INSTITUTE
OF ECONOMIC STUDIES
Faculty of Social Sciences
Charles University

A PROLONGED PERIOD OF LOW INTEREST RATES: UNINTENTED CONSEQUENCES

Simona Malovaná
Josef Bajzík
Dominika Ehrenbergerová
Jan Janků

IES Occassional Paper 1/2021

Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Bibliographic information:
Malovaná S., Bajzík J., Ehrenbergerová D., Janků J. (2021): "A Prolonged Period of Low Interest Rates: Unintended Consequences" IES Occassional Papers 1/2021. IES FSV. Charles University.

This paper can be downloaded at: http://ies.fsv.cuni.cz

A Prolonged Period of Low Interest Rates: Unintended Consequences

Simona Malovaná[a]
Josef Bajzík[b]
Dominika Ehrenbergerová[c]
Jan Janků[d]

[a]Czech National Bank, e-mail: simona.malovana@cnb.cz
[b]Czech National Bank and Charles University, e-mail: josef.bajzik@cnb.cz
[c]Czech National Bank and Charles University,
e-mail: dominika.ehrenbergerova@cnb.cz
[d]Jan Janků, Czech National Bank and VSB – Technical University of Ostrava,
e-mail: jan.janku@cnb.cz

April 2021

Abstract:
Based on intraday data for a large cross-section of individual stocks and Exchange traded funds, we show that short-term as well as long-term fluctuations of realized market and average idiosyncratic higher moments risks are priced in the cross-sectionof asset returns. Specifically, we find that market and average idiosyncratic volatility and kurtosis are significantly priced by investors mainly in the long-run even if controlled by market moments and other factors, while skewness is mostly short-run phenomenon. A conditional pricing model capturing the time-variation of moments confirms downward-sloping term structure of skewness risk and upward-sloping term structure of kurtosis risk, moreover the term structures connected to market skewness risk and average idiosyncratic skewness risk exhibit different dymanics.

JEL: E52, E58, G2
Keywords: financial stability, financial vulnerabilities, low interest rates, monetary policy, natural rate of interest

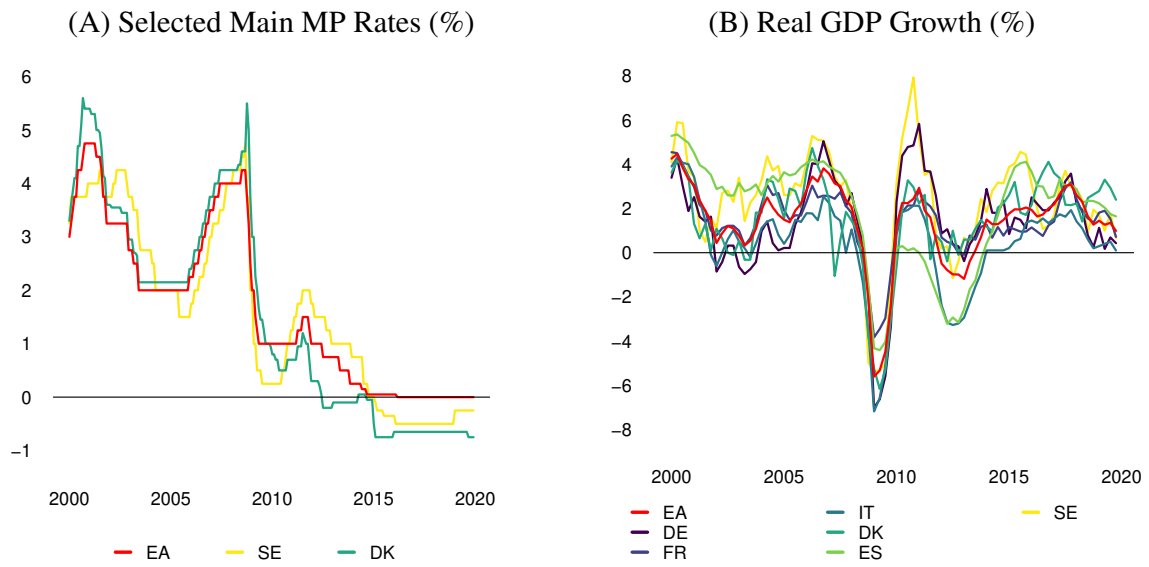
Acknowledgements: We would like to thank Jan Frait, Martin Hodula, Boris Hofmann, Jiří Schwarz, and CNB seminar participants for useful comments.

The authors note that the paper represents their own views and not necessarily those of the Czech National Bank. All errors and omissions remain the fault of the authors.

1. Introduction

After the Global Financial Crisis (GFC), the central banks of many advanced economies significantly eased monetary conditions. Monetary policy easing helped fight the immediate consequences of the GFC. Central banks around the world turned their attention to enhancing the liquidity of financial institutions and markets, restoring confidence in the financial system, and containing the impact of the crisis on the real economy. In addition to the conventional monetary policy of managing short-term interest rates, central banks used unconventional measures, especially various asset purchase programs. Mainly in Europe, monetary policy remained highly accommodative long after the GFC, even though a number of economies experienced an expansion in economic activity (see Figure 1). As a consequence of this monetary policy easing – unprecedented in scope and length – both short-term and long-term risk-free interest rates have declined to zero or below it, and risk premiums have been compressed, which has had some unintended adverse consequences for financial stability.

Figure 1: Monetary Policy Rates and Business Cycles in Selected Countries



Source: Eurostat Database, BIS policy rate statistics

Some economists pointed to the potential negative implications quite early on. For instance, Borio and Zhu (2008, 2012) were among the first to draw more attention to the link between monetary policy and the perception and pricing of risks in the economy (the risk-taking channel of monetary policy). They argue that the importance of the risk-taking channel is increasing with changes in the financial system and prudential regulation. As such, the standard macroeconomic models omitting these links may not be well suited for monetary policy analysis and recommendations. A related paper by Adrian and Shin (2010) stresses the importance of short-term interest rates in influencing the size of financial intermediaries' balance sheets and hence their risk appetite. Jiménez et al. (2009, 2014) complement the previous papers with an empirical investigation of the effects of monetary policy on credit risk-taking using an exhaustive credit register of loan applications and contracts. Their findings show that lower short-term interest rates induce low-capitalized banks to provide more loans to riskier firms.

The financialization[1] of advanced economies has increased significantly since the 1970s, strengthening the importance of financial factors and the correlation between the business and financial cycles. Economies have become significantly leveraged, which has increased the role of credit in determining business cycle fluctuations. More financialized economies exhibit lower and less volatile real growth, higher tail risk, and stronger links between the real and financial sides (Jordà et al., 2017). Credit-driven economic expansions tend to be followed by deeper recessions and slower recoveries (Jordà et al., 2013; Drehmann et al., 2012). The literature shows that the co-movement between rapid credit growth and asset prices tends to play a key role in building financial imbalances with the potential to result in a financial crisis and a contraction in the business cycle (Borio and Lowe, 2004; Borio and Drehmann, 2009; Drehmann et al., 2012; Jordà et al., 2015a,b; Mian et al., 2017).

Over the last decade, the body of empirical literature exploring the adverse effects of the low interest rate environment after the GFC has grown significantly. Numerous recent studies document how this environment has contributed to the build-up of financial vulnerabilities, resulting in higher systemic risk. This has motivated us to offer the interested reader an overview of this stream of literature, categorize it, and provide a few policy considerations. It is important to stress that there is a significant number of studies supporting the need for, and the effectiveness of, both the conventional and unconventional monetary policy tools deployed in the recent decade. However, macro-financial linkages may not always form part of such analyses, which may potentially create a bias.

Some studies argue that monetary policy was not accommodative enough after the GFC, and that this had significant long-run costs in terms of low inflation, slow recovery, and heightened unemployment. For instance, Acharya et al. (2018) show that, given the magnitude of the shock during the GFC, monetary policy in the US was accommodative enough to avert permanent stagnation, but not enough to prevent a slow recovery. Similarly, Cúrdia et al. (2015) show that while monetary policy was accommodative relative to the Taylor rule, it was not accommodative enough to prevent the interest rate gap from increasing and output from falling below potential. These conclusions do not contradict our view, because they usually call for a swifter and stronger reaction immediately after the adverse shock occurs. The main argument here is that if monetary policy, or macroeconomic policy in general, had been more accommodative immediately after the GFC, there would have been no need to maintain accommodative monetary policy for a prolonged period. Conceptually, we agree with that and we continue with the story – because monetary policy has been accommodative for a prolonged period and interest rates have been at all-time lows for longer than at any time in history, some financial vulnerabilities have been created and heightened.

We take multiple perspectives by exploring observable and unobservable parts of the story. We start with a historical description of the environment of very low or even negative interest rates (the observable part of the story; see section 2). While real interest rates have been negative many times throughout history (about 30% of the time since 1930), zero or negative nominal interest rates are a new phenomenon of the recent period.

Following that, we devote some space to estimating the natural rate of interest and discussing its potential impact on monetary policy decision-making (the unobservable part of the story; see section 3). The natural rate of interest is considered to be the neutral level of the monetary policy rate and is often used to explain the downward trend in real interest rates observed all over the

[1] Financialization refers to the growing importance of financial markets and financial institutions in the economy. It is usually associated with a growing credit-to-GDP ratio and rising leverage (Jordà et al., 2017).

world. However, one cannot measure the natural rate of interest directly, and its estimation proves to be strongly model- and assumption-dependent. Given the significant financialization of advanced economies, financial factors should play a prominent role in macroeconomic models, including those used to estimate the natural rate of interest. Therefore, we provide a unique comparison of natural rates of interest estimated using two approaches – with and without financial factors – for six large European economies inside and outside the euro area. Each approach yields a different estimate and therefore leads to different monetary policy recommendations with different implications for the real economy and the financial system over the longer term.

Next, we provide a comprehensive review of the empirical literature on the adverse effects of low interest rates. Based on this review, we define five broad categories and 22 subcategories of financial vulnerabilities which may be created or fueled by such an environment, and we describe the effects and mechanisms in each subcategory (section 4). In addition, we discuss the undesirable impacts of a prolonged period of low interest rates on monetary policy transmission and the point-of-no return situation (i.e., the situation in which it may be costly to normalize monetary policy; see section 5).

Finally, we summarize the main conclusions and provide a few monetary policy considerations, including a short discussion of the role of macroprudential policy.

2. A Brief History of Low and Negative Short-Term Interest Rates

Since the onset of the GFC, central banks have pursued highly accommodative monetary policy via conventional and unconventional monetary policy measures. While real negative interest rates have been present across several time periods in history, negative nominal interest rates are a new phenomenon of the post-GFC era (see Figures B1 and B2 in Appendix B). In the following subsections, we provide a brief historical overview of negative nominal and real interest rates.

2.1 Nominal Interest Rates

Eight European central banks[2] and Japan were using negative policy rates as of 2019. The main reasons and objectives for deploying negative interest rate policy differed across the central banks concerned. Some of them were seeking price stability and some of them exchange rate stability, while others were simply following the ECB's policy, as their currencies were pegged to the euro (see below). As of 2019, negative interest rate policy had been in place for more than six years in the euro area and Switzerland and eight years in Denmark, with the lowest level of -0.75% reached in Denmark and Switzerland.

Some central banks are most likely at their lower bound according to the literature. The estimates of the effective lower bound, i.e., the lower limit on interest rates, ranges between -0.25% and -2.00%. The estimate for Canada lies most likely between -0.25% and -0.75% (Witmer et al., 2015). Simply observing the recent experience with negative interest rates, Jackson (2015) suggests that the effective lower bound is -1.0% on average. Some authors suggest that central banks can go even further, to -2% (Kolcunová and Havránek, 2018) or even lower, depending on the configuration of the tiering system (Barr et al., 2016).

[2] The central banks of Denmark, Sweden, Switzerland, Norway, Hungary, Bulgaria, and Bosnia and Herzegovina, and the ECB.

Table 1: Percent of the Time Central Bank Policy Rates Have Been Zero or Negative (%)

	Nominal CB policy rate			Real CB policy rate		
	Total	Before 2008	2008+	Total	Before 2008	2008+
Euro area	8	0.0	31.5	39.8	28.7	71.6
Other European countr.	4.5	0.0	16	32.7	25.2	50.9
Asia	2.3	2.2	2.5	30.4	25.7	37.8
US	0.0	0.0	0.0	31.7	20.7	81.1
Canada	0.0	0.0	0.0	27.2	13.3	83.1
Japan	10.9	7.8	27.3	38.8	34.3	61.3

Note: Frequency calculated as number of months when central bank policy rate was zero or negative divided by total number of months, in percent. Time period: 1M 1957–11M 2019. Euro area: AT, BE, CY, FI, FR, DE, GR, IE, IT, MT, NL, PT, SI, SK, ES. Other European countries: CZ, DK, HU, IS, NO, PL, RO, SE, CH, UK. Asia: CN, IN, ID, IL, JP, KR, MY, PH, RU, TH, TR.
Source: BIS policy rate statistics and consumer price statistics, ECB database

Danmarks Nationalbank (DNB) was the first central bank in Europe to introduce negative interest rates. In summer 2012, the DNB set its one-week deposit rate below zero. The rate reached technical zero in April 2014 but went back into negative territory in September 2014. This was a reaction to the ECB's policy of negative rates; as the Danish krone is pegged to the euro via ERM II, the DNB wanted to avoid financial inflows and pressures on the exchange rate (Angrick and Nemoto, 2017; Arteta et al., 2016). The certificate of deposit rate applies to only a part of the reserves held at the central bank.

The ECB set its overnight deposit facility rate to zero in June 2014; the interbank overnight rate was immediately pulled below zero. In June 2014, the ECB lowered all three policy rates – the marginal lending facility rate, the main refinancing operations rate, and the deposit rate. Large injections of additional liquidity via large-scale asset purchase programs helped lower market interest rates too – the EONIA (Euro OverNight Index Average) turned negative in October 2014, and the Euribor (Euro Interbank Offered Rate) did likewise soon afterward.

After the ECB set its overnight deposit facility rate below zero, a number of other European central banks followed suit. Sveriges Riksbank introduced a negative repo rate in February 2015,[3] the Swiss National Bank in December 2014, and Norges Bank in September 2015. In Sweden, the motivation to introduce negative interest rates again was different from that of the DNB – while the DNB was aiming for exchange rate stability, Sweden was primarily concerned about price stability (Angrick and Nemoto, 2017). The three-month Stibor (Stockholm Interbank Offered Rate) followed the policy rate and turned negative in April 2015. The Swiss National Bank set its policy rate below zero just before the Swiss franc's peg to the euro ended. Similarly to the Danish case, Switzerland was aiming to counter pressures on the Swiss franc and had thus been intervening in the foreign exchange market before the period of negative interest rates. Only the portion of the sight deposit balance account exceeding a certain threshold is subject to the negative interest rate. The Swiss franc three-month Libor fell below zero almost immediately after the negative interest rate was introduced. In Norway, the key policy rate – the interest rate on banks' overnight deposits – has never dropped below zero. However, the reserve rate – the rate on deposits above a certain threshold (quota), which is always one percentage point lower than the key policy rate – has. Norway's three-month interbank rate did not follow the reserve rate into negative numbers.

[3] Sveriges Riksbank had adopted a negative interest rate before – the overnight deposit rate was maintained at -0.25% between July 2009 and September 2010. However, at that time the main policy rate – the one-week repo rate – was not negative yet.

Among the Eastern European central banks, the Hungarian Central Bank, the Bulgarian National Bank, and the Central Bank of Bosnia and Herzegovina adopted negative interest rate policy. The motivation for the Hungarian Central Bank was both price stability and exchange rate stability (Arteta et al., 2016; Jobst and Lin, 2016). On the other hand, the Bulgarian National Bank and the Central Bank of Bosnia and Herzegovina had to follow the ECB's monetary policy, as they are pegged directly to the euro.

The Bank of Japan officially adopted negative interest rate policy in January 2016. The primary focus of the Bank of Japan was to deliver additional monetary easing in an attempt to achieve higher consumer price inflation. Additionally, commercial banks' reserves were divided into three tiers. Each tier was subjected to a different interest rate: 0.1%, 0%, and -0.1%. The majority of the reserves came under the first two tiers, so only a minimum of them earned negative interest.

Following the drop in monetary policy interest rates and huge quantitative and qualitative easing programs, government bond yields have fallen into negative territory too. In the aftermath of the GFC, ten European countries have experienced negative yields on 1-year government bonds, the same number on 5-year government bonds, and six countries on 10-year government bonds. The equivalency of marginal policy rates and government bond yields arises at high maturities. The maturity of government bonds on which the yield is the same as the policy rate is increasing over time. The European countries with the lowest government bond yields include Sweden, Denmark, and Germany, with yields as low as -0.5 to -0.6% p.a. at the one-year horizon.

2.2 Real Interest Rates

While negative nominal interest rates are a new phenomenon, negative real interest rates have been quite common throughout history. Negative real interest rates appeared in the 1930s, 1940s, 1970s, 2000s, and 2010s. In advanced economies, real interest rates were zero or negative approximately one third of the time between 1957 and 2019. In the euro area and Japan, the number is even higher, reaching 40% (see Table 1). The average in Asia as a whole is a solid 30% as well.

There was massive and simultaneous plunge in real interest rates in many countries during the 1970s. The fall was caused by a combination of large inflation shocks and financial repression (Turner and Spinelli, 2012). In these countries, real interest rates turned positive only after crucial financial reforms were delivered in the 1980s and 1990s (Escolano et al., 2017). A second, long and ubiquitous period of negative real interest rates has taken place since the GFC. In this case, the reason for real interest rates being negative is completely different. It is a result not of high inflation, but of low nominal rates. Since 2008, the ex-post real interest rate, measured as the central bank policy rate minus consumer price inflation, has been zero or negative for around 70% of the time in the euro area, 50% of the time in other European countries, and more than 80% of the time in the US (see Table 1). That means a significant portion of time in which spending and investment have been challenged. While in the US and Canada this has been a result of positive inflation, in the euro area and Japan negative nominal interest rates have played a significant role.

3. Real and Natural Interest Rates: What's the Real Story?

The natural rate of interest is an *unobservable* variable which helps economists determine the neutral level of the monetary policy rate. If the real interest rate (the monetary policy rate adjusted for inflation) is below the natural rate of interest, monetary policy is considered to be accommodative; if the real interest rate is above the natural rate of interest, monetary policy is considered to be restrictive. Why is this important? Because real interest rates all over the world have been on a downward trend for a very long time and have remained exceptionally low since the GFC. Does this mean that monetary policy has been highly accommodative for an extended period of time? Or have natural rates of interest declined along with monetary policy rates, and could monetary policy therefore be considered less accommodative, more or less neutral, or even restrictive? Answering this question could be difficult, as views differ widely depending on the approach used to estimate the *unobservable* natural rate of interest.

There are two opposing views as to the main drivers of the natural rate of interest, one relating to structural factors and the other to cyclical factors. Both views are model-dependent, meaning that the estimated natural rate of interest strongly depends on the model used and the assumptions made.

The first – much older and prevailing – approach defines the natural rate of interest as the real interest rate consistent with output equaling its potential and with inflation stable close to the target.[4] More importantly, monetary policy cannot influence the natural rate of interest permanently, and therefore tracks it only passively. In other words, monetary policy is neutral in the medium to long term. As a result, the downward trend in real interest rates reflects a fall in natural rates of interest, driven by changes in structural factors. These factors include, for example, lower productivity growth and low investment demand, demographic trends (population aging), rising inequality, and increased globalization (see Table 2 for more details). It is believed that these factors have led to savings permanently exceeding investment and to a fall in real interest rates, thus exerting downward pressure on nominal interest rates. This view is known as "Wicksellian," after Wicksell (1898), and was adopted by, for example, Laubach and Williams (2003). From this point on, we will refer to this estimate as the Laubach and Williams (2003) natural rate of interest, or the natural rate of interest without financial factors.

The second – broader – approach takes into consideration financial factors in estimating the natural rate of interest. The basic idea is that output cannot be at its sustainable level if the financial side of the economy is not. As a result, monetary policy can influence natural rate of interest via its impact on the financial cycle. Since financial cycles can lead to permanent output losses, monetary policy may not be neutral in the medium to long run (Juselius et al., 2016). Omitting financial factors from estimating the natural rate of interest may potentially contribute to incorrect monetary policy prescription, amplifying the financial cycle and having a long-lasting impact on output (Ball, 2014; Schularick and Taylor, 2012; BCBS, 2010). This, in turn, may influence the estimate of the natural rate of interest and create a vicious circle.[5]

[4] A key signal that output is not at its potential is given by inflation. All else equal, if the output gap is positive, inflation rises and monetary policy should be tightened. If the output gap is negative, inflation falls and monetary policy should be eased.

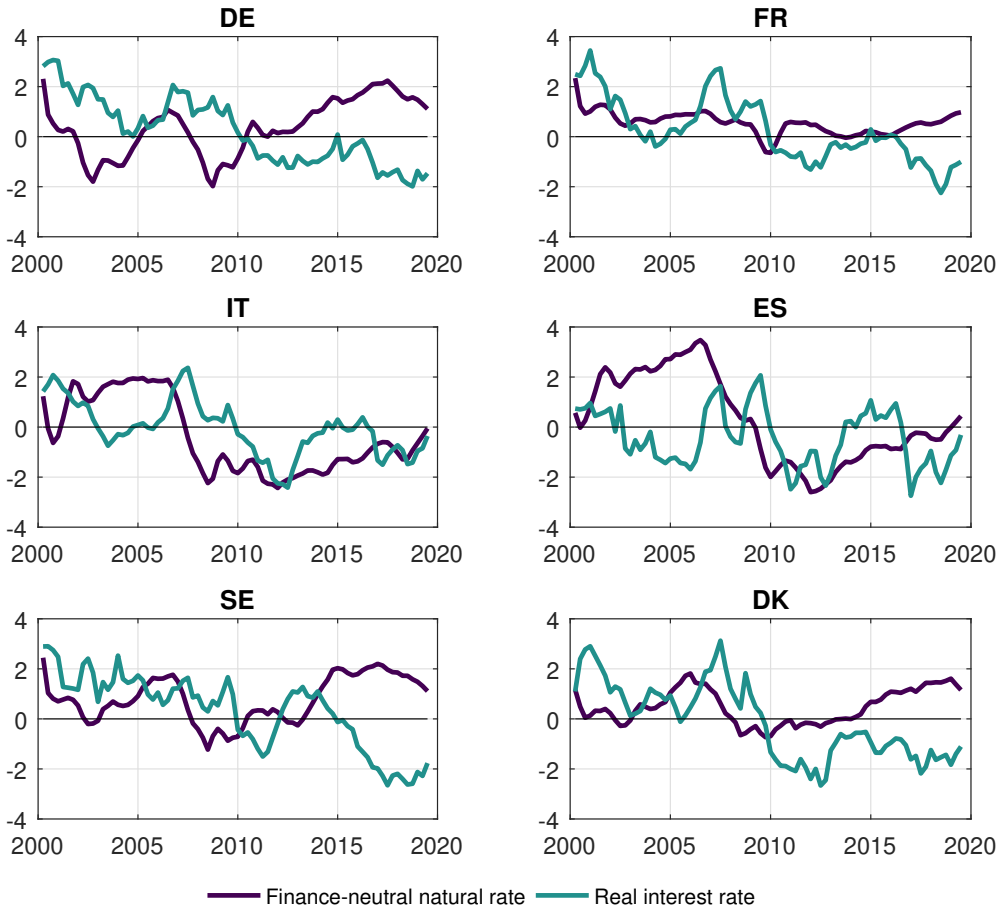
[5] Under the Laubach and Williams (2003) approach, the IS curve depends only on the interest rate gap; therefore, if the output gap is negative (positive) the estimated natural rate of interest must be below (above) the observed real rate. Under the Juselius et al. (2016) approach, the Phillips curve and the interest rate gap in the IS curve do not play such prominent roles, since the leverage gap enters the IS curve alongside the interest rate gap.

Table 2: The Decline in the Natural Rate of Interest – Structural Factors

Factor	Impact
Population aging	Population aging leads to a rising fraction entering retirement, which results in weaker labor force growth and a higher dependency ratio (Aaronson et al., 2014). Population aging may also lead to rising aggregate household saving, as those approaching retirement in advanced economies typically have above-average saving rates (Rachel and Smith, 2018). The weaker labor force and rising saving rates put downward pressure on output trend growth, which reduces natural rates of interest. Gagnon et al. (2016) find that demographic factors have led to a decline in the natural rate of interest in the US since 1980. This finding complements those of Ikeda and Saito (2014) for Japan and Carvalho et al. (2016) for the OECD, both of which show that a rise in the proportion of retired adults lowers real interest rates.
Slower productivity growth	Slower productivity growth leads to higher savings and lower investment, both of which tend to push down growth prospects and exert downward pressure on the natural rate of interest. The lower productivity growth primarily reduces the future expected income of households, lowering their current consumption and boosting their savings. However, it also lowers investment demand, because the slower pace of innovation creates fewer profitable opportunities in which to invest (Gordon, 2017; Fernald et al., 2015). The empirical evidence on the link between trend growth and the natural rate of interest is rather mixed (Laubach and Williams, 2003; Hamilton et al., 2016), and the link between the real rate and consumption growth is weak (Hamilton et al., 2016).
Subdued investment	Low investment demand pushes down long-term growth prospects and, consequently, the natural rate of interest. Low investment demand may be a result, for example, of lower productivity growth (fewer profitable opportunities), higher perceived uncertainty (reluctance to invest), and lower capital intensity of firms (for example, due to technological progress). According to Summers (2014), the reduction in demand for debt-financed investment is a reflection of the legacy of a period of excessive leverage. It is a consequence of greater restrictions on financial intermediation after the GFC. However, probably to a greater extent, the author argues, it is a reflection of the changing character of productive economic activity (the leading technological companies nowadays are much less capital-intensive than companies of the past).
Income inequality	Higher income inequality may reduce aggregate demand, which puts downward pressure on economic growth and the natural rate of interest. This is because the highest income earners typically spend a lower proportion of their income than do other income groups (Auclert and Rognlie, 2018; Dynan et al., 2004). Rachel and Smith (2018) show that shifts in saving and investment are the main cause of the long-term decline in the natural rate. According to the authors, the global saving schedule has shifted due to demographic forces, higher inequality, and, to a lesser extent, the glut of precautionary saving by emerging markets.
Increased globalization	Increased globalization (trade and financial links) creates potential for spillovers. A slowdown in the long-term growth prospects of significant world economies and regions (e.g., the US and the EA) may exert appreciation pressure on the domestic exchange rate and consequently lower net exports. This may impact domestic growth prospects and put downward pressure on the domestic natural rate of interest. Hördahl et al. (2016) confirm that international linkages between interest rates in different currencies are strong and conditioned by two global benchmarks - the Federal funds rate at the short end and the world real interest rate at the long end.
Regulatory arbitrage	Increasing regulatory requirements in the banking sector have created incentives for regulatory arbitrage (the structuring of activities in a way that reduces the impact of regulation without a corresponding reduction in the underlying risk; see, for example, Buchak et al., 2018) and leakages (the shifting of activities to non-bank financial institutions; see, for example, Gebauer and Mazelis, 2020). Regulatory arbitrage and leakages maintain downward pressure on lending and funding rates through competition from non-bank financial institutions.

We estimate the natural rate of interest for selected large European countries following the broader cyclical approach. We follow the strategy proposed by Juselius et al. (2016), who extend a version of the Laubach and Williams (2003) model by incorporating two financial variables - the leverage gap and the debt service gap. This modification is supposed to capture the long-term relationship between financial and real variables and to introduce the financial cycle into the model. The leverage gap refers to the co-integrating relationship between the credit-to-GDP ratio and real asset prices. The debt service gap refers to the co-integrating relationship between the credit-to-GDP ratio and the lending rate on outstanding debt. The model consists of five main equations: a reduced-form IS equation, a Phillips curve, an equation for potential output, an equation for the natural rate of interest, and an equation for the leverage gap (for more detail, see Appendix A).[6] Following Juselius et al. (2016), we will refer to this estimate as the finance-neutral natural rate of interest, or the natural rate of interest with financial factors.

Figure 2: The Finance-Neutral Natural Rate of Interest and the Real Interest Rate



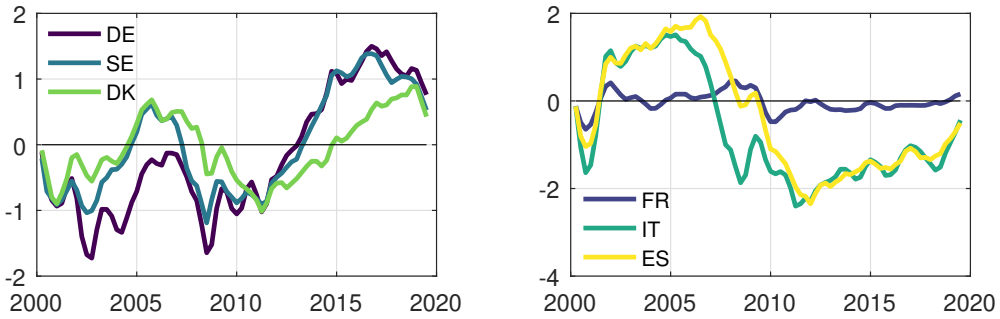
Note: For more details on the estimation, see Appendix A.

Our estimates suggest that different European countries may have different needs in terms of monetary policy. There are significant differences in the estimated finance-neutral natural rates of interest between the Southern and Northern European countries (see Figure 2). Before the GFC, the real interest rates in Italy and Spain stayed far below the natural rates of interest, indicating that monetary policy conditions were accommodative in these countries. As a result, this period may

[6] For more detail and further discussion on the model, we refer the reader to the original paper by Juselius et al. (2016).

have contributed to the build-up of financial imbalances, amplifying the impact of the GFC. Studies show that the short- and long-term impacts of the GFC were more prominent in these countries relative to others (Ball, 2014). After the GFC, the finance-neutral natural rates of interest in Italy and Spain dropped more than in other countries and remained very low for a prolonged period, reflecting worse financial conditions. The difference is especially noticeable when compared to Germany, Sweden, and Denmark. In these countries, the finance-neutral natural rate of interest has risen steadily in the last couple of years while the real interest rate has remained exceptionally low. The need for additional monetary policy easing has therefore been less pressing, and the latter three countries might even have benefited from restrictive monetary policy between 2015 and 2020.

Figure 3: Difference Between the Finance-Neutral and Laubach and Williams (2003) Natural Rates of Interest



Note: For more details on the estimation, see Appendix 3.

We compare the finance-neutral and Laubach and Williams (2003) natural rates of interest. The approach by Laubach and Williams (2003) draws on a set of reduced-form equations derived from the pre-crisis models without financial variables. After the GFC, however, a need to incorporate the missing link between the real economy and the financial system into the existing macroeconomic models emerged. Consequently, a significant amount of academic literature has addressed this issue and stressed the importance of reflecting these results in the analytical frameworks and structural models of policy decision-making institutions.

As shown by our estimates, the natural rate of interest with financial factors is lower than that without financial factors in Southern European countries and higher in Northern and Western European countries, reflecting a different role of financial factors and a different position in the financial cycle (see Figure 3). The differences between countries support the intuition presented above. Before the GFC, the finance-neutral natural rate of interest was higher for most countries, indicating a need for higher monetary policy rates in order to be neutral. During the GFC, the finance-neutral natural rate of interest fell below the Laubach and Williams (2003) natural rate of interest in all countries, reflecting deteriorating financial conditions. The finance-neutral natural rate of interest has remained significantly lower for more than a decade in Italy and Spain, while it has been on an upward trend since 2014 for Germany, Sweden, and Denmark.

Our estimation results indirectly imply that both the business and financial cycles of individual economies may not be well synchronized, with the financial cycle being more desynchronized. We are not the first to show this. Oman (2019) discusses the existing literature on the synchronization of business and financial cycles in the euro area while providing some empirical evidence himself. He shows, among other things, that financial cycles are less synchronized than business cycles, and

business cycle synchronization has increased while financial cycle synchronization has decreased. These findings are in line with the literature documenting both significant heterogeneity across euro-area financial cycles (Samarina et al., 2017; Stremmel and Zsámboki, 2015; ECB, 2014) and increasing synchronization of business cycles (De Grauwe and Ji, 2016; Jordà et al., 2017).

Our estimation results also indicate that financial factors may play a prominent role in the monetary policy needs of some European countries outside the euro area. This is important to acknowledge because of significant monetary policy spillovers, implying that the interest rate declines seen over the last decade in the US and the euro area have influenced interest rates elsewhere. The interest rates of many advanced and emerging economies have moved closely together, despite their business cycles often being at different stages. The fact that the monetary policy of major world central banks affects that of others is supported by numerous empirical studies showing that the short- and long-term interest rates of large world economies significantly affect the corresponding rates in other economies (Hofmann and Takáts, 2015; Obstfeld, 2015; Turner and Sobrun, 2015; Miyajima et al., 2014; Turner, 2014; He and McCauley, 2013), while these spillovers at least partially reflect monetary policy spillovers (Edwards, 2015; Hofmann and Takáts, 2015; Takáts and Vela, 2014; Gray, 2013). The spillovers from these large monetary unions go beyond interest rates, affecting exchange rates, bond spreads, output growth, and overall financial conditions (Rey, 2016; Varghese and Zhang, 2018; Chen et al., 2017; Horvath and Voslarova, 2017; Falagiarda et al., 2015).

4. Financial Vulnerabilities Fueled by the Low Interest Rate Environment

Monetary policy may not be fully neutral in the medium to long run, as it works by affecting financial variables. As mentioned earlier, highly accommodative monetary policy after the GFC has led to a prolonged period of low interest rates. On the one hand, such an environment may improve the current financial conditions, but on the other hand it may create and increase future financial vulnerabilities. In the short term, favorable financial conditions can increase the resilience of the financial system via better access to cheaper funding and improved borrower creditworthiness, supporting bank capital and reducing non-performing loans (see, for example, Freixas et al., 2011; Kiyotaki and Moore, 2019; Gertler et al., 2013). Nevertheless, a prolonged period of low interest rates may offset this effect in the medium to long run by depressing the profitability of financial institutions and consequently reducing their capitalization and solvency. Heightened financial vulnerabilities may amplify adverse shocks and pose risks to financial stability if accompanied by weakened resilience of the financial system.[7]

It is important to distinguish between a few key concepts – financial conditions, financial vulnerabilities, and risk. It is not uncommon for these concepts to be mixed up or used incorrectly. Financial conditions refer to the current state of financial variables, including anything that characterizes the supply of, or demand for, financial instruments, such as asset prices and risk premiums (Hatzius et al., 2010). Financial conditions also cover broad funding conditions, which affect the future state of the economy via changes in the behavior of various economic agents (in the private and public sector and in the financial and non-financial sector). Financial vulnerability refers to a weakness or a gap in the system. It is the degree to which the financial system can be "wounded" or, in other words, adversely affected by shocks. Risk is the probability of loss as a result of an adverse shock exploiting, and being amplified by, the vulnerability.

[7] Some studies indicate that the adverse impact of a low or negative interest rate environment goes beyond financial stability. For example, Palley (2016) and Randow and Kennedy (2016) suggest that negative nominal interest rates may reduce aggregate demand and promote currency wars.

It is important to understand that financial conditions and financial vulnerabilities are not the same and have different impacts on financial stability. Tightening or easing financial conditions do not pose an immediate risk to financial stability. As long as the financial system is robust, performs its functions, operates with no serious failures or undesirable impacts on the present and future economic situation, and withstands shocks, it can be considered stable. However, if an adverse shock is amplified by financial vulnerabilities, it may potentially have serious negative impacts on the financial system and the economy as a whole (Adrian and Liang, 2018).

In what follows, we define five broad categories and 22 subcategories of financial vulnerabilities which may be created and fueled by a low interest rate environment (see Table 3). The list was compiled on the basis of an extended body of literature discussed in detail in the following sub-section.[8] We acknowledge that our list may not be complete, but we try to provide an overview of the most exposed parts of the financial system, financial activities, or the economy. We focus primarily on the link between the low interest rate environment and financial vulnerabilities; we also briefly discuss its impact on the resilience of the financial system.

Table 3: Financial Vulnerabilities Potentially Created and Fueled by Low Interest Rates

Broad Category	**Subcategory**
Excessive credit growth and leverage	1. Overindebtedness and excessive debt service burdens of non-financial private sector
	2. Excessive leverage of banks/low capitalization in relation to assets
	3. Excessive securitization/rapid increase in banks' off-balance sheets
	4. Regulatory (capital) arbitrage and leakages
	5. Excessive leverage of non-bank financial institutions
	6. Use of derivatives to mimic leverage
Mispriced risk	7. Deteriorating underwriting standards
	8. Changes in portfolio quality
	9. Compressed risk premiums on credit
	10. Compressed risk premiums in various asset classes (equities, bonds, real estate)
	11. Compressed term premiums
	12. Undervalued risk parameters used to calculate regulatory capital requirements
Excessive maturity mismatch and market illiquidity	13. Excessive use of short-term or floating rate debt by non-financial sector
	14. Excessive lengthening of asset maturities
	15. Lower liquidity and solvency of insurance companies and pension funds
Misaligned incentives and moral hazard	16. Moral hazard of high deposit banks with lower equity
	17. Moral hazard of friendly corporate governance
	18. Excessive size of financial institutions bearing critical functions (too big to fail)
High interconnectedness and exposure concentration	19. Rapid increase in common asset holdings/highly correlated risks in balance sheets
	20. Higher interconnectedness of financial systems
	21. Excessive size of central counterparties, higher risk-taking and inadequate risk management
	22. Shift from banking-based financial system toward capital markets

4.1 Excessive Credit Growth and Leverage of Banks and Non-Bank Financial Institutions

Low interest rates can boost credit growth, induce firms to switch from equity to debt financing, and even encourage banks to increase their leverage. Low interest rates can seriously hamper banks' profitability (see sub-section 4.6). In order to achieve their target profitability, traditional banks need to increase the quantity of credit they provide, as they cannot raise its price. A few

[8] When characterizing these categories and subcategories, we refer to a type of behavior which is "excessive" in some way. We do not provide a single numerical benchmark (i.e., some normal) or threshold above which the behavior is identified as excessive, because these benchmarks can differ among empirical studies. By "excessive" we mean behavior which leads to a build-up of financial vulnerabilities with implications for systemic risk, as described in this section.

factors meet here. Banks can increase the quantity of credit they provide by acquiring more clients, by increasing the average loan amount, or both. As a result, they may lend to clients who would not be eligible for loans under normal (i.e., monetary policy neutral) circumstances, and may lend them more than usual. Higher loan amounts may be a result of inflated asset prices (for example, a client needing a bigger mortgage to buy a house). The combination of borrowers with riskier characteristics and higher average loan amounts secured by collateral with overvalued prices creates an explosive mixture. As debt is cheaper than equity, firms may be inclined to switch from equity to debt financing by paying special dividends to shareholders and making debt-financed share buybacks. This has been happening since the 2008 recession. As a result, corporations are more indebted and have more leveraged balance sheets (Palley, 2016). Negative policy rates, if transmitted to lower or even negative bond yields, can encourage firms to get even more into debt by issuing corporate bonds. As shown by Dell'Ariccia et al. (2014), banks also tend to increase their leverage, as low interest rates reduce the costs of their liabilities. Higher credit growth and leverage will negatively affect banks' capitalization.

From selected studies, Jordà et al. (2015a) show on a sample of 17 advanced economies between 1870 and 2012 that more accommodative monetary policy leads to excessive lending and an increase in housing prices, and that these effects intensify over time. Laséen and Strid (2013) demonstrate a significantly stronger effect of loose monetary policy on credit growth than on the GDP of the Swedish economy. One of the key findings of the post-crisis literature is that a significant increase in the credit-to-GDP ratio is strongly correlated with subsequent banking crises (Adrian and Liang, 2018; Borio, 2014). At the same time, some studies indicate that in advanced economies, the likelihood of a financial crisis in response to excessive credit expansion has increased in recent decades (Gertler and Hofmann, 2018). Gertler and Hofmann (2018) show that between 1950 and 2011, an increase in the credit-to-GDP ratio of 10% over five years led to an increase in the probability of a crisis of 2 percentage points, while between 1985 and 2011 this relationship intensified to 4 percentage points.

Economic expansions accompanied by excessive credit growth are often followed by deeper recessions and slower-than usual economic recoveries. Jordà et al. (2013) demonstrate this by analyzing more than 200 different economic recessions in 14 advanced economies between 1870 and 2008. Jordà et al. (2017) also assert that while a higher ratio of credit to income may be associated with lower business cycle volatility, it is also associated with worse recessions (more severe tail events). Aikman et al. (2016) reach a similar conclusion for the US economy after examining the non-linear impact of an increase in the non-financial sector credit-to-GDP gap on the real economy. Their results indicate that at a high level of indebtedness relative to the trend, a further increase in indebtedness leads to a recession. The general problem in such a situation is to set a specific threshold for "already high indebtedness." Lombardi et al. (2017) focus on this issue by examining the impact of rising household indebtedness in a panel of 54 countries. The authors show that an increase in household indebtedness relative to GDP boosts household consumption and GDP growth in the short run, but reduces it in the long run.

Deteriorating profitability can push banks' capital to the regulatory limit or to the point at which it becomes difficult for banks to access wholesale funding markets. In such a situation, banks may opt for greater use of derivatives, which will help them increase their net interest margins, as they are compensated for the increased risk (ESRB, 2016b; Rajan, 2006). Bubeck et al. (2020) show that negative rates incentivize banks in the euro area to invest more in securities, especially in those yielding higher returns. These effects are stronger for less capitalized banks, while the banks concerned also take higher risks when lending. Higher securitization not only results in assets yielding attractive returns for investors, but also enhances bank lending capacity. That is, banks

may be incentivized to shift a proportion of their assets to their off-balance sheets in order to raise their capital ratios and cope with increasingly stringent banking regulation (i.e., using derivatives to mimic leverage; Adrian and Liang, 2018).

Low profitability and increasingly stringent banking regulation can also motivate banks to search for less regulated environments. More stringent banking regulation accompanied by a prolonged period of low interest rates may further reduce the profitability of traditional banking products relative to the products of non-bank financial institutions. Such a situation may motivate banks to engage in search-for-yield behavior in order to achieve their return targets and may potentially create incentives for regulatory arbitrage (the structuring of activities in a way that reduces the impact of regulation without a corresponding reduction in the underlying risk) and leakages (the shifting of activities to non-bank financial institutions). Less regulated segments are generally more sensitive to market shocks. As such, the combination of highly accommodative monetary policy and more stringent capital regulation may not only stimulate growth of "shadow banking" (Hodula, 2019; Hodula et al., 2020; Lysandrou, 2014; Goda et al., 2013), but also increase demand for non-bank loans in the private non-financial sector (Hodula, 2019).

4.2 Mispriced Risk

Highly accommodative monetary policy can compress term premiums and risk premiums on various asset classes and credit. A prolonged period of low interest rates flattens the yield curve. In an effort to mitigate the decline in current yields, banks and investors have to rebalance their portfolios toward longer-term bonds. As a result, longer-term bond prices increase and term premiums decline (Hanson and Stein, 2015). In addition, the reduced term premiums may incentivize financial institutions to seek riskier asset classes in order to compensate for lower expected returns. This may lead to compression of risk and liquidity premiums (Rajan, 2006; Adrian et al., 2014). Consequently, prices for non-interest-bearing asset classes (such as equity and real estate) may rise (see Figure 4, Panel A), depressing yields in these markets as well (Illing, 2018). Low interest rates accompanied by increasingly stringent capital regulation (and possible regulatory arbitrage) also exert downward pressure on risk premiums on credit through competition between financial institutions. However, there seems to be a limit on how far risk premiums can be compressed (Borio and Zabai, 2016). It is often argued that cuts below zero are considered a sign of desperation in financial markets, resulting in higher risk premiums (Grisse et al., 2017).

In the years before the COVID-19 crisis, yield spreads on US and European high-yield corporate bonds fell to unusually low levels close to their pre-GFC levels (see Figure 4, Panel B). Rather than a low risk level, this may indicate a reduced ability of the markets to price risks. A sudden correction in bond prices in response to adverse shocks could then be amplified by low market liquidity on bond markets. Owing to strong correlation between many assets, there could be contagion to other markets and subsequent sizable market losses.

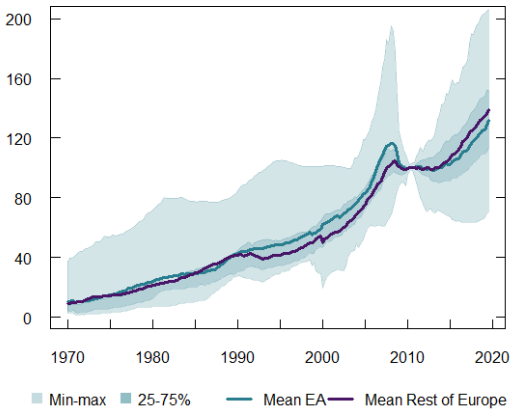
Accommodative monetary policy reduces borrowing constraints via its effect on risk premiums and asset prices. If the situation persists, asset prices (i.e., collateral prices) become overvalued and risk premiums (i.e., lending rates) undervalued. As a result, the underwriting quality of credit is reduced and the risk may become mispriced. In such a situation, underwriting standards do not reflect the true financial leverage, i.e., the loan-to-market value ratio is lower than the loan-to-equilibrium

value ratio (Bian et al., 2018). When relaxed credit standards are combined with a long period of low growth, asset quality may worsen (ESRB, 2016a).[9] [10]

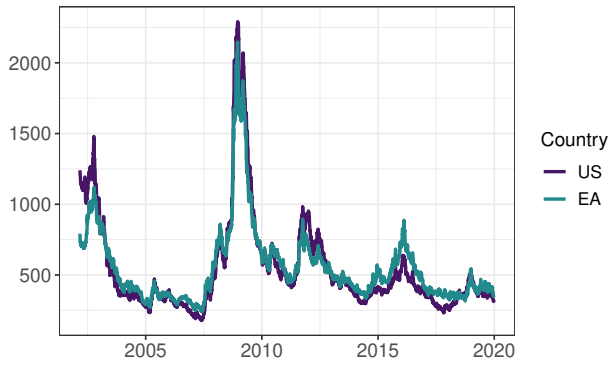
Compressed risk premiums and inflated asset prices inherently increase the risk tolerance and distort the risk valuation of financial institutions. Risk premiums and asset prices affect borrower-based characteristics (e.g., debt service burden, collateral value, and firms' income and cash flow), which then serve as a basis for estimating the risk parameters (probability of default, loss given default) used to calculate regulatory capital requirements and loan loss provisions. If these parameters are over- or undervalued, they may misrepresent the risk undertaken. Seeking higher yields by investing in riskier assets, together with worse underwriting standards, negatively affects overall portfolio quality. Basten and Mariathasan (2018) show that banks more exposed to negative rates reduced their safe reserves more strongly, implying a stronger rebalancing of their portfolios toward mortgages, uncollateralized loans, and financial assets. Lower portfolio quality may manifest in higher credit losses. These may not be sufficiently covered, as the risk itself is mispriced and, as a result, capital requirements and loan loss provisions are underestimated (Bikker and Vervliet, 2018; Bubeck et al., 2020).

Figure 4: Property Prices and Spreads on High-Yield Corporate Bonds

(A) Nominal Property Prices – Europe



(B) Yield Spreads on Risky Private Sector Bonds



Note: Right panel: US – HE00, EA – H0A0
Source: Refinitiv

4.3 Excessive Maturity Mismatch and Market Illiquidity

Low interest rates may lead to a preference for short-term deposits and long-term loans, creating maturity mismatch. A prolonged period of low rates, eventually flattening the yield curve, may incentivize banks' clients to shift from term deposits to overnight deposits as the spread between the deposit rates on term and overnight deposits shrinks. This was seen in Europe in the years before the COVID-19 crisis (see Figure 5). On the other hand, demand for long-term loans and

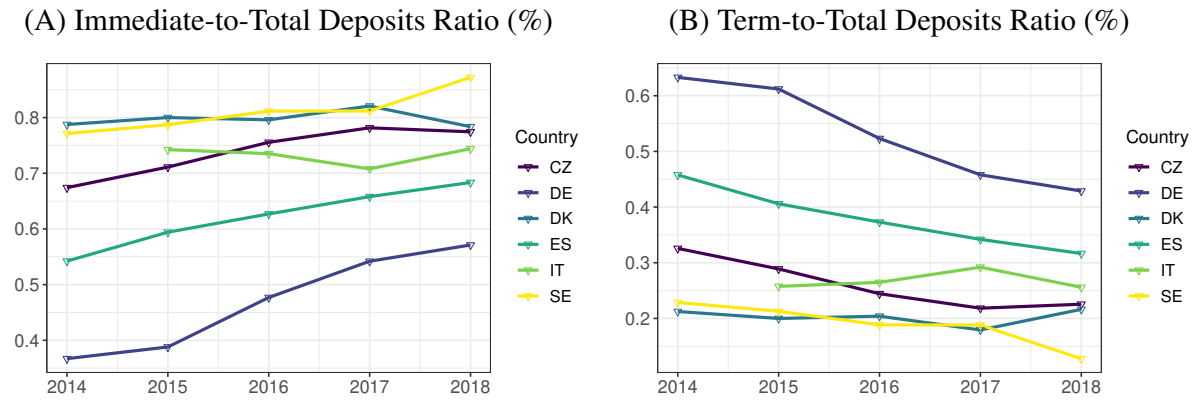
[9] The negative relationship between the real interest rate and the housing return has long been established theoretically since Fisher (1930) and has been confirmed empirically by numerous studies dating back to the 1970s (Gibson, 1972; Schwab, 1983; Harris, 1989; Hui and Yiu, 2003; Yim Yiu, 2009; Peshev and Beev, 2016, among others).

[10] Accommodative monetary policy has lowered bank lending standards. Empirical evidence for the US and EU countries is provided in Maddaloni and Peydró (2011) and Maddaloni and Peydro (2013). Data from bank lending surveys show easing standards not related to borrowers' characteristics leading to increased bank risk-taking at times of accommodative monetary policy.

longer interest rate fixation periods may increase the maturity of banks' assets. In an effort to maintain their target profitability, banks may even prefer to hold shorter liabilities and longer assets, as they can benefit from maturity mismatches when they borrow from short-term depositors and lend long term at higher interest rates. This behavior increases interest rate risk and vulnerability when interest rates grow significantly. In such case, banks would likely experience valuation losses on long-duration assets and credit losses on loans (CGFS, 2018; Basten and Mariathasan, 2018).

Low interest rates may undermine the solvency of insurance companies and pension funds. Low interest rates boost the present discounted value of both assets and liabilities. The assets held by insurance companies and pension funds are generally of shorter duration than their liabilities. With lower interest rates, the present value of liabilities rises more than that of assets, thus undermining solvency. This is even more pronounced if the maturity mismatch is excessive. If a period of low interest rates ends with a sudden rise in rates, insurance policyholders may withdraw their funds ahead of maturity (surrenders). This will become a source of liquidity vulnerability for insurance companies (CGFS, 2018).

Figure 5: Deposits in Europe



Source: ECB Statistical Data Warehouse

4.4 Misaligned Incentives and Moral Hazard

Low interest rates may increase the moral hazard undertaken by financial institutions. Squeezed interest rate margins may create pressure on banks' capital. In such an environment, high-deposit banks with low equity may be more prone to the internal agency problem, which raises banks' external finance premium and gives them less incentive to screen and monitor risky borrowers (Heider et al., 2019). Low profitability may also induce banks to search for yield and take on more risk, based on the reckoning that their failure would be a threat to the whole financial system. In other words, the awareness that some institutions are too big to fail can lead to misaligned incentives and produce moral hazard. In such a situation, banks may be incentivized to take on not only individual, but also correlated (systemic) risk, because government help is more likely to be triggered if there is a risk of simultaneous bank failures (Gaganis et al., 2020). This behavior may be fueled by inflating balance sheets (banks getting larger), reflecting rapid growth in credit and other financial assets. Some institutions may also bear even more critical functions if other financial institutions are forced to leave the market because of low profitability (Vučinić, 2016).

4.5 High Interconnectedness and Exposure Concentration

A prolonged period of low interest rates motivates financial institutions to explore alternative investments and more complex financial products in a search for yield. As a result, financial institutions increase not only their own vulnerability, but also the vulnerability of the whole financial system, as they increase their concentration and common exposures. In a traditional banking sector, common exposures to the real estate sector may be especially relevant (Nakaso, 2017). Exposures to various asset classes with suppressed risk premiums would create and increase the vulnerability of non-bank financial institutions to potential future repricing (CGFS, 2018; ESRB, 2016a). Spillovers from low interest rates in advanced economies (AEs) may encourage capital inflows into emerging market economies (EMEs) and excessive local credit expansion, and may lead to higher capital interconnectedness between AEs and EMEs and heightened competitive pressures for EME banks (CGFS, 2018).

A prolonged period of low interest rates may accelerate the shift from a banking-based financial system toward capital markets. Low profitability and increasingly stringent banking regulation encourage and speed up the shift of financial resources from banks to less regulated segments (Hodula et al., 2020). Those segments are generally more exposed to common asset holdings, high concentration, and correlated risks, i.e., they are more sensitive to market shocks and repricing of risks (ESRB, 2016a).

The prolonged period of accommodative monetary policy has led to strong growth in central clearing. Over time, corrections in market value may test the defenses of central clearing. First, central clearing may affect the propagation of price corrections through domino effects: losses deriving from a counterparty default could trigger further defaults and spread the shock through the system. Second, central clearing may be perceived as too risky on its own (due, for example, to risk management practices), which may trigger an endogenous run. The propagation of a shock through the system would be amplified by the size and riskiness of the assets under consideration (Domanski et al., 2015).

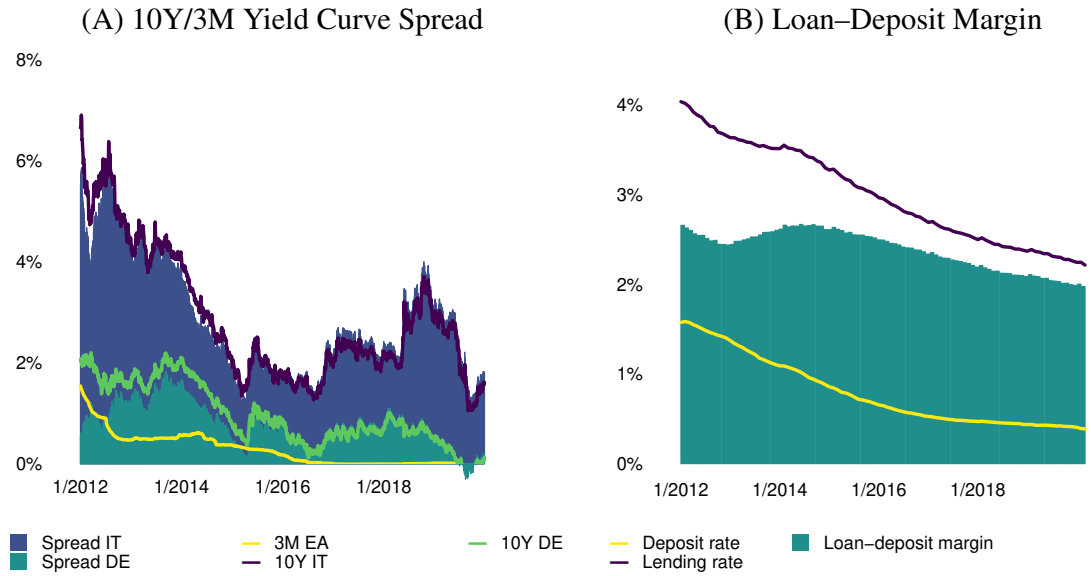
4.6 The Common Conduit – Low Profitability and Excessive Risk-Taking

There are two recurring themes in the transmission discussed above – low profitability and engaging in risky activities – which serve as a conduit between too accommodative monetary policy, higher vulnerabilities, and amplified shock impact. Monetary policy operates through its effect on the short-term interest rate and the slope of the yield curve (see Figure 6, panel A). The effect of negative nominal interest rates on financial institutions depends on the balance sheet structure of each bank. If assets are of longer duration than liabilities (which is usually the case with banks), low interest rates may be advantageous to begin with. But in the long run, interest margins are squeezed and the yield curve is flattened (Wang, 2017). The level of interest rates and the slope of the yield curve can be expected to affect the various components of bank profitability, i.e., net interest income, non-interest income, and loan loss provisions.

The empirical evidence strongly suggests that both a low short-term interest rate and a flatter yield curve are associated with lower net interest income (Claessens et al., 2018; Urbschat, 2018; Borio et al., 2017; Lopez et al.; Altavilla et al., 2018). Moreover, Claessens et al. (2018) find that the lower the level of interest rates is and the longer the period of low interest rates persists, the more adversely net interest income is affected (see Figure 6, panel B). The situation becomes particularly difficult for banks in countries with zero or negative policy rates. In order to avoid withdrawals of

deposits, banks usually do not transmit negative interest rates to their clients and absorb the costs themselves by squeezing their interest rate margins.[11]

Figure 6: Profitability of Banks in the Euro Area



Note: Left panel: 2012–2019 daily data; 10-year government yield minus 3-month interbank rate; 1/20xx – first trading day of respective year.
Right panel: 2012–2019 monthly data; the lending rate is a weighted average of the lending rate on loans to households and loans to non-financial corporations, with weights equal to the outstanding loan amount in each category; the deposit rate is a weighted average of rates on deposits with agreed maturity, deposits redeemable at notice, and overnight deposits of households and non-financial corporations, with weights equal to the outstanding deposit amount in each category; 1/20xx – first month of respective year.
Source: Bloomberg and ECB Statistical Data Warehouse

The link between accommodative monetary policy and non-interest income is not so straightforward. Some studies identify a negative relationship between interest rates and non-interest income, i.e., at low rates non-interest income rises (Borio et al., 2017; Lopez et al.). This may reflect higher fees and commissions charged by banks to offset the loss of net interest income. Basten and Mariathasan (2018) show that Swiss banks under negative interest rate policy try to maintain non-negative deposit rates for clients, so they introduce higher fees and raise lending rates as compensation for their squeezed liability margins. Despite the non-negative deposit rates, costs are transmitted through those channels to customers. Other studies do not find any relationship between low interest rates and non-interest income (Altavilla et al., 2018; Urbschat, 2018). This may reflect losses from hedging activities going in the opposite direction to higher fees. When hedging against interest rate risk, banks tend to pay fixed rates and receive floating rates. As banks' assets are usually of longer maturity than their liabilities, they incur valuation losses at lower rates (Borio et al., 2017).

For given macroeconomic conditions, and abstracting from the accounting lag, low interest rates are expected to have a positive impact on loan loss provisions. Lower interest rates reduce the probability of default on the existing stock of loans with floating rates and consequently also loan

[11] Until 2019, the moderately negative deposit rates in some countries applied mainly to firms. At the end of 2019, however, some banks started to communicate that they were also considering applying negative rates to holders of large retail deposits.

loss provisions. Interest rates may work in the opposite direction through new loans, as lower rates encourage risk taking and hence increase the probability of default. The amount of new loans, however, does not reach the same level as the stock of loans. Indeed, empirical evidence strongly suggests that the relationship between interest rates and provisions is negative (Altavilla et al., 2018; Urbschat, 2018; Borio et al., 2017).

The overall impact of a prolonged period of low interest rates on banks' profitability is rather negative. Lower interest rates can lead to higher non-interest income and loan loss provisions and therefore offset the negative impact on net interest income. However, the evidence suggests that banks may benefit from non-interest income and loan loss provisions only in the short run, while interest rates being low for too long will eventually erode profits for most banks (Bikker and Vervliet, 2018; Urbschat, 2018). The fact that some studies do not identify any effect on overall profitability may be due to heterogeneity among banks. For example, Urbschat (2018) shows that the share of deposits plays a crucial role in this transmission, i.e., banks with high deposit ratios face lower net interest income and lower credit growth rates. Claessens et al. (2018), Lopez et al., Urbschat (2018), and Molyneux et al. (2019) find that the effects of low rates on bank profitability are stronger for small banks. Arce et al. (2018) and Molyneux et al. (2019) show that banks' capitalization may play a role. Molyneux et al. (2019) find that the negative effect on banks' overall profitability is stronger for banks with "interest-oriented" business models, for banks that weakly hedge against interest rate risk, and for banks lending within national borders. The effect seems to be stronger if interest rates are negative (Claessens et al., 2018; Lopez et al.; Molyneux et al., 2019) and if banks operate in sectors with predominantly floating loan rates (Molyneux et al., 2019). The heterogeneity in banks' profitability measures according to different characteristics is apparent from Table 4. All the factors mentioned above seem to play a role – size, capitalization, deposits, and earnings ratio.

Life insurance companies and pension funds face similar risks regarding a decrease in profitability. Their assets may have shorter maturities than their liabilities, so a decline in interest rates increases the present value of liabilities more than that of assets. Specifically, this means that plans formed, for example, 20 years ago were based on an assumption that government bond yields would fluctuate around 4%. Thus, the sustainability of pension fund plans with defined benefits and guaranteed returns is cast in doubt under very low rates, especially in the longer term. In particular, there is upward pressure on premiums and downward pressure on the transparency of selling techniques (Bernardino, 2016; ESRB, 2016c). This solvency risk is marginal for some European countries (such as the Czech Republic) but high for others. If it were to materialize, the problems could spill over to other sectors and cause a lack of confidence in the stability of the financial system as a whole. In addition, the current interest rate environment is discouraging financial institutions from providing products with guaranteed returns and generating incentives to transfer risks to clients.

For many European banks, the room for cutting funding costs will be limited by the obligation to acquire further eligible liabilities in order to comply with the MREL requirement and raise regulatory capital. Banks can try to reduce their operating costs, but this has its limits. Another option is to increase the volume of remunerated assets. However, this is difficult to do in economies where sectors are so indebted that demand for further loans is weak. As discussed earlier, banks can partially relax their credit standards and invest in more profitable but potentially riskier assets (Rajan, 2006; Gambacorta, 2009; Adrian and Shin, 2010; Borio and Zhu, 2012; Adrian and Liang, 2018; Jiménez et al., 2014; Dell'Ariccia et al., 2017). This search for higher

yield is also present among non-bank financial institutions (see, for example, Lysandrou, 2014; Ammer et al., 2018; Hodula, 2019).[12]

Recommendations for mitigating these risks exist but are rather general. They focus mainly on strengthening the resilience of the riskiest segments through higher capitalization and various types of buffers. In the case of banking, they concentrate on the use of macroprudential instruments to prevent a build-up of systemic risk. However, instruments for mitigating specific risks of non-bank financial institutions are mostly in the initial discussion phase.

[12] Lysandrou (2014) shows that investors searching for higher-yielding assets in hedge funds before the GFC boosted the supply of these securities, which then significantly amplified the impact of the initial shock and led to the near collapse of the whole financial system. Hodula (2019) shows that monetary policy easing after the GFC caused massive inflows into investment funds as a result of search for yield behavior induced by persistently low interest rates. Ammer et al. (2018) explore a specific case of search for yield on foreign investment in riskier US corporate bonds.

Table 4: Profitability of Banks in the Euro Area

	2013–2014	2015–2017	2018–2019	Median and standard deviation over 2013–2019							
				Large	Small	High deposit/loan ratio	Low deposit/loan ratio	High earning assets/assets ratio	Low earning assets/assets ratio	High equity/assets ratio	Low equity/assets ratio
ROAA	0.3	0.28	0.31	0.39	0.39	0.23	0.3	0.4	0.36	0.66	0.22
	(1.03)	(1.15)	(3.43)	(0.74)	(5.44)	(0.5)	(5.41)	(5.22)	(2.5)	(5.77)	(0.81)
ROAE	3.35	2.96	3.08	5.27	3.22	3.65	3.59	3.66	4.28	3.51	4.73
	(9.48)	(10.2)	(9.58)	(9.86)	(10.13)	(12.91)	(13.2)	(10.06)	(20.12)	(11.39)	(22.67)
Net interest income over operating revenues	67.71	64.41	62.84	56.77	66.57	65.99	57.48	68.47	52.83	58.81	61.71
	(23.57)	(20.38)	(30.12)	(36.06)	(25.74)	(26.27)	(48.91)	(45.27)	(34.05)	(34.5)	(41.59)
Non-interest income over operating revenues	32.29	35.62	37.19	43.23	33.47	34.01	42.52	31.55	47.39	41.23	38.31
	(23.62)	(20.5)	(30.21)	(36.09)	(25.86)	(26.34)	(48.91)	(45.29)	(34.15)	(34.58)	(41.6)
Net interest margin	2.13	1.89	1.7	1.46	2.01	1.69	1.62	1.4	1.98	1.84	1.42
	(1.89)	(1.62)	(3.4)	(1.43)	(2.49)	(1.34)	(5.98)	(1.6)	(6.17)	(5.95)	(1.42)
Net interest income over total assets	1.99	1.76	1.54	1.28	1.81	1.59	1.4	1.35	1.49	1.64	1.27
	(1.15)	(1.03)	(1.22)	(0.79)	(1.75)	(0.77)	(2.23)	(1.56)	(2.08)	(2.47)	(0.86)
Net fees and commissions over total assets	0.63	0.64	0.64	0.56	0.59	0.62	0.55	0.37	0.7	0.58	0.54
	(2.45)	(2.93)	(2.78)	(0.45)	(5.15)	(0.56)	(8.06)	(2.34)	(7.34)	(8.42)	(0.64)
Loan loss provisions over total assets	0.12	0.07	0.07	0.13	0.02	0.04	0.26	0.03	0.14	0.06	0.08
	(0.9)	(1.02)	(0.76)	(0.71)	(0.79)	(0.78)	(1.85)	(1.09)	(1.97)	(1.87)	(0.92)

Note: BankFocus; 2013–2019; median (less sensitive to outliers); standard deviation in brackets; large/high – top 10% of institutions; small/low – bottom 10% of institutions. 2,885 institutions in total.

5. Consequences for Monetary Policy Transmission

5.1 Interest Rate Pass-Through at Low Levels of Interest Rates

A prolonged period of low interest rates may weaken the interest rate pass-through. Potentially impaired transmission is a common argument against the use of negative interest rates. It is assumed that either market participants will become motivated to switch to cash, or the market itself will develop some mechanism to eliminate the costs of negative interest rates (IMF, 2017). Thus, this type of policy may even hinder financial intermediation instead of supporting the economy. Nevertheless, a flight to cash has not been observed yet in countries which have introduced negative interest rates. The amount of currency in circulation has not increased in the prolonged period of low interest rates. On the contrary, it has either declined significantly (Sweden), or its growth has diminished (Denmark, Japan, and Switzerland). This may have been caused by the non-zero costs of holding cash (e.g., transaction costs, including transportation, storage, and insurance of large amounts of physical currency, and convenience costs, which are the costs associated with the loss of convenience of electronic payments; see section 2). Thus, the lower bound on interest rates is not zero but rather slightly negative. The reasons may also be cultural ones and public attitudes to electronic payment methods. Some nations value cash more, while others are following the already established long-term trend toward a cashless economy (for example, Sweden; see Arvidsson, 2019).

Non-linearities linked to the level of interest rates may affect the interest rate pass-through. A decrease in interest rates can be expected to have a stronger negative effect on banks' interest margins and interest income at lower levels of interest rates, because banks are reluctant to lower their deposit rates into negative territory. As such, they reflect the drop in monetary policy and market interest rates in their lending rates more than in their deposit rates. Among empirical studies, Borio and Gambacorta (2017) confirm non-linear effects, showing that a reduction in short-term interest rates becomes less effective at very low levels of interest rates. Nevertheless, in some countries (especially the Benelux countries, Germany, Austria, Spain, and Ireland – see Table 5) negative interest rates have been levied on deposits of non-financial corporations and retail customers, especially on deposits above a certain amount. On the other hand, some studies find no evidence that bank interest rates become less responsive to monetary policy and market interest rates when they are close to zero or negative (Horvath et al., 2018; Altavilla et al., 2020; Debortoli et al., 2020). For instance, Altavilla et al. (2020) show that the interest rate pass-through was similar before and after the GFC for a median euro area bank. Nevertheless, Horvath et al. (2018) argue that negative effects of negative rates are likely to materialize in the future unless the negative interest rate policy is abandoned and find that the interest rate pass-through is complete only for small firm loans and incomplete for other loan categories.

The effectiveness of very low or negative interest rates may be influenced by other unconventional monetary policy measures. Negative interest rates in combination with other measures may create a market perception that the central bank is willing to lower interest rates even further. This can provide additional monetary policy easing even in the absence of actual rate cuts and reveals another dimension in addition to the standard channels of forward guidance (Boucinha and Burlon, 2020). Furthermore, various asset purchase programs have created persistent excess liquidity (reserves) in the euro area banking sector, which have to be sterilized usually by repo operations. In such a situation, very low or negative monetary policy rates have a direct negative impact on banks' costs, as banks are required to pay interest on excess liquidity with the central bank. As discussed earlier, banks may not be able to charge their retail customers negative rates on their deposits, which may adversely affect banks' profitability. There are two streams of literature describing banks' possible

reactions to negative interest rates. According to the first stream, banks may cut back on their lending, increase their lending rates, or both (Brunnermeier and Koby, 2019; Eggertsson and Wold, 2017). According to the second stream, banks may rebalance the composition of their balance sheets toward higher-yielding assets and increase lending to the real economy (Demiralp et al., 2019). The second stream of literature is in line with studies that point to higher risk-taking by banks as a reaction to negative rates (see section 4.6). The interactions of unconventional monetary policy measures, especially negative policy rates, forward guidance, and asset purchase programs, are described in more detail by BIS (2019), for example.

Table 5: Deposit Interest Rates with Maturity of Up to 1Y – Non-Financial Corporations

	1-5/2020	2019	2018	2017	2016	2015	2014
Denmark	**-0.60**	**-0.57**	**-0.38**	**-0.31**	0.09	0.02	0.23
Germany	**-0.21**	**-0.10**	**-0.08**	**-0.08**	**-0.03**	0.13	0.20
Netherlands	**-0.19**	**-0.08**	**-0.24**	**-0.21**	**-0.04**	0.03	0.16
Spain	**-0.16**	**-0.08**	0.26	0.20	0.20	0.34	0.76
Belgium	**-0.13**	**-0.10**	**-0.20**	**-0.16**	**-0.07**	0.12	0.30
Ireland	**-0.08**	**-0.02**	0.00	0.01			
Austria	**-0.07**	0.00	0.12	0.10	0.23	0.30	0.43
Luxembourg	**-0.07**	**-0.15**	**-0.15**	**-0.13**	**-0.18**	0.04	0.19
Sweden	0.05	**-0.06**	**-0.20**	**-0.09**	0.14	0.28	0.73

Note: New business; deposit rates in each year are calculated as simple averages over the twelve months (five months for 2020). Negative numbers in bold.
Source: ECB Statistical Data Warehouse

5.2 Point of No Return

A prolonged period of low interest rates may lead to a situation where it may be costly to normalize monetary policy. The reason may be that the prolonged period of low interest rates has created financial vulnerabilities or increased them to such levels that a reversal of the monetary policy stance would create risks to financial stability. Among the most prominent variables usually discussed in this context are high levels of indebtedness, excessive debt service burdens, and squeezed term and risk premiums.

High indebtedness and excessive debt service burdens make economies more sensitive to interest rate hikes, especially if coupled with a high share of loans at variable interest rates. Since the GFC, both the credit stock and the credit-to-GDP ratio of the private and public sector have increased or remained elevated in many European countries (see Figures 7–9). Some of the countries displaying a significant rise in indebtedness have also experienced a high share of new loans granted at variable interest rates or very short interest rate fixation periods (see Figure 10), increasing their interest rate sensitivity. The share of total new loans with variable interest rates or rates fixed for up to one year has long been above 50% in the euro area. In Sweden, Spain, and Italy the share is even higher, at around 75–80%. The share of new loans for house purchase with variable interest rates or rates fixed for up to one year is only around 20% in the euro area but about 75% in Sweden. As for the impacts, a 1 pp hike in the repo rate over the course of three years has been estimated to subdue the disposable income of households by 1.3% in the Swedish economy (Riksbank, 2018a).

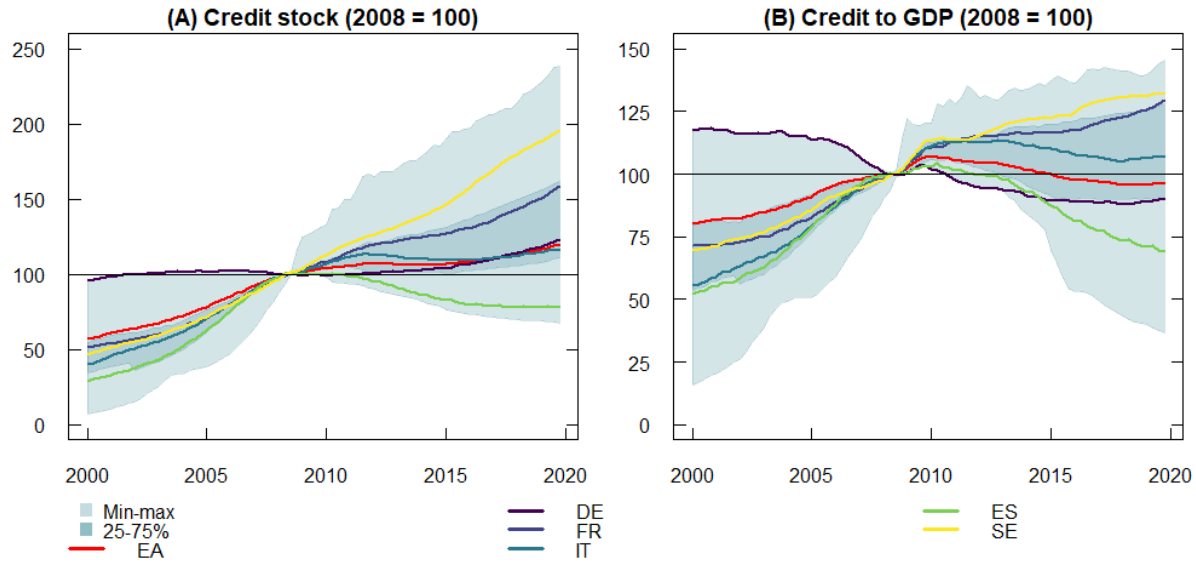
Squeezed term and risk premiums increase the risk of abrupt repricing and limit the space for normalizing monetary policy. In a prolonged period of low interest rates, the longer end of the

yield curve and, to some extent, also risk premiums are pushed down.[13] Lower risk premiums can then be multiplied via balance sheet effects (Drechsler et al., 2018). Such a situation may lead to risk mispricing and overvaluation of asset prices, which, in turn, may increase the risk of asset repricing if the economy is hit by an adverse shock (see section 4). The more term and risk premiums are squeezed, the more central banks must be cautious in tightening monetary policy. In an extreme situation, central banks may be forced to ease monetary policy even more in order to avoid higher uncertainty in financial markets.

Advanced economies have been experiencing an increasing number of "zombie firms," with the prolonged period of low interest rates considered to be one of the possible causes. Banerjee and Hofmann (2020) documents an increase from 4% in the 1980s to 15% in 2017 in advanced economies. Zombie firms are firms that lack profitability over an extended period of time. The exact definition varies between authors, but they are usually understood to be companies that are not able to cover their interest expenses with operating profits (McGowan et al., 2018), are not profitable and have low stock valuation (Banerjee and Hofmann, 2020), or have a high interest-to-earnings ratio and a high indebtedness-to-income ratio and can obtain extremely cheap external resources (Acharya et al., 2020b). Banerjee and Hofmann (2018) argue that low interest rates, reflected in decreased financial pressure, have increased the share of zombie firms. Other complementary reasons for the rise of zombie firms include banks' forbearance, banks' weakness, and badly designed insolvency regimes and policy initiatives making it impossible to restructure. Many zombie firms have been found to be linked to weak, undercapitalized, or stressed banks that extend lending to zombie firms to avoid the recognition of non-performing loans and to meet capital requirements (Andrews and Petroulakis, 2019; Caballero et al., 2008; Schivardi et al., 2017; Storz et al., 2017; Acharya et al., 2020b). A vicious cycle of low interest rates, weak banks, and zombie firms is thus created, pushing firms' markups and prices further down. Acharya et al. (2020b) focus on the link between the existence of zombie firms and inflation in Europe. Even weak companies can finance themselves incredibly cheaply, which allows them to survive. The result is a gradual "zombification" of the economy, leading to a vicious circle – low rates lead to an increase in the share of weak banks, which have an increased incentive to support zombie businesses. All this then leads to overcapacity and downward pressure on markups and prices. While some studies do not find a link between a low interest rate environment and the prevalence of zombie firms (Danmarks Nationalbank, 2019), we assume this might be due in part to the definition itself: with low interest rates, it is easier for companies to meet the definition based on the interest expense ratio and (inappropriately) not to fall into the category of zombie firms.

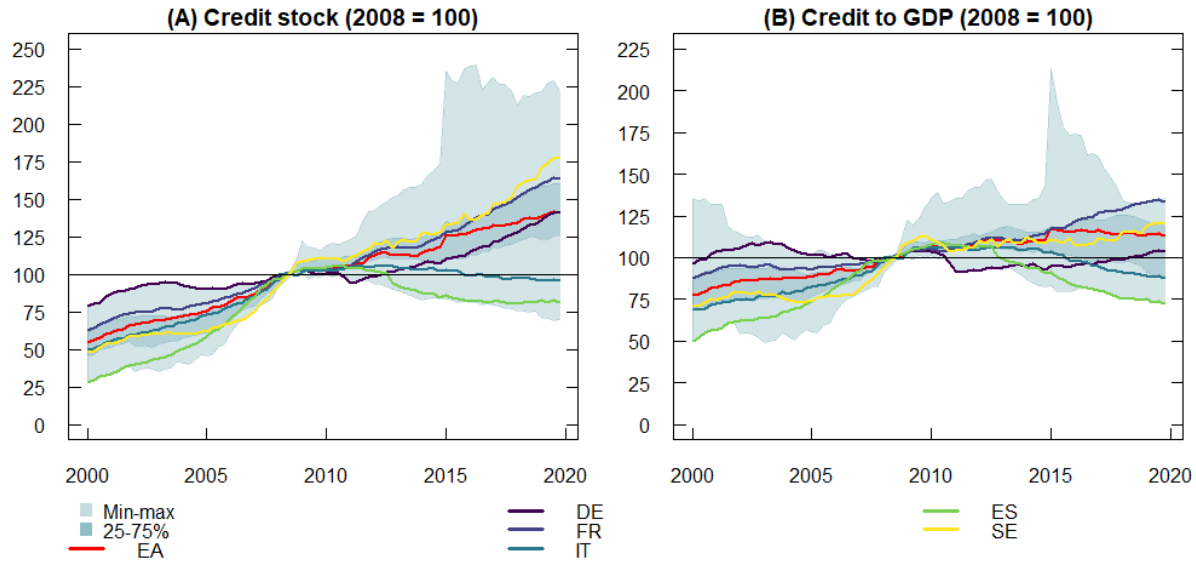
[13] Evidence of monetary policy affecting risk premiums has been found in many studies (see section 4 or, for example, Drechsler et al., 2018; Ireland, 2015; Ozdagli and Velikov, 2020).

Figure 7: Indebtedness of Households



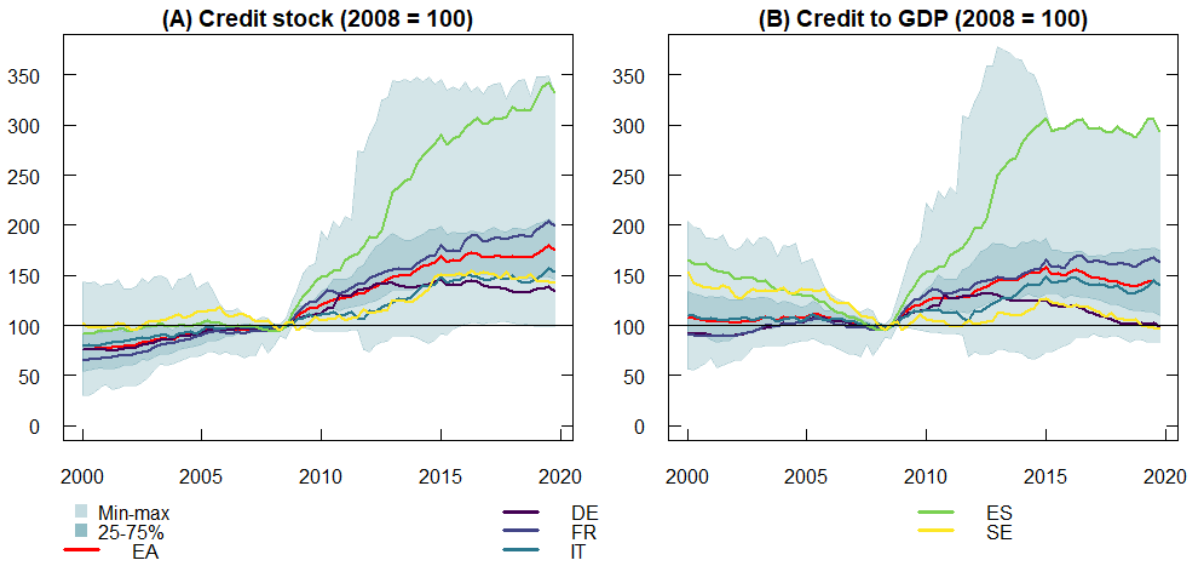
Source: BIS Statistics Warehouse – Credit Statistics. Credit from all sectors in the domestic currency; the base of the index equals the average for all four quarters of 2008. Countries in the sample: AT, BE, SW, CZ, DE, DK, ES, FI, FR, UK, GR, HU, IE, IT, NL, NO, PL, PT, SE.

Figure 8: Indebtedness of Non-Financial Corporations



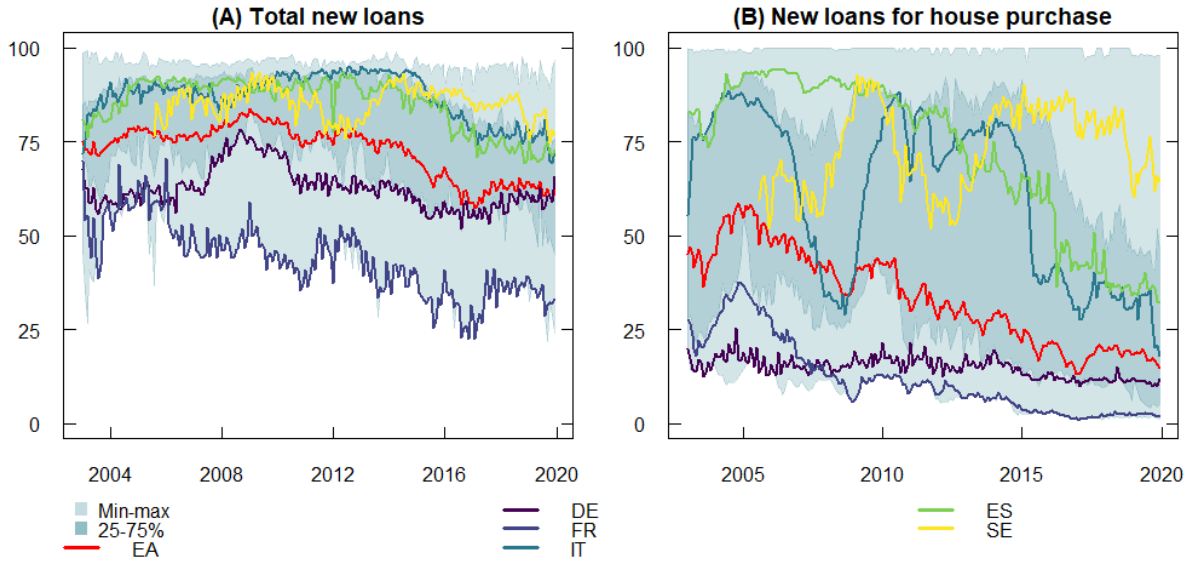
Source: BIS Statistics Warehouse – Credit Statistics. Credit from all sectors in the domestic currency; the base of the index equals the average for all four quarters of 2008. Countries in the sample: AT, BE, SW, CZ, DE, DK, ES, FI, FR, UK, GR, HU, IE, IT, NL, NO, PL, PT, SE.

Figure 9: Government Indebtedness



Source: BIS Statistics Warehouse – Credit Statistics. Credit from all sectors in the domestic currency; the base of the index equals the average for all four quarters of 2008. Countries in the sample: AT, BE, SW, CZ, DE, DK, ES, FI, FR, UK, GR, HU, IE, IT, NL, NO, PL, PT, SE.

Figure 10: Share of Loans with Floating Rates or Rates Fixed for Up to 1Y



Source: ECB Statistical Data Warehouse. Countries in the sample: AT, BE, CZ, DE, DK, ES, FI, FR, UK, GR, HU, IE, IT, NL, PL, PT, SE, SI, SK.

6. Conclusions and Policy Considerations

In this paper, we examine the potential adverse effects of a prolonged period of low interest rates on financial stability. First, we describe the evolution of nominal and real interest rates. While real interest rates have been negative many times throughout history, negative nominal interest rates are a new phenomenon of the post-crisis period.

Second, we estimate the natural rate of interest for selected large European economies using two competing model specifications – with and without financial factors. Given the significant financialization of advanced economies and stronger correlation between the business and financial cycles, macro-financial links should play a prominent role in current macroeconomic models. Therefore, we provide a unique comparison of the two model specifications and visualize the implications of omitting macro-financial links. Our estimation results point to a significant difference between the two approaches, stressing the role of financial factors. The difference between estimates of the natural rate of interest with and without financial factors varies geographically and over time. Before the GFC, the estimates with financial factors tend to be significantly higher for Spain and Italy. After the GFC, on the other hand, they tend to be significantly lower for these economies. The opposite is true for Northern and Western European countries, namely, Germany, Sweden, and Denmark. These results may point to different and changing needs in terms of monetary policy not only between economies, but also over time. Excluding macro-financial links from the estimation of the natural rate of interest may therefore potentially result in advice for incorrect policy on either side, i.e., too loose or too tight.

Third, we provide a comprehensive review of the empirical literature on the adverse effects of a low interest rate environment on financial stability. Based on this review, we define five broad categories and 22 subcategories of financial vulnerabilities which may be created and fueled by a prolonged period of low interest rates.

Last but not least, we discuss the undesirable impacts of a prolonged period of low interest rates on monetary transmission itself, and the situation in which low interest rates may lead to a point of no return by contributing to higher indebtedness, overvalued asset prices and underpriced risks, resource and credit misallocation, and lower productivity.

With respect to all of that, we suggest that the implications for monetary policy be discussed and examined further. First, monetary policy should act symmetrically over the medium to long term. We understand symmetry and asymmetry in the conduct of monetary policy in the broader sense. Monetary policy is symmetric if the extent and the strength of monetary policy easing is offset by an amount of monetary policy tightening such that monetary policy is neutral in the medium-to-long term. In other words, monetary policy does not create or magnify financial imbalances or overall economic instability by being too accommodative or too restrictive over the medium-to-long term.

Second, both the short-term and long-term costs and benefits of pursuing accommodative or restrictive monetary policy should be accounted for. From the conceptual perspective, this may be viewed as a reasonable requirement. From the practical point of view, it might be difficult for the central bank to credibly assess both the short-term and long-term effects of its monetary policy on price stability and financial stability due to different probabilities of failure to fulfil the two main objectives (Adrian and Liang, 2018). It is highly likely that the macroeconomic forecast will imply failure to hit the inflation target in the short-to-medium term, whereas systemic risk will have the potential to materialize usually in the medium-to-long term only. One of the first steps the central bank can take in this regard is to enhance its analytical framework by including financial variables

and linkages between the real economy and the financial system, accounting for potential non-linear effects and feedback loops, and prolonging the analytical horizon beyond the monetary policy horizon. Such an enhancement would call for a suite of models rather than a single one.[14] This would help the bank better assess the symmetry of monetary policy over the medium to long term, as adverse effects will be captured by the enhanced framework.

Third, monetary and macroprudential policies need to be coordinated, and their interactions should be accounted for in order to find the best policy mix for the economy. Many argue that macroprudential regulation and microprudential supervision should be responsible primarily for financial stability, while monetary policy should focus on price stability. However, this approach may prove counterproductive over the long term given the tight macro-financial links described in this paper. Keeping in mind their limitations, macroprudential policy measures can to a certain extent help mitigate heightened financial vulnerabilities and increase the resilience of the financial system. The measures are as follows.

Additional capital buffers and add-ons can be useful in preserving banks' resilience. Nevertheless, it may be difficult for some banks to meet this requirement in a prolonged period of low interest rates and poor profitability.

Some types of financial vulnerabilities may be addressed by borrower-based measures such as limits on LTV, DTI, or DSTI ratios. These measures can prevent the provision of risky loans and improve underwriting standards. Even in this instance, however, the desired effect may not be achieved. As suggested by some recent studies, borrower-based limits may have distributional and reallocation effects. For instance, Acharya et al. (2020a) show that LTV and LTI limits in Ireland have had reallocation effects which, on the one hand, have slowed down house price growth in overheated areas, but, on the other hand, have increased risk taking by the more-constrained banks. These banks have re-balanced their portfolios toward holdings of securities and corporate credit, consistent with the search-for-yield motive. In a similar vein, Peydró et al. (2020) show that UK LTI limits have had distributional effects which have led the more-constrained lenders to issue fewer high-LTI mortgages but have also increased the average loan size of these high-LTI mortgages and increased the LTV ratio.

Another potential set of macroprudential and supervisory measures which can be used to address mispriced risks is targeted at banks' risk weights (Articles 124, 164, and 458 of the CRR and Articles 101 and 103 of the CRD). However, the use of some of these measures can be materially and administratively demanding and requires discussion in a number of EU bodies, which reduces their flexibility and extends the reaction time. In addition, the effectiveness of the measures regarding commercial real estate exposures is very limited.

A combination of more demanding macroprudential policy and a prolonged period of low interest rates may incentivize a shift of activities toward non-bank financial institutions, which are less regulated. For instance, Hodula et al. (2020) find that growth of EU non-bank financial institutions is positively related to more stringent capital regulation. In addition, they show that the relationship between monetary policy and growth of non-bank financial institutions is level-dependent, with the relationship being positive if interest rates are low. Furthermore, Hodula (2019) demonstrates that

[14] A few notable examples in this respect are Bank of England (Burgess et al., 2013), Bank of Canada (Bank of Canada, 2020), and Sveriges Riksbank (Riksbank, 2018b), which support their main forecasting models with complementary satellite models, empirical models, and semi-structural models. These then serve as an alternative to, or a check of, the main forecasting model.

the post-crisis monetary policy easing caused massive inflows into investment funds as a result of search for yield induced by persistently low interest rates.

While monetary policy measures are implemented immediately or with a short delay, macroprudential policy measures are often announced well in advance and implemented with a relatively long delay. As such, macroprudential policy measures are best applied preemptively to build the needed resilience and to mitigate potential financial vulnerabilities which might not be obvious at that time. Given all this, monetary and macroprudential policies need to be coordinated, and their interactions should be accounted for, preferably well in advance.

References

AARONSON, S., T. CAJNER, B. FALLICK, F. GALBIS-REIG, C. SMITH, AND W. WASCHER (2014): "Labor Force Participation: Recent Developments and Future Prospects." *Brookings Papers on Economic Activity,* 2014(2):197–275.

ACHARYA, S., J. BENGUI, K. DOGRA, AND S. L. WEE (2018): "Slow Recoveries and Unemployment Traps: Monetary Policy in a Time of Hysteresis." CEPR Discussion Papers 13409, Centre for Economic Policy Research.

ACHARYA, V. V., K. BERGANT, M. CROSIGNANI, T. EISERT, AND F. MCCANN (2020): "The Anatomy of the Transmission of Macroprudential Policies." IMF Working Papers 20/58, International Monetary Fund.

ACHARYA, V. V., M. CROSIGNANI, T. EISERT, AND C. EUFINGER (2020): "Zombie Credit and (Dis)inflation: Evidence from Europe." NBER Working Papers 27158, National Bureau of Economic Research.

ADRIAN, T. AND N. LIANG (2018): "Monetary Policy, Financial Conditions, and Financial Stability." *International Journal of Central Banking,* 14(1):73–131.

ADRIAN, T. AND H. SHIN (2010): "Financial Intermediaries and Monetary Economics." *Handbook of Monetary Economics,* 3:601–650.

ADRIAN, T., E. ETULA, AND T. MUIR (2014): "Financial Intermediaries and the Cross-section of Asset Returns." *The Journal of Finance,* 69(6):2557–2596.

AIKMAN, D., A. LEHNERT, J. N. LIANG, AND M. MODUGNO (2016): "Financial Vulnerabilities, Macroeconomic Dynamics, and Monetary Policy." Finance and Economics Discussion Series 2016-055, Board of Governors of the Federal Reserve System (U.S.).

ALTAVILLA, C., M. BOUCINHA, J.-L. PEYDRÓ, AND T. BECK (2018): "Monetary Policy and Bank Profitability in a Low Interest Rate Environment." *Economic Policy,* 33(96):531–586.

ALTAVILLA, C., F. CANOVA, AND M. CICCARELLI (2020): "Mending the Broken Link: Heterogeneous Bank Lending Rates and Monetary Policy Pass-through." *Journal of Monetary Economics,* 110:81–98.

AMMER, J., S. CLAESSENS, A. M. TABOVA, AND C. WROBLEWSKI (2018): "Searching for Yield Abroad: Risk-taking Through Foreign Investment in U.S. Bonds." International Finance Discussion Papers 1224, Board of Governors of the Federal Reserve System (U.S.).

ANDREWS, D. AND F. PETROULAKIS (2019): "Breaking the Shackles: Zombie Firms, Weak Banks and Depressed Restructuring in Europe." Working Paper Series 2240, European Central Bank.

ANGRICK, S. AND N. NEMOTO (2017): "Central Banking Below Zero: The Implementation of Negative Interest Rates in Europe and Japan." *Asia Europe Journal,* 15(4):417–443.

ARCE, O., M. GARCÍA-POSADA, S. MAYORDOMO, AND S. ONGENA (2018): "Adapting Lending Policies when Negative Interest Rates Hit Banks' Profits." Working Papers 1832, Banco de España.

ARTETA, C., A. KOSE, M. STOCKER, AND T. TASKIN (2016): "Negative Interest Rate Policies: Sources and Implications." Policy Research Working Paper Series 7791, The World Bank.

ARVIDSSON, N. (2019): *Building a Cashless Society: The Swedish Route to the Future of Cash Payments.* Springer Nature. ISBN 978-3030106898.

AUCLERT, A. AND M. ROGNLIE (2018): "Inequality and Aggregate Demand." NBER Working Papers 24280, National Bureau of Economic Research.

BALL, L. (2014): "Long-term Damage from the Great Recession in OECD Countries." *European Journal of Economics and Economic Policies,* 11(2):149–160.

BANERJEE, R. AND B. HOFMANN (2018): "The Rise of Zombie Firms: Causes and Consequences." BIS Quarterly Review September 2016, Bank for International Settlements.

BANERJEE, R. N. AND B. HOFMANN (2020): "Corporate Zombies: Anatomy and Life Cycle." BIS Working Papers 882, Bank for International Settlements.

BANK OF CANADA (2020): "Decision-making Process." Available at: https://www.bankofcanada.ca/core-functions/monetary-policy/decision-making-process/

BARR, M., B. KASMAN, AND D. MACKIE (2016): "Negative Policy Rates: The Bound Is Lower Than You Think." JPM Economic Research Series, J. P. Morgan.

BASTEN, C. AND M. MARIATHASAN (2018): "How Banks Respond to Negative Interest Rates: Evidence from the Swiss Exemption Threshold." CESifo Working Paper Series 6901, CESifo Group Munich.

BCBS (2010): "An Assessment of the Long-term Economic Impact of Stronger Capital and Liquidity Requirements." Report, Bank for International Settlements: Basel Committee on Banking Supervision.

BERNARDINO, G. (2016): "Low Level of Interest Rates and Their Implications for Insurers and Pension Funds." Presentation at the European Systemic Risk Board Annual Conference, 23 September 2016.

BIAN, X., Z. LIN, AND Y. LIU (2018): "House Price, Loan-to-value Ratio and Credit Risk." *Journal of Banking Finance,* 92:1–12.

BIKKER, J. A. AND T. M. VERVLIET (2018): "Bank Profitability and Risk-taking Under Low Interest Rates." *International Journal of Finance and Economics,* 23(1):3–18.

BIS (2019): "Unconventional Monetary Policy Tools: A Cross-country Analysis." CGFS Papers 63, Committee on the Global Financial System, Bank for International Settlements.

BORIO, C. (2014): "The Financial Cycle and Macroeconomics: What Have We Learnt?" *Journal of Banking & Finance,* 45:182–198.

BORIO, C. AND L. GAMBACORTA (2017): "Monetary Policy and Bank Lending in a Low Interest Rate Environment: Diminishing Effectiveness?" *Journal of Macroeconomics,* 54:217–231.

BORIO, C. AND A. ZABAI (2016): "Unconventional Monetary Policies: A Re-appraisal." BIS Working Papers 570, Bank for International Settlements.

BORIO, C. AND H. ZHU (2008): "Capital Regulation, Risk-taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" BIS Working Papers 268, Bank for International Settlements.

BORIO, C. AND H. ZHU (2012): "Capital Regulation, Risk-taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial Stability,* 8(4):236–251.

BORIO, C., L. GAMBACORTA, AND B. HOFMANN (2017): "The Influence of Monetary Policy on Bank Profitability." *International Finance,* 20(1):48–63.

BORIO, C. E. AND M. DREHMANN (2009): "Assessing the Risk of Banking Crises-revisited." BIS Quarterly Review March 2016, Bank for International Settlements.

BORIO, C. E. AND P. W. LOWE (2004): "Securing Sustainable Price Stability: Should Credit Come Back from the Wilderness?" BIS Working Papers 157, Bank for International Settlements.

BOUCINHA, M. AND L. BURLON (2020): "Negative Rates and the Transmission of Monetary Policy." ECB Economic Bulletin, Issue 3/2020, European Central Bank.

BRUNNERMEIER, M. K. AND Y. KOBY (2019): "The Reversal Interest Rate." IMES Discussion Paper Series 19-E-06, Institute for Monetary and Economic Studies, Bank of Japan.

BUBECK, J., A. MADDALONI, AND J. L. PEYDRÓ (2020): "Negative Monetary Policy Rates and Systemic Banks' Risk-Taking: Evidence from the Euro Area Securities Register." *Journal of Money, Credit and Banking,* 50(1):197–231.

BUCHAK, G., G. MATVOS, T. PISKORSKI, AND A. SERU (2018): "Fintech, Regulatory Arbitrage, and the Rise of Shadow Banks." *Journal of Financial Economics,* 130(3):453–483.

BURGESS, S., E. FERNANDEZ-CORUGEDO, C. GROTH, R. HARRISON, F. MONTI, K. THEODORIDIS, AND M. WALDRON (2013): "The Bank of England's Forecasting Platform: COMPASS, MAPS, EASE and the Suite of Models." Working Papers 471, Bank of England.

CABALLERO, R. J., T. HOSHI, AND A. K. KASHYAP (2008): "Zombie Lending and Depressed Restructuring in Japan." *American Economic Review,* 98(5):1943–1977.

CARVALHO, C., A. FERRERO, AND F. NECHIO (2016): "Demographics and Real Interest Rates: Inspecting the Mechanism." *European Economic Review,* 88:208–226.

CGFS (2018): "Financial Stability Implications of a Prolonged Period of Low Interest Rates." CGFS Papers 61, Committee on the Global Financial System, Bank for International Settlements.

CHEN, Q., M. J. LOMBARDI, A. ROSS, AND F. ZHU (2017): "Global Impact of US and Euro Area Unconventional Monetary Policies: A Comparison." BIS Working Papers 610, Bank for International Settlements.

CLAESSENS, S., N. COLEMAN, AND M. DONNELLY (2018): "Low-for-long" Interest Rates and Banks' Interest Margins and Profitability: Cross-country Evidence." *Journal of Financial Intermediation,* 35(A):1–16.

CÚRDIA, V. ET AL. (2015): "Why So Slow? A Gradual Return for Interest Rates." FRBSF Economic Letter 2015, Federal Reserve Bank of San Francisco.

DANMARKS NATIONALBANK (2019): "Low Prevalence of Zombie Firms in Denmark." Analysis, No. 29, 18 December 2019, Danmarks Nationalbank. Available at: https://www.nationalbanken.dk/en/publications/Pages/2019/12/Low-prevalence-of-zombie-firms-in-Denmark.aspx

DE GRAUWE, P. AND Y. JI (2016): "Synchronisation in Business Cycles: An Endogenous Explanation." Blog post, VoxEU. Available at: https://voxeu.org/article/synchronisation-business-cycles

DEBORTOLI, D., J. GALÍ, AND L. GAMBETTI (2020): "On the Empirical (Ir)relevance of the Zero Lower Bound Constraint." *NBER Macroeconomics Annual,* 34(1):141–170.

DELL'ARICCIA, G., L. LAEVEN, AND R. MARQUEZ (2014): "Real Interest Rates, Leverage, and Bank Risk-taking." *Journal of Economic Theory,* 149(C):65–99.

DELL'ARICCIA, G., L. LAEVEN, AND G. A. SUAREZ (2017): "Bank Leverage and Monetary Policy's Risk-taking Channel: Evidence from the United States." *The Journal of Finance,* 72(2):613–654.

DEMIRALP, S., J. EISENSCHMIDT, AND T. VLASSOPOULOS (2019): "Negative Interest Rates, Excess Liquidity and Retail Deposits: Banks' Reaction to Unconventional Monetary Policy in the Euro Area." Working Paper Series 2283, European Central Bank.

DOMANSKI, D., L. GAMBACORTA, AND C. PICILLO (2015): "Central Clearing: Trends and Current Issues." BIS Quarterly Review December 2015, Bank for International Settlements.

DRECHSLER, I., A. SAVOV, AND P. SCHNABL (2018): "A Model of Monetary Policy and Risk Premia." *The Journal of Finance,* 73(1):317–373.

DREHMANN, M., C. BORIO, AND K. TSATSARONIS (2012): "Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!" BIS Working Papers 380, Bank for International Settlements.

DYNAN, K. E., J. SKINNER, AND S. P. ZELDES (2004): "Do the Rich Save More?" *Journal of Political Economy,* 112(2):397–444.

ECB (2014): "Capturing the Financial Cycle in Euro Area Countries, November." Financial Stability Review, vol. 2, European Central Bank.

EDWARDS, S. (2015): "Monetary Policy Independence under Flexible Exchange Rates: An Illusion?" *The World Economy,* 38(5):773–787.

EGGERTSSON, G., E. J. AND E. WOLD (2017): "Are Negative Nominal Interest Rates Expansionary?" NBER Working Papers 24039, National Bureau of Economic Research.

ESCOLANO, J., A. SHABUNINA, AND J. WOO (2017): "The Puzzle of Persistently Negative Interest-rate Growth Differentials: Financial Repression or Income Catch-up?" *Fiscal Studies,* 38:179–217.

ESRB (2016): "The Impact of Low Interest Rates and Ongoing Structural Changes on Financial Markets and Financial Infrastructure: Assessment of Vulnerabilities, Systemic Risks and Implications for Financial Stability." Technical documentation (Section D), European Systemic Risk Board.

ESRB (2016): "The Impact of Low Interest Rates and Ongoing Structural Changes on Noncredit Institutions: Vulnerabilities, Systemic Risks and Implications for Financial Stability." Technical documentation (Section C), European Systemic Risk Board.

ESRB (2016): "Macroprudential Policy Issues Arising from Low Interest Rates and Structural Changes in the EU Financial System." Joint Task Force of ESRB ATC, ESRB ASC and ECB FSC, European Systemic Risk Board.

FALAGIARDA, M., P. MCQUADE, AND M. TIRPÁK (2015): "Spillovers from the ECB's Nonstandard Monetary Policies on Non-euro Area EU Countries: Evidence from an Event-study Analysis." Working Paper Series 1869, European Central Bank.

FERNALD, J., B. WANG, ET AL. (2015): "The Recent Rise and Fall of Rapid Productivity Growth." FRBSF Economic Letter 9, Federal Reserve Bank of San Francisco.

FISHER, I. (1930): *The Theory of Interest.* Macmillan, New York, US. ISBN 978-1614273318.

FREIXAS, X., A. MARTIN, AND D. SKEIE (2011): "Bank Liquidity, Interbank Markets, and Monetary Policy." *The Review of Financial Studies,* 24(8):2656–2692.

GAGANIS, C., A. LOZANO-VIVAS, P. PAPADIMITRI, AND F. PASIOURAS (2020): "Monetary Policy of Low Interest Rates and Bank Stability: The Role of Corporate Governance." SSRN Electronic Journal. Available at: https://ssrn.com/abstract=3513756

GAGNON, E., B. K. JOHANNSEN, AND D. LOPEZ-SALIDO (2016): "Understanding the New Normal: The Role of Demographics." Finance and Economics Discussion Series 2016-080, Board of Governors of the Federal Reserve System (U.S.).

GAMBACORTA, L. (2009): "Monetary Policy and the Risk-taking Channel." BIS Quarterly Review December 2009, Bank for International Settlements.

GEBAUER, S. AND F. MAZELIS (2020): "Macroprudential Regulation and Leakage to the Shadow Banking Sector." Working Paper Series 2406, European Central Bank.

GERTLER, M., P. KARADI, ET AL. (2013): "QE 1 vs. 2 vs. 3...: A Framework for Analyzing Large-scale Asset Purchases as a Monetary Policy Tool." *International Journal of Central Banking,* 9(1):5–53.

GERTLER, P. AND B. HOFMANN (2018): "Monetary Facts Revisited." *Journal of International Money and Finance,* 86:154–170.

GIBSON, W. E. (1972): "Interest Rates and Inflationary Expectations: New Evidence." *The American Economic Review,* 62(5):854–865.

GODA, T., O. LYSANDROU, AND C. STEWART (2013): "The Contribution of U.S. Bond Demand to the U.S. Bond Yield Conundrum of 2004 to 2007: An Empirical Investigation." *Journal of International Financial Markets, Institutions and Money,* 27:113–136.

GORDON, R. J. (2017): *The Rise and Fall of American Growth: The US Standard of Living since the Civil War,* volume 70 of. Princeton University Press. ISBN 978-0691175805.

GRAY, C. (2013): "Responding to a Monetary Superpower: Investigating the Behavioral Spillovers of US Monetary Policy." *Atlantic Economic Journal,* 41(2):173–184.

GRISSE, C., S. KROGSTRUP, AND S. SCHUMACHER (2017): "Lower-bound Beliefs and Long-term Interest Rates." *International Journal of Central Banking,* 13(3):165–202.

HAMILTON, J. D., E. S. HARRIS, J. HATZIUS, AND K. D. WEST (2016): "The Equilibrium Real Funds Rate: Past, Present, and Future." *IMF Economic Review,* 64(4):660–707.

HANSON, S. G. AND J. C. STEIN (2015): "Monetary Policy and Long-term Real Rates." *Journal of Financial Economics,* 115(3):429–448.

HARRIS, J. (1989): "The Effect of Real Rate of Interest on Housing Prices." *Journal of Real Estate Finance and Economics,* 2(1):47–60.

HATZIUS, J., P. HOOPER, F. S. MISHKIN, K. L. SCHOENHOLTZ, AND M. W. WATSON (2010): "Financial Conditions Indexes: A Fresh Look after the Financial Crisis." NBER Working Papers 16150, National Bureau of Economic Research.

HE, D. AND R. MCCAULEY (2013): "Transmitting Global Liquidity to East Asia: Policy Rates, Bond Yields, Currencies and Dollar Credit." BIS Working Papers 431, Bank for International Settlements.

HEIDER, F., F. SAIDI, AND G. SCHEPENS (2019): "Life Below Zero: Bank Lending under Negative Policy Rates." *The Review of Financial Studies,* 32(10):3728–3761.

HODULA, M. (2019): "Monetary Policy and Shadow Banking: Trapped between a Rock and a Hard Place." Working Papers 5/2019, Czech National Bank.

HODULA, M., A. MELECKY, AND M. MACHACEK (2020): "Off the Radar: Factors behind the Growth of Shadow Banking in Europe." *Economic Systems,* 44(3).

HOFMANN, B. AND E. TAKÁTS (2015): "International Monetary Spillovers." BIS Quarterly Review September 2015, Bank for International Settlements.

HORVATH, R. AND K. VOSLAROVA (2017): "International Spillovers of ECB's Unconventional Monetary Policy: The Effect on Central Europe." *Applied Economics,* 49(24):2352–2364.

HORVATH, R., J. KOTLEBOVA, AND M. SIRANOVA (2018): "Interest Rate Pass-through in the Euro Area: Financial Fragmentation, Balance Sheet Policies and Negative Rates." *Journal of Financial Stability,* 36:12–21.

HUI, E. AND C. YIU (2003): "Market Dynamics of Private Residential Real Estate Price – An Empirical Test in Hong Kong." *Journal of Financial Management of Property and Construction,* 8(3):155–165.

HÖRDAHL, P., J. SOBRUN, AND P. TURNER (2016): "Low Long-term Interest Rates as a Global Phenomenon." BIS Working Papers 574, Bank for International Settlements.

IKEDA, D. AND M. SAITO (2014): "The Effects of Demographic Changes on the Real Interest Rate in Japan." *Japan and the World Economy,* 32:37–48.

ILLING, G. (2018): "The Limits of a Negative Interest Rate Policy (NIRP)." *Credit and Capital Markets,* 51(4):561–586.

IMF (2017): "Negative Interest Rate Policies – Initial Experiences and Assessments." IMF Policy Papers March 2017, International Monetary Fund.

IRELAND, P. N. (2015): "Monetary Policy, Bond Risk Premia, and the Economy." *Journal of Monetary Economics,* 76:124–140.

JACKSON, H. (2015): "The International Experience with Negative Policy Rates." Staff Discussion Paper 2015-13, Bank of Canada.

JIMÉNEZ, G., S. ONGENA, J. L. PEYDRÓ, AND J. SAURINA (2009): "Hazardous Times for Monetary Policy: What Do Twenty-three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-taking?" Working Papers 0833, Banco de España.

JIMÉNEZ, G., S. ONGENA, J. L. PEYDRÓ, AND J. SAURINA (2014): "Hazardous Times for Monetary Policy: What Do Twenty-three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-taking?" *Econometrica,* 82(2):463–505.

JOBST, A. AND H. H. LIN (2016): "Negative Interest Rate Policy (NIRP): Implications for Monetary Transmission and Bank Profitability in the Euro Area." IMF Working Papers 16/172, International Monetary Fund.

JORDÀ, Ò., M. SCHULARICK, AND A. M. TAYLOR (2013): "When Credit Bites Back." *Journal of Money, Credit and Banking,* 45(2):3–28.

JORDÀ, Ò., M. SCHULARICK, AND A. M. TAYLOR (2015): "Betting the House." *Journal of International Economics,* 96(S1):2–18.

JORDÀ, Ò., M. SCHULARICK, AND A. M. TAYLOR (2015): "Leveraged Bubbles." *Journal of Monetary Economics,* 76(5):1–20.

JORDÀ, Ò., M. SCHULARICK, AND A. M. TAYLOR (2017): "Macrofinancial History and the New Business Cycle Facts." NBER Macroeconomics Annual 2016, National Bureau of Economic Research.

JUSELIUS, M., C. BORIO, P. DISYATAT, AND M. DREHMANN (2016): "Monetary Policy, the Financial Cycle and Ultralow Interest Rates." *International Journal of Central Banking,* 13 (3):55–89.

KIYOTAKI, N. AND J. MOORE (2019): "Liquidity, Business Cycles, and Monetary Policy." *Journal of Political Economy,* 127(6):2926–2966.

KOLCUNOVÁ, D. AND T. HAVRÁNEK (2018): "Estimating the Effective Lower Bound on the Czech National Bank's Policy Rate." *Finance a Úvěr,* 68(6):550–577.

LASÉEN, S. AND I. STRID (2013): "Debt Dynamics and Monetary Policy: A Note." Working Paper Series 283, Sveriges Riksbank.

LAUBACH, T. AND J. C. WILLIAMS (2003): "Measuring the Natural Rate of Interest." *The Review of Economics and Statistics,* 85(4):1063–1070.

LOMBARDI, M., M. MOHANTY, AND I. SHIM (2017): "The Real Effects of Household Debt in the Short and Long Run." BIS Working Papers 607, Bank for International Settlements.

LOPEZ, J. A., A. K. ROSE, AND M. M. SPIEGEL: "Why Have Negative Nominal Interest Rates Had Such a Small Effect on Bank Performance? Cross Country Evidence." *European Economic Review,* 124.

LYSANDROU, P. (2014): "The Primacy of Hedge Funds in the Subprime Crisis." *Journal of Post Keynesian Economics,* 34(2):225–253.

MADDALONI, A. AND J.-L. PEYDRO (2013): "Monetary Policy, Macroprudential Policy, and Banking Stability: Evidence from the Euro Area." *International Journal of Central Banking,* 9(1):121–169.

MADDALONI, A. AND J.-L. PEYDRÓ (2011): "Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the US Lending Standards." *The Review of Financial Studies,* 24(6):2121–2165.

MCGOWAN, M. A., D. A., AND V. MILLOT (2018): "The Walking Dead? Zombie Firms and Productivity Performance in OECD Countries." *Economic Policy,* 33(96):685–736.

MIAN, A., A. SUFI, AND E. VERNER (2017): "Household Debt and Business Cycles Worldwide." *The Quarterly Journal of Economics,* 132(4):1755–1817.

MIYAJIMA, K., M. S. MOHANTY, AND J. YETMAN (2014): "Spillovers of US Unconventional Monetary Policy to Asia: The Role of Long-term Interest Rates." BIS Working Papers 478, Bank for International Settlements.

MOLYNEUX, P., A. REGHEZZA, AND R. XIE (2019): "Bank Margins and Profits in a World of Negative Rates." *Journal of Banking and Finance,* 107(C).

NAKASO, H. (2017): "New Frontier of Macroprudential Policy – Addressing Financial Institutions' Low Profitability and Intensified Competition." Speech at the Financial Discussion Meeting, Tokyo, 29 November 2017, Bank for International Settlements.

OBSTFELD, M. (2015): "Trilemmas and Trade-offs: Living with Financial Globalisation." BIS Working Papers 480, Bank for International Settlements.

OMAN, W. (2019): "The Synchronization of Business Cycles and Financial Cycles in the Euro Area." *International Journal of Central Banking,* 15(1):327–362.

OZDAGLI, A. AND M. VELIKOV (2020): "Show Me the Money: The Monetary Policy Risk Premium." *Journal of Financial Economics,* 135(2):320–339.

PALLEY, T. (2016): "Why Negative Interest Rate Policy (NIRP) Is Ineffective and Dangerous." *Real World Economics Review,* 76:5–15.

PESHEV, P. AND I. BEEV (2016): "Negative Nominal Interest Rates on Loans: The Newly-established Normal Practice?" *Economic Alternatives,* 2:149–158.

PEYDRÓ, J.-L., F. RODRIGUEZ-TOUS, J. TRIPATHY, AND A. ULUC (2020): "Macroprudential Policy, Mortgage Cycles and Distributional Effects: Evidence from the UK." Staff Working Paper 866, Bank of England.

RACHEL, L. AND T. D. SMITH (2018): "Are Low Real Interest Rates Here to Stay?" *50th issue (September 2017) of the International Journal of Central Banking.*

RAJAN, R. G. (2006): "Has Finance Made the World Riskier?" *European Financial Management,* 12(4):499–533.

RANDOW, J. AND S. KENNEDY (2016): "Negative Interest Rates." Bloomberg QuickTake, 17 September 2016.

REY, H. (2016): "Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence." NBER Working Papers 21162, National Bureau of Economic Research.

RIKSBANK (2018): "How Are Household Cashflows and Consumption Affected by Rising Interest Rates?" Monetary Policy Report December 2018, Sveriges Riksbank.

RIKSBANK (2018): "Evaluation of the Riksbank's Forecasts." Riksbank Studies March 2018, Sveriges Riksbank.

SAMARINA, A., L. ZHANG, AND D. BEZEMER (2017): "Credit Cycle Coherence in the Eurozone: Was There an Euro Effect?" *Journal of International Money and Finance,* 77:77–98.

SCHIVARDI, F., E. SETTE, AND G. TABELLINI (2017): "Credit Misallocation During the European Financial Crisis." Bank of Italy Temi di Discussione 1139, Bank of Italy.

SCHULARICK, M. AND A. TAYLOR (2012): "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008." *American Economic Review,* 102(2): 1029–1061.

SCHWAB, R. (1983): "Real and Nominal Interest Rates and the Demand for Housing." *Journal of Urban Economics,* 13:181–195.

STORZ, M., M. KOETTER, R. SETZER, AND A. WESTPHAL (2017): "Do We Want These Two to Tango? On Zombie Firms and Stressed Banks in Europe." Working Paper Series 2104, European Central Bank.

STREMMEL, H. AND B. ZSÁMBOKI (2015): "The Relationship between Structural and Cyclical Features of the EU Financial Sector." Working Paper Series 1812, European Central Bank.

SUMMERS, L. H. (2014): "US Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound." *Business Economics,* 49(2):65–73.

TAKÁTS, E. AND A. VELA (2014): "International Monetary Policy Transmission." BIS Papers 78, Bank for International Settlements.

TURNER, D. AND F. SPINELLI (2012): "Interest-rate-growth Differentials and Government Debt Dynamics." *OECD Journal: Economic Studies,* 1:103–122.

TURNER, P. (2014): "The Global Long-term Interest Rate, Financial Risks and Policy Choices in EMEs." BIS Working Papers 441, Bank for International Settlements.

TURNER, P. AND J. SOBRUN (2015): "Bond Markets and Monetary Policy Dilemmas for the Emerging Markets." BIS Working Papers 508, Bank for International Settlements.

URBSCHAT, F. (2018): "The Good, the Bad, and the Ugly: Impact of Negative Interest Rates and QE on the Profitability and Risk-taking of 1600 German Banks." CESifo Working Paper 7358, CESifo.

VARGHESE, R. AND Y. S. ZHANG (2018): "A New Wave of ECB's Unconventional Monetary Policies: Domestic Impact and Spillovers." IMF Working Papers 18/11, International Monetary Fund.

VUČINIĆ, M. (2016): "Importance of Macroprudential Policy Implementation for Safeguarding Financial Stability." *Journal of Central Banking Theory and Practice,* 5(3):79–98.

WANG, J. C. (2017): "Banks' Search for Yield in the Low Interest Rate Environment: A Tale of Regulatory Adaptation." Working Papers 17-3, Federal Reserve Bank of Boston.

WICKSELL, K. (1898): *Interest and Prices. A Study of the Causes Regulating the Value of Money.* London: Macmillan. ISBN 978-1443722797.

WITMER, J., J. YANG, ET AL. (2015): "Estimating Canada's Effective Lower Bound." Bank of Canada Review, Bank of Canada.

YIM YIU, C. (2009): "Negative Real Interest Rate and Housing Bubble Implosion – An Empirical Study in Hong Kong." *Journal of Financial Management of Property and Construction,* 14 (3):257–270.

Appendix A: Natural Rate of Interest Estimation

We follow the strategy proposed by Juselius et al. (2016), who extend a version of the Laubach and Williams (2003) model by including financial variables – the leverage gap $\hat{lev}_t$ and the debt service gap $\hat{dsr}_t$. The version of the Laubach and Williams (2003) model without financial variables is shown in black; the modification is shown in blue.

The model consists of five key equations: a reduced-form IS equation (A1), an equation for potential output (A2), a Phillips curve (A3), an equation for the natural rate of interest (A4), and an equation for the leverage gap (A5). In addition, there is an equation (A6) capturing growth in potential output and an equation (A7) capturing other determinants of the natural rate of interest (e.g., the rate of time preference).

$$\hat{y}_t = \alpha_1 \hat{y}_{t-1} + \alpha_2 \hat{y}_{t-2} - \alpha_3 \hat{r}_{t-1} - \alpha_4 \hat{lev}_{t-1} + \varepsilon_{1t} \tag{A1}$$

$$y^*_t = y^*_{t-1} + g_t + \varepsilon_{2t} \tag{A2}$$

$$\pi_t = \alpha_5 \pi_{t-1} + \alpha_6 \pi_{t-2|4} + \alpha_7 \hat{y}_t + \varepsilon_{3t} \tag{A3}$$

$$r^*_t = \alpha_8 r^*_{t-1} + \alpha_9 (g_t + z_t) + \varepsilon_{4t} \tag{A4}$$

$$g_t = g_{t-1} + \varepsilon_{6t} \tag{A5}$$

$$z_t = \alpha_{10} z_{t-1} + \varepsilon_{7t} \tag{A6}$$

$$\hat{lev}_t = \alpha_{11} \hat{lev}_{t-1} + \alpha_{12} \hat{r}_{t-1} + \alpha_{13} \hat{dsr}_{t-1} + \varepsilon_{5t} \tag{A7}$$

where $\hat{y}_t$ is the output gap, y^*_t is potential output, $\hat{r}_t$ is the real interest rate gap, r^*_t is the natural rate of interest, π_t is inflation, g_t is growth in potential output, and z_t are other determinants of the natural rate of interest; ε_i are error terms following $N(0, \sigma_i)$. The model is estimated using the Kalman filter.

The leverage gap is defined as the difference between leverage and its sample mean; the debt service gap is defined as the difference between the debt service ratio and its sample mean (see Figure A1). Leverage is calculated as the log-difference between the private non-financial credit-to-GDP ratio and the real asset price index. The real asset price index is calculated as a credit-weighted average of a property price index and a share price index adjusted for CPI inflation. The debt service ratio is obtained from the BIS, which calculates it as the ratio of interest payments plus amortizations to income. As such, the leverage gap refers to the co-integrating relationship between the credit-to-GDP ratio and the real asset price index, while the debt service gap refers to the co-integrating relationship between the credit-to-GDP ratio and the lending rate on outstanding debt. This closely follows the idea proposed by Juselius et al. (2016). Co-integration tests confirm the existence of the co-integrating relationships in our data.

We estimate the natural rate of interest for the four largest euro area economies (Germany, France, Italy, and Spain) and two European countries outside the euro area (Sweden and Denmark). Data were extracted from the OECD and the BIS database. The credit-to-GDP ratio captures both bank and non-bank credit.

The model parameters are estimated using the Bayesian approach with an independent Normal-Gamma prior distribution:

$$\alpha_i \sim N(v_i, s) \tag{A8}$$

$$\sigma_i \sim iG(S^{-1}, v) \tag{A9}$$

The prior mean v is set to the original parametrization from Juselius et al. (2016) and the prior standard deviation s is set to 0.2; the prior hyperparameters S and v are set, respectively, to 30 and to the number of estimated parameters plus 1.

The posterior distribution is then:

$$\alpha_i | data, \sigma_i^{-1} \sim N(v_i^{post}, s^{post}) \tag{A10}$$

$$\sigma_i^{-1} | data, \alpha_i \sim iG(S^{post,-1}, v^{post}) \tag{A11}$$

where

$$s^{post} = (s^{-1} + \sum x_t' \sigma_i^{-1} y_t)^{-1} \tag{A12}$$

$$v_i^{post} = s^{post}(s^{-1} v_i + \sum x_t' \sigma_i^{-1} y_t) \tag{A13}$$

$$S^{post} = S + \sum (y_t - x_t \alpha_i)(y_t - x_t \alpha_i)' \tag{A14}$$

$$v^{post} = T + v \tag{A15}$$

where y_t is the dependent variable and x_t are the independent variables.

The estimation results are shown in Table A1. The filtered finance-neutral output gap is presented in Figure A2.

Table A1: Posterior Estimates for the Parameters

Eq.	Parameter	Prior		Posterior					
				DE	FR	IT	ES	SE	DK
(A1)	α_1	mean	1.80	1.63	1.62	1.63	1.62	1.63	1.63
		s.d.	0.20	0.39	0.39	0.39	0.39	0.38	0.39
	α_2	mean	-1.10	-1.28	-1.28	-1.28	-1.27	-1.28	-1.28
		s.d.	0.20	0.39	0.39	0.38	0.39	0.38	0.39
	α_3	mean	-0.06	-0.06	-0.07	-0.07	-0.06	-0.06	-0.07
		s.d.	0.20	0.45	0.45	0.45	0.45	0.45	0.45
	α_4	mean	-0.02	-0.13	-0.14	-0.08	-0.09	-0.14	-0.13
		s.d.	0.20	0.30	0.31	0.18	0.21	0.32	0.30
(A3)	α_5	mean	0.60	0.61	0.61	0.61	0.61	0.61	0.61
		s.d.	0.20	0.45	0.45	0.45	0.44	0.45	0.45
	α_6	mean	0.03	0.04	0.04	0.04	0.04	0.04	0.04
		s.d.	0.20	0.45	0.45	0.45	0.45	0.45	0.45
	α_7	mean	0.30	0.30	0.31	0.29	0.30	0.30	0.30
		s.d.	0.20	0.45	0.45	0.45	0.45	0.45	0.45
(A4)	α_8	mean	0.60	0.60	0.61	0.61	0.61	0.60	0.60
		s.d.	0.20	0.45	0.45	0.45	0.45	0.45	0.46
	α_9	mean	0.40	0.41	0.40	0.41	0.41	0.40	0.41
		s.d.	0.20	0.46	0.45	0.45	0.45	0.45	0.45
(A6)	α_{10}	mean	0.60	0.61	0.60	0.61	0.61	0.61	0.61
		s.d.	0.20	0.45	0.45	0.44	0.45	0.45	0.46
(A7)	α_{11}	mean	0.70	0.82	0.81	0.92	0.92	0.81	0.81
		s.d.	0.20	0.32	0.34	0.19	0.22	0.34	0.33
	α_{12}	mean	0.02	0.05	0.03	0.05	0.05	0.04	0.04
		s.d.	0.20	0.45	0.45	0.45	0.45	0.45	0.46
	α_{13}	mean	0.20	0.21	0.22	0.21	0.19	0.20	0.23
		s.d.	0.20	0.44	0.44	0.46	0.39	0.45	0.42

Note: Results from estimating system of equations (A1)–(A7) using the Kalman filter.

Figure A1: Leverage Gap (Left-Hand Scale) and Debt Service Gap (Right-Hand Scale)

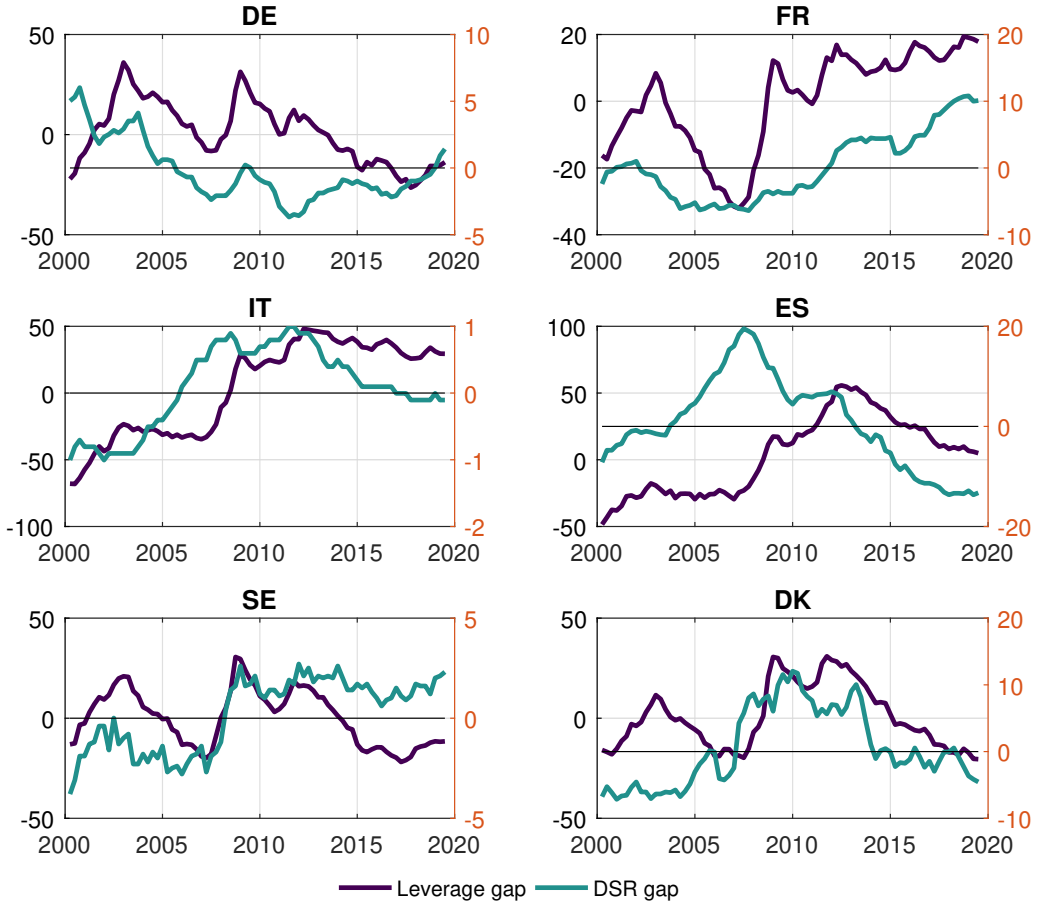
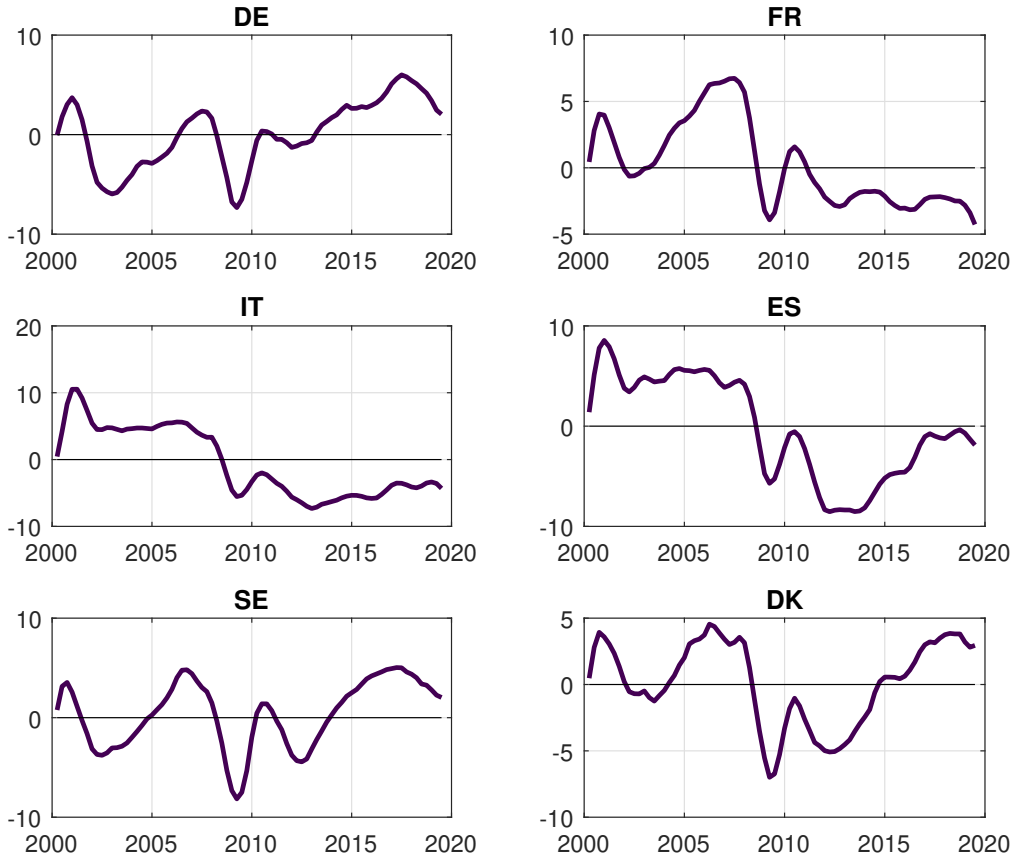
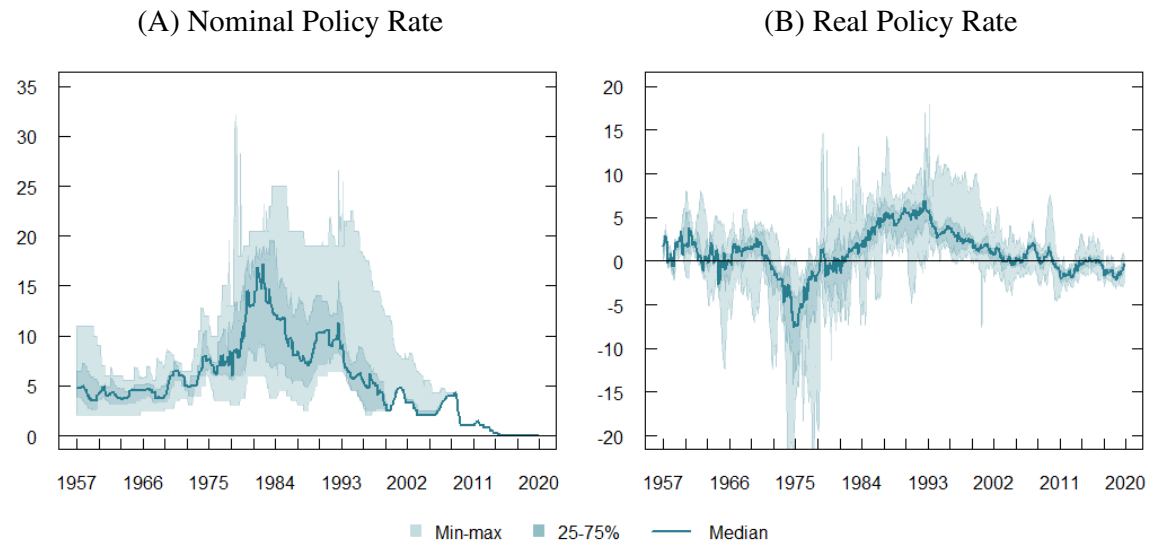


Figure A2: Finance-Neutral Output Gap



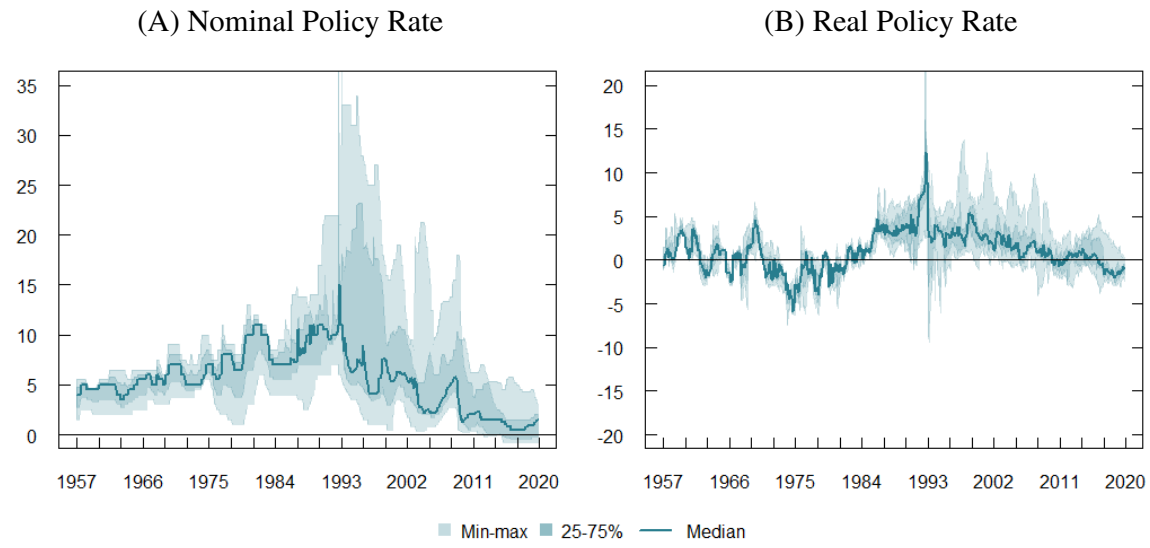
Appendix B: Central Bank Policy Rate

Figure B1: Euro Area (Member Countries as of 2019)



Note: The real policy rate is calculated as the nominal policy rate minus actual consumer inflation.
Source: BIS policy rate statistics and consumer price statistics

Figure B2: European Countries Other Than the Euro Area



Note: The real policy rate is calculated as the nominal policy rate minus actual consumer inflation.
Source: BIS policy rate statistics and consumer price statistics

IES Occassional Paper Series

2021

1. Simona Malovaná, Josef Bajzík, Dominika Ehrenbergerová, Jan Janků:
   A Prolonged Period of Low Interest Rates: Unintended Consequences

All papers can be downloaded at: http://ies.fsv.cuni.cz

Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz