio	0,5	+
	Free capital/Total assets	0,5	+
Asset quality	Gross non-performing loans/Gross loans	0,33	-
	Net NPL/Equity	0,33	-
	Fixed assets/Total assets	0,33	-
Profitability	Net profit/Total assets	0,5	+
	Net profit/Equity	0,5	+
Liquidity	Liquid assets/Total assets	0,4	+
	Assets with a maturity up to 3 months/Liabilities with a maturity up to 3 months	0,6	+
Interest rate risk	(Domestic currency assets with a maturity up to 1 month)/Domestic currency liabilities with a maturity up to 1 month/Equity	0,5	-
	(FX assets with a maturity up to 1 month/FX liabilities with a maturity up to 1 month)/Equity	0,5	-
Exchange rate risk	On-balance sheet FX position/Own funds	0,5	-
	FX net general position/Own funds	0,5	-

Source: Central Bank of the Republic of Turkey (2006).

Table 2: Banking stability index for the Czech Republic

Partial indicator	Banking stability index		
	Indicators	Weight	Impact
Capital adequacy	Capital adequacy ratio	0,05	+
Asset quality	Non-performing loans/Total loans	0,25	-
Profitability	Return on assets	0,25	+
	Return on equity		
Liquidity	Quick assets/Total assets	0,25	+
Interest rate risk	Cumulative net balance sheet position to 3 months/Assets	0,1	+
Foreign exchange risk	Absolute value of open total position in foreign exchange/Tier 1 capital	0,1	-
	Absolute value of open balance sheet position in foreign exchange/Tier 1 capital		

Source: Geršl and Hermanek (2006).

Table 3: Banking stability index for Romania

Sub-indices	Aggregate financial stability indicator		
	Indicators	Weight	Weight
Financial development index	Market capitalisation/GDP	0,25	0,2
	Total credit in lei/GDP	0,25	
	Interest spread	0,25	
	Banking reform & interest rate liberalisation	0,25	
Financial vulnerability index	Inflation rate	0,125	0,4
	General budget deficit/GDP	0,125	
	Current account deficit/GDP	0,125	
	REER excessive depreciation or appreciation	0,125	
	Non-governmental credit/Total credit	0,125	
	Loans as a percentage of deposits	0,125	
	Deposits/M2 (variation)	0,125	
	(Reserves/Deposits)/(Note & coins/M2)	0,125	
Financial soundness index	Non-performing loans/Total loans	0,2	0,25
	Regulatory capital/Risk weighted assets	0,2	
	Own capital ratio (Own capital/Total assets)	0,2	
	Liquidity ratio (Effective liquidity/Required liquidity)	0,2	
	General risk ratio	0,2	
World Economic Climate Index (WECI)	Economic Climate Index – CESifo	0,33	0,15
	World Inflation	0,33	
	World Economic Growth Rate	0,33	

Source: Albulescu (2010).

Table 4: Banking stability index for Macao

Sub-indices	Aggregate financial stability index		
	Category	Indicators	Weight
Financial soundness index	Capital adequacy	Capital adequacy ratio	0,125
		Ratio of NPL net of provisions to capital	0,125
	Asset quality	Ratio of NPL to total loans	0,125
	Liquidity	Ratio of liquid assets to total assets	0,125
		Loan-to-deposit ratio	0,125
	Profitability	Return on assets	0,125
		Interest margin-to-gross income ratio	0,125
		Non-interest expenses-to-gross income ratio	0,125
Financial vulnerability index	External sector	Current account balance-to-GDP ratio	0,11
		Ratio of M2 to foreign exchange reserves	0,11
		Ratio of external assets to total assets	0,11
		Ratio of foreign currency assets to foreign currency liabilities	0,11
	Financial sector	M2 multiplier	0,11

Source: Cheang and Choy (2011).

Table 5: Banking stability index and financial conditions index for Macedonia

	Indicators
Banking stability index	Insolvency risk
	Credit risk
	Profitability
	Liquidity risk
	Currency risk
Financial conditions index	Decrease in banks' leverage
	Capital adequacy ratio
	Market capitalisation of shares
	Real estate prices
	Real exchange rate
	Macedonian stock exchange index
	Share of FX deposits including foreign exchange-indexed to total deposits
	Profitability
	Loans to deposit ratio
	Interest rates and the spread

Source: Petrovska and Mucheva Mihajlovska (2013).

Table 6: Banking stability index for Israel

	Indicators
Financial stability index	Assets to gross domestic product (GDP)
	Assets to total financial system assets
	Commercial real estate loans to total loans
	Customer deposits to total (non-interbank) loans
	Earnings to interest and principal expenses
	Foreign-currency-denominated liabilities to total liabilities
	Foreign-currency-denominated loans to total loans
	Household debt to GDP
	Interest margin to gross income
	Non-interest expenses to gross income
	Personnel expenses to non-interest expenses
	Residential real estate loans to total loans
	Residential real estate prices
	Return on assets
	Return on equity
	Total debt to equity

Source: Arzamasov and Penikas (2014).

Appendix 2

Table 1: Description and sources of data

Index	Indicators	Description	Source
Systemic risk accumulation index	Loans with an interest rate variable within 1 year/Total loans	First difference/Fourth difference	CNB
	F/c indexed loans/Total loans	First difference/Fourth difference	CNB
	F/c deposits/Total deposits	First difference/Fourth difference	CNB
	Deposits net of parent bank deposits/Loans	First difference/Fourth difference	CNB
	Corporate debt/GDP	First difference/Fourth difference	CNB, HANFA, CBS
	Rate of change in corporate loans	Quarterly/Annual rate of change	CNB
	Household debt/GDP	First difference/Fourth difference	CNB, HANFA, CBS
	Rate of change in household loans	Quarterly/Annual rate of change	CNB
	Rate of change in government loans	Quarterly/Annual rate of change	CNB
	External debt/GDP	First difference/Fourth difference	CNB, CBS
	Public debt/GDP	First difference/Fourth difference	MoF, CBS
	Current account balance/GDP	First difference/Fourth difference (negative sign)	CNB, CBS
	Hedonic real estate price index	Quarterly/Annual rate of change	CNB calculation, author's calculation
	Share index CROBEX	Quarterly/Annual rate of change	ZSE, author's calculation
Systemic risk materialisation index	Share of non-performing corporate loans in total loans	First difference/Fourth difference	CNB
	Share of non-performing household loans in total loans	First difference/Fourth difference	CNB
	Return on bank assets (ROA)	Net income/Total bank assets. First difference/Fourth difference	CNB
	Inventories/Operating income	First difference/Fourth difference	FINA
	Short-term asset turnover ratio	First difference/Fourth difference	FINA
	Corporate profitability	First difference/Fourth difference	FINA
	Share of interest expense in income	First difference/Fourth difference	CNB, CBS
	Registered unemployment rate	First difference/Fourth difference	CES
	Real wage bill	First difference/Fourth difference	CNB, CBS
	Tax revenues	First difference/Fourth difference	MoF
	Consumer price index	Quarterly/Annual rate of change	CNB
	Country risk premium	First difference/Fourth difference	J. P. Morgan, Bloomberg
	Capital/Assets	Share of bank capital in total assets. First difference/Fourth difference	CNB
	Bank reserves with the CNB/ Bank assets	Bank reserves include bank deposits with the central bank. First difference/Fourth difference	CNB
	International reserves/GDP	Gross international reserves. First difference/Fourth difference	CNB, CBS