Charles University

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

Key Determinants of Net Interest Margin of Banks in the EU and the US

Author: **Bc. Petr Hanzlík**

Supervisor: **doc. PhDr. Petr Teplý, Ph.D.**

Academic Year: **2017/2018**

Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

The author grants to Charles University permission to reproduce and to distribute copies of this thesis document in whole or in part.

Prague, May 4, 2018

Signature

Acknowledgments

The author is especially grateful to his supervisor doc. Petr Teplý who gave him a good advice on data sources, suggested many useful papers and articles, regularly consulted all the difficulties coming during writing the thesis, and supported the author in timely finishing the work on it.

The author is also very grateful to doc. Jozef Baruník and PhDr. Karolína Vozková for consulting the system GMM estimation method, either from theoretical, or practical point of view, helping him a lot with its application in the thesis.

Abstract

The thesis considers the impact of short-term interest rate and slope of the yield curve on the net interest margin (NIM) while controlling for other bank specific and country specific factors that may influence the NIM. The analysis is conducted using a unique panel dataset of banks in the EU and United States. Special focus is put on observing differences caused by bank heterogeneity by size, or by bank specialisation, differences arising due to the fact that some countries are considered capital based financial market, while the other as bank based, or differences caused by differing market concentration. Some of the models also use dummy variable indicating the existence of negative interest rate environment in a given country and year. The results show positive but concave relationship of NIM and short-term rate. They also confirm differences caused by institutional factors (bank based vs. capital based) as well as by market concentration.

JEL Classification	C33, E43, E52, E58, G21
Keywords	net interest margin, bank heterogeneity, bank profitability, interest rates, non-linearity, unconventional monetary policy, GMM

Author's e-mail	96193552@fsv.cuni.cz
Supervisor's e-mail	petr.teply@fsv.cuni.cz

Abstrakt

Diplomová práce se zabývá vlivem krátkodobých úrokových sazeb a sklonu výnosové křivky na čistou úrokovou marži (NIM) bank, přičemž využívá unikátní panelová data kombinující banky v Evropské unii a Spojených státech. Analýza se zvláště zaměřuje na rozdíly v NIM způsobené bankovní heterogenitou, jak v důsledku specializace dané banky, tak její velikosti, dále na rozdíly mezi bankami působícími v zemích považovaných za kapitálově orientované finanční trhy nebo bankovně orientované trhy, případně na rozdíly způsobené rozdílnou tržní koncentrací. V neposlední řadě je v některých modelech použita umělá proměnná indikující situaci, kdy v dané zemi v příslušném roce byly záporné krátkodobé sazby. Výsledky ukazují positivní, ale konkávní vztah NIM a krátkodobé úrokové míry. Dále také potvrzují vliv institucionálních faktorů (kapitálově orientované vs. bankovně orientované trhy) i rozdílné tržní koncentrace.

Klasifikace JEL C33, E43, E52, E58, G21

Klíčová slova čistá úroková marže, bankovní heterogenita, ziskovost bank, úrokové sazby, nelinearita, nekonvenční měnová politika, GMM

E-mail autora `96193552@fsv.cuni.cz`

E-mail vedoucího práce `petr.teply@fsv.cuni.cz`

Contents

List of Tables

List of Figures

Acronyms

NIM Net interest margin

ROAA Return on average assets

ROAE Return on average equity

GDP Gross domestic product

ZLB Zero lower bound

GMM Generalized method of moments estimator

OLS Ordinary least squares estimator

(F)GLS (Feasible) generalized least squares estimator

LSDV Least squares dummy variables estimator

FRED Federal Reserve Economic Data (database of Federal Reserve Bank of St. Louis)

OECD Organisation for Economic Co-operation and Development

Master's Thesis Proposal

Author	Bc. Petr Hanzlík
Supervisor	doc. PhDr. Petr Teplý, Ph.D.
Proposed topic	Key Determinants of Net Interest Margin of Banks in the EU and the US

Motivation The aim of this thesis will be to analyze the factors influencing the net interest margin (NIM) of banks in the EU member states and in the United States in recent years. Banks heterogeneity has not been researched in recent years by size (small, medium, and large) and by bank type (i.e. bank holding companies, commercial banks, cooperative banks, real estate & mortgage banks or savings banks).

During this period following the global financial crisis, there existed quite specific macroeconomic conditions while the very low, in certain cases even negative, interest rates were among them. As the existing literature on impact of low interest rates on banks' performance and monetary transmission suggests this is still rather under researched area. Claessens et al. (2017) for example discuss quite deeply how the low and "low for long" interest rates can lead to deterioration of NIM of banks and what implications it has for monetary policy and the whole economy. But he does not consider the bank heterogeneity.

Bank heterogeneity is somewhat considered in Arsenau (2017) who discusses the possible impact of possible introduction of negative rates in the United States on U.S. banks profitability. He considers the bank heterogeneity coming from differences in liquidity provision practices which can lead to non-linearity in the expected impact of decreasing rates on their profitability. On the other hand, he does not include heterogeneity by size or by bank type since he uses data only of 22 large bank holding companies. The hypothesis about existence of non-linearities in the impact of interest rate environment can be supported e.g. by results of Borio, Gambacorta and Hofmann (2015). Heterogeneity by size is discussed for example in Terraza (2015) who analyses large panel of European banks, but she uses ROAA as dependent variable.

In my thesis, I will consider the non-linearity phenomenon on a larger scale by including both EU and U.S. banks. This will also mean comparison of two different banking systems, i.e. bank based system in the EU and capital market based system in the U.S.

Finally, there may be country specific characteristics which may lead to differences between banks in different countries. These include structure of bank ownership in certain country, market concentration and differing consumers' preferences.

Hypotheses

Hypothesis #1: Decrease of NIM was deeper in EU (which can be considered bank based financial market) than in U.S. (which can be considered capital market based financial market).

Hypothesis #2: NIM eroded most significantly in small banks in both EU and U.S.

Hypothesis #3: Savings banks reported the highest NIM.

Hypothesis #4: Protracted period of low (and even negative) interest rates in the EU eroded all type of banks' NIM.

Hypothesis #5: Situation differs for each country based on specific market characteristics (bank ownership structure, market concentration etc.). Especially, it can be assumed that higher market concentration in general leads to lower decrease in NIM.

Methodology For writing the thesis I will use data available in the Orbis Bank Focus database. From the database panel dataset of banks located in the United States and in EU member countries will be obtained. For analysis of this panel data standard approaches as fixed effects, random effects or GMM estimation will be used. The dependent variable of the models will be NIM. The set of independent variables will include both bank-specific variables as well as country specific variables. Bank specific variables will cover possible effects of heterogeneity coming from bank size, and from certain bank's business model. Country specific variables will cover effects of various macroeconomic, market specific and other characteristics leading to bank heterogeneity across the countries. The analyzed period will be 2011-2016 due to data availability.

Expected Contribution It is an up to date topic and there still exists space for deeper research of the transmission mechanism from low market rates into the banks' NIM. Unique dataset from Orbis Bank Focus including large sample of European and U.S. banks will be used. Special consideration will be given to phenomenon of heterogeneity coming from different bank types, bank size and geographic location. Last but not least the thesis will bring comparison of differences in market rate-NIM link in bank based and in capital market based countries.

Outline

1. Introduction
2. Theoretical Background (basic terms, zero lower bound, banking regulation)
3. Literature Review
4. Methodology
5. Empirical Analysis
6. Data Analysis
7. Discussion of results
8. Conclusion

Core bibliography

Arseneau, David M. (2017). "How Would US Banks Fare in a Negative Interest Rate Environment?," Finance and Economics Discussion Series 2017-030. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2017.030.

Bikker, Jacob Antoon and Vervliet, Tobias (2017). Bank Profitability and Risk-Taking Under Low Interest Rates. De Nederlandsche Bank Working Paper No. 560. Available at SSRN: https://ssrn.com/abstract=3002480

Borio, C., Gambacorta, L. & Hofmann, B. (2015). The influence of monetary policy on bank profitability. BIS Working Papers, No 514.

Claessens, Stijn, Nicholas Coleman, and Michael Donnelly (2017). "Low-For-Long" Interest Rates and Banks' Interest Margins and Profitability: Cross-Country Evidence. International Finance Discussion Papers 1197. https://doi.org/10.17016/IFDP.2017.1197

Demiralp, S., Eisenschmidt, J., & Vlassopoulos, T. (2017). Negative interest rates, excess liquidity and bank business models: Banks' reaction to unconventional monetary policy in the euro area. Available at SSRN: https://ssrn.com/abstract=2941377

Fišerová, T., Teplý, P., Tripe, D. (2015). The Performance of Foreign-Owned Banks in Host Country Economies. Prague Economic Papers, 2015(5), 538-561.

Terraza, V. (2015). The effect of bank size on risk ratios: Implications of banks' performance. Procedia Economics and Finance, 30, 903-909.

Author

Supervisor

Chapter 1

Introduction

Last decade was characterized among other things by an unprecedented situation of very low, in some countries even negative interest rates. This situation was closely related to an unconventional monetary policy performed by major central banks all around the world and it raised also questions about the implications of so low or even negative interest rates for the banks' profitability. Bank profitability is usually measured by measures such as return on average assets (ROAA), return on average equity (ROAE), or net interest margin (NIM). The last of these ratios is linked to the most important part of bank's income - the net interest income which arises from the difference of interest paid on deposits and other instruments on liability side of bank's balance sheet and interest earned on loans and other instruments on the asset side of the balance sheet. And by its nature, this part of bank's profitability is the one most sensitive to interest rate environment. Somewhat surprisingly, the literature aimed at assesment of this relationship is not yet very rich. Some analyses were done by Borio *et al.* (2015), Claessens *et al.* (2017), or Bikker & Vervliet (2017), but generally it is still rather under-researched area.

The objective of this thesis is to analyse the impact of the low and negative interest rate environment on banks' NIM. For the analysis, a unique dataset of 629 banks from EU countries and 526 banks from United States is used. The analysis is conducted both on the whole sample as well as only on the European dataset. The relationship of NIM with short-term interest rate and with the slope of the yield curve is assumed in both cases to be non-linear. Moreover, the models are constructed in order to control for the specific impact of existing negative short-term rate, for the differences by banks operating in bank based and banks operating in capital based financial market, as well as for the differences implied by bank specialisation and size. Specifically, the thesis aims to test following five hypotheses:

Hypothesis #1: Decrease of NIM was deeper in the EU (which can be considered bank based financial market) than in the U.S. (which can be considered capital market based financial market).

Hypothesis #2: NIM eroded most significantly in small banks in both the EU and the U.S.

Hypothesis #3: Savings banks reported the highest NIM.

Hypothesis #4: Protracted period of low (and even negative) interest rates in the EU eroded all type of banks' NIM.

Hypothesis #5: Situation differs for each country based on specific market characteristics (bank ownership structure, market concentration etc.). Especially, it can be assumed that higher market concentration in general leads to lower decrease in NIM.

The thesis is structured as follows: Chapter 2 gives a theoretical background explaining some key concepts and theories relevant for the topic. Chapter 3 provides a literature review for the impact of low (negative) interest rate environment on banks' profitability, or NIM specifically. In Chapter 4 the impact is analysed on the combined EU-U.S. dataset focusing especially on the impact of negative rate environment, and differences between capital and bank based markets. Chapter 5 then uses the dataset restricted on EU to asses the impact of market structure. Chapter 6 summarizes our findings.

Chapter 2

Theoretical Background

The aim of this chapter is to introduce some key concepts that will be used throughout this thesis. These include net interest margin, banking regulation, bank heterogeneity, zero lower bound (or effective lower bound respectively), and quantitative easing. Last but not least the monetary transmission and its impact on banks' profitability is discussed.

2.1 Banking Regulation

Banking regulation is the first key concept for this thesis. Banking belongs to the most regulated industries in modern economy. The reasons for regulation are discussed in many textbooks. Mejstřík *et al.* (2014, p. 210 - 213) state three main reasons for banking regulation as information asymmetry, high leverage of a bank, and systemic risk.

Information asymmetry arises when there exists so called principal-agent problem, i.e. the relation of two sides of a contract with different information about the conditions of the contract. Common examples of principal-agent relations are relations between debtor and creditor, between depositor and bank, between owners and managers of a bank (or company in general), etc. The existence of information asymmetry then can lead either to *adverse selection*, or to *moral hazard*.

In case of adverse selection, the problem appears before the conclusion of the contract. An example may be that someone with higher probability of injury from risky behaviour will apply for insurance covering such injuries, while people who do not behave in such risky way will not buy the insurance. Hence the insurance premiums may not be sufficient to cover the adverse events.

On the other hand, the problem of moral hazard appears after the conclusion of the transaction. The core of the problem lies in possible opportunistic behaviour of the principal who may have incentive to increase the riskiness of his behaviour after the conclusion, e.g. someone may start doing adrenaline sports after signing an insurance contract. More examples on consequences of existing information asymmetry, including famous "Lemons model", can be found e.g. in Akerlof (1970).

Both problems may as well appear in banking, especially in case of loan provision. It is likely that more often people with lower ability to repay a loan will apply for it (adverse selection). Also when a loan is granted to the debtor, he may have incentives to opportunistic behaviour, e.g. using the loan for a different purpose than reported to the bank and thus lowering his ability to repay (moral hazard), i.e. both phenomena are connected with credit risk. Banks thus play a role of delegated monitors instead of the depositor who is less capable of monitoring the financial condition and performance of the borrower. This task is delegated to the bank as a more efficient intermediary. Delegated monitoring should overcome to a large extent the information asymmetries of depositors, creditors and debtors. (Mejstřík *et al.* 2014, p. 211) However, the banks may fail to fulfill this task. Hence the regulators may step in to protect the interests of depositors.

High leverage of banks means that banks operate with very low share of equity on their total liabilities. This makes up the second reason for banking regulation. The potential instability of the banking sector caused by relatively high level of insolvency and liquidity risks is closely connected to the high leverage of banks. On the other hand, banks' asset portfolios are more liquid and diversified than the assets of production companies. But still, the potential fragility is present as a natural property of the banking sector (Mejstřík *et al.* 2014, p. 211).

Finally, the third main reason for bank regulation is the systemic risk. Since banking is highly dependent on trust, problems of one important bank may have significant impact on stability of the financial system as a whole. For this reason, financial stability (or macroprudential) policies have become common practice of banking regulators during years following the financial crisis. Further discussion of reasons for bank regulation is provided in Golin & Delhaise (2013, p. 717-780).

2.2 Bank Heterogeneity

Bank heterogeneity arises due to various factors. Individual banks differ from each other in many ways and it may lead to significant differences in impact of various shocks to the banking sector on individual banks. The heterogeneity can be observed by size, i.e. we can divide banks on small, medium and large. Another approach to heterogeneity can be based on the bank's business model. It means that we can distinguish between commercial banks, cooperative banks, real estate and mortgage banks, savings banks, investment banks, bank holding companies, etc. In this thesis all mentioned but the investment banks are observed.

Mejstřík *et al.* (2014, p. 99) mention two microeconomic phenomenons related to bank heterogeneity - *economies of scale* and *economies of scope.* Economies of scale mean that with proportional growth of production factors, usually considered just as capital and labour, there is more than proportional growth of production, or earning assets in a specific case of banks. While economies of scope mean that costs of production in separated factories are higher than costs of joint production. In case of banking it may imply that it is more efficient to offer different banking products in one single institution than for example having specialized mortgage bank or investment bank. On the other hand, bank specialization may be sometimes supported by legal conditions as it was for example by US Glass-Steagal Act of 1933.

It also needs to be pointed out that bank heterogeneity has implications for liquidity management of a bank. *"For example, American analyses show that big multinational banks tend to have a higher share of large and institutional deposits, which are better to manage but are not insured. Multinational banks maintain liquidity by purchasing sources while regional and local banks or savings banks depend more on liquid assets reserves and on core deposits, and on sources from the local market that are more stable and relatively cheaper in comparison with purchased sources ... "*(Mejstřík *et al.* 2014, p. 311). Hence, it is quite reasonable to assume that there might be significant differences in how the small and large banks fared in the very low interest rate environment during last years.

2.3 Net Interest Margin

The third key concept and probably the most important for the topic of this thesis is *net interest margin* (NIM). NIM is one of the main indicators used to measure the bank's profitability together with other ratios including return on average assets (ROAA) and return on average equity (ROAE). While ROAA and ROAE belong to so called return type profitability ratios, NIM is considered to be a margin type ratio. Except for return type and margin type there exist also cost-efficiency type ratios, e.g. cost to income ratio (Golin & Delhaise 2013, p. 275).

The importance of NIM comes from the nature of banks' business model based on spread between interest paid on banks' liabilities and interest earned on the assets. The income arising from existence of this spread is called net interest income. Formal definition of NIM is given in Mejstřík *et al.* (2014, p. 609) as:

$$NIM(\%) = \frac{NII}{(i.e.assets_t + i.e.assets_{t+1})\,/2} \cdot 100 \tag{2.1}$$

where NII stands for net interest income and $i.e.assets_t$ for interest earning assets in year t.

NIM can be observed to differ both across individual banks and from time to time. Factors influencing individual bank's NIM can be divided into macro and micro influences. Macroeconomic factors include regulations of bank activities, level of concentration of certain market and most importantly the general level of interest rate and slope of the yield curve. It is necessary to realize that government policy and market factors will usually affect all banks in a similar way. The macroeconomic influences can thus be considered as country-level specific. Due to this fact, the analyses should focus on anomalies between bank and its peers. A bank's individual strategy and management competence is capable in making a certain difference in how succesfully the bank performs compared to its competitors (Golin & Delhaise 2013, p. 296).

"At the micro level, again several factors may affect a bank's NIM and explain changes in the profitability of a bank's spread business as well as why one bank may be able to charge premium rates while another is burdened by above-average funding costs. For example, a bank's NIM may rise as a consequence of the bank's strategy to expand its deposit base. The bank might open new branches allowing it to capture low-cost deposits." (Golin & Delhaise 2013, p.

296). Bank can also use some short-term tactics, e.g. temporarily increase the deposit rates or lower credit rates in comparison to its competitors to attract new clients, etc.

Due to the fact that net interest income is major part of bank's income and that it is also the part of income which is by its nature most sensitive to changes in interest rate environment, NIM is probably the best indicator to capture the impact of interest rate environment on banks' profitability and will be used as a dependent variable in models in empirical part of the thesis.

2.4 Zero Lower Bound

During the years following the financial crisis of 2007-2009 large drop in short term interest rates to levels close to the zero occured in most advanced economies. There are likely to be multiple causes of this large drop including both the lack of trust on financial markets as well as the monetary policy of the major central banks. In this situation many economists started to discuss *zero lower bound* (ZLB) problem, i.e. the limitations of monetary policy in case the short term rate is close to the zero.

In normal times, when interest rates are at higher levels, the main operational tool of central banks is setting the policy rate by which the central bank influences the short term rate and then through multiple transmission channels the money supply in the economy. With some degree of simplification we can say that in case the central bank aims to lower the inflation and prevent the economy from overheating, it increases the policy rate and thus reduces the money supply, on the other hand when the economy is below its potential output and inflation is low or even there exist deflation risks, the central bank responds by decreasing the policy rate and thus loosens the monetary conditions.

However, in case the policy rate is already almost zero, the central bank can not loosen the monetary policy in a usual way, because it would have to set negative policy rate. Even though some central banks eventually decided for such tool, it has significant drawbacks. It can be assumed that even if the policy rate may become somewhat negative, it would not be fully transmitted into the market rates because in such case it would be reasonable to hold cash instead of bank deposits or other instruments bearing negative interest.

Previously there was rather little experience with situation of ZLB, but there were some cases. The most famous example is probably the period of low growth and deflation in Japan during 1990s. This example is often mentioned in literature considering the ZLB, e.g. in Bernanke & Reinhart (2004), Jung *et al.* (2005) or Svensson (2006).

2.5 Monetary Policy under ZLB

Due to the lack of experience with ZLB there does not exist broad consensus about how the monetary policy should be conducted in such situation. Bernanke & Reinhart (2004) discuss some possibilities how the monetary policy can be done in situation of very low short-term interest rates to achieve the goals of monetary policy. They mention three ways: *" . . . (i) providing assurance to investors that short rates will be kept lower in the future than they currently expect, (ii) changing the relative supplies of securities in the marketplace by altering the composition of the central bank's balance sheet, and (iii) increasing the size of the central bank's balance sheet beyond the level needed to set the short-term policy rate at zero ('quantitative easing'). . . "* (Bernanke & Reinhart 2004, p. 85). All these measures aim at shaping the market expectations about future inflation and short-term rates by making the yield curve more flat, i.e. by lowering the long-term rates.

Jung *et al.* (2005) support this aim by solving central bank's intertemporal loss-minimization problem in which they consider the non-negativity constraint on nominal interest rates. They found out that in case of an adverse demand shock, the central bank should make a credible commitment to keep the policy rate by zero for longer time than previously expected.

Another possible way of escaping from situation of ZLB was suggested by Svensson (2003) who called his proposed strategy "Foolproof Way" for escaping from liquidity trap and deflation. This strategy demands central bank's commitment to a higher future price level, i.e. adoption of price-level targeting, concrete action that demonstrates central bank's will to fulfill its commitment, and an exit strategy to return to normal monetary policy after the unconventional policy becomes unnecessary. Concrete action may for example take form of an exchange rate commitment as it was done by the Czech National Bank. For more detail Franta *et al.* (2014) can be seen. The use of the exchange rate as a monetary policy tool in ZLB situation was also advocated by McCallum (2000).

Theoretically, negative nominal interest rates are another possible unconventional tool of monetary policy. However, as mentioned above they may be problematic in practice because if they were fully transmitted to the deposit rates for households and firms, they would incentivise them to hold cash instead of bank deposits. On the other hand, it can be assumed that due to the incomplete transmission the level under which the policy rate may not fall does not necessarily have to be zero, but it can be some slightly negative number. We then speak about *effective lower bound* instead of ZLB.

The negative policy rates may also bring certain legal issues since there may exist penalty rates based on central bank's policy rates and hence the negative rates would mean that creditors should start to pay debtors. This was one of the concerns why negative rates were not chosen as policy tool by the Czech National Bank (Franta *et al.* 2014, p. 32). On the other hand, other central banks, including the European Central Bank or the Danish National Bank, decided to use negative policy rates as their monetary policy tool.

The last major unconventional tool of monetary policy used in recent years is the *quantitative easing* which is discussed in next subchapter.

2.6 Quantitative Easing

Quantitative easing generally means large-scale purchases of assets by central bank and expansion of its balance sheet. Purchased assets include mainly government bonds, but they may also include certain commercial papers. The expansion of asset side is on the liability side offset mainly by increase in bank reserves. *"Quantitative easing may affect the economy through several possible channels. In particular, if money is an imperfect substitute for other financial assets, then large increases in the money supply will lead investors to seek to rebalance their portfolios, raising prices and reducing yields on long-term assets will stimulate economic activity. ... Quantitative easing may also work by altering expectations of the future path of policy rates. ... Lastly, quantitative easing that is sufficiently aggressive and perceived to be long-lived may have expansionary fiscal effects."* (Bernanke & Reinhart 2004, p. 88) On the other hand, other authors doubt about the real effects of the quantitative easing. Cúrdia & Woodford (2011) analysed the effects of quantitative easing using basic New Keynesian model of monetary transmission extended by inclusion of the central bank's balance sheet. They conclude that the expansion of the supply of reserves has little effect on aggregate demand. However, they also state that it serves as signalling about future interest-rate policy and thus it can still be a way to provide monetary stimulus in situation of ZLB.

Quantitative easing was used by Bank of Japan in 2001-2006. This example is mentioned in both Bernanke & Reinhart (2004) and Cúrdia & Woodford (2011). After the fall of Lehman Brothers in September 2008, U.S. Federal Reserve System started to use this policy tool as well. Bank of England first employed quantitative easing in March 2009, whereas European central Bank began with much longer delay in March 2015.

2.7 Monetary Transmission and Banks' Profitability

Monetary policy, no matter if conducted in conventional or unconventional way, has always been an important factor influencing the profitability of the commercial banks. During the years following the financial crisis, the understanding of how the monetary policy and banks' profitability are connected has gained in importance. But before discussion of how specifically the unconventional monetary policy has influenced the profitability of banking sector, it is necessary to briefly describe the monetary transmission mechanism.

Generally, the central banks aim at steering the inflation and thus influencing the macroeconomy. But the monetary policy can affect the inflation only indirectly. Under almost direct influence of the central bank's policy tools are only the short-term interest rates. Central bank usually has one main policy rate which is set by its monetary policy committee. (It may be accompanied by other policy rates, e.g. discount and lombard rates, which make up a certain corridor around the main policy rate.) This policy rate represents a price for which the commercial banks can borrow additional liquidity from central bank or for which they can deposit their excess liquidity in the central bank. Since the commercial banks can always obtain additional liquidity or get rid of excess liquidity for this price, the short-term rates on interbank market closely follow the path of the policy rate. However, the transmission from short-term rates change to the inflation is rather a "black box", i.e. very complex mechanism working through various channels with substantial level of uncertainty.

In the literature, the number and definitions of monetary transmission channels differ. In this thesis definitions of Černohorský & Teplý (2011), who distinguish four channels - exchange rate channel, interest rate channel, credit channel, and asset price channel, are followed.

Exchange rate channel works through exchange rate appreciation or depreciation in response to change in interest rates. It can be assumed that in case of interest rate hike there occurs inflow of speculative capital into the domestic economy because the relative profitability of domestic assets increases. This inflow causes higher demand for domestic currency and hence the exchange rate appreciation. The appreciation then causes the imported goods to be relatively cheaper. That by itself contributes to disinflation and moreover it causes higher imports and lower exports, i.e. lower net exports which are by national accounts definition part of the output. It thus lead to lower aggregate demand and hence slowing down of the macroeconomy meaning increasing unemployment and decreasing inflation.

Interest rate channel is based on interest rate sensitivity of economic agents. In case of interest rate hike it becomes more reasonable for households to save and postpone their consumption into the future. Decreasing consumption leads to decreasing aggregate demand. Interest hike has also impact on investment of firms because they have incentives to prefer investment into financial assets rather than to other assets. Moreover, they face higher interest costs of credit financing. For both these reasons the overall investment activity decreases and it also causes the decrease of aggregate demand which leads to decreasing inflation.

Credit channel is the most important channel for banking sector. The interest rate level determines the supply of credit provided by banks as well as the demand for credit by borrowers. With interest hike the demand is likely to decrease because less economic agents will be able to pay the higher interest on the credit. It is not obvious how the supply will be influenced because on one hand higher interest rates on credit mean higher interest income for banks, but it may be on the other hand offset by the higher interest on deposits, i.e. interest costs. This transmission channel is rather slow because the amount of credit influences the economy in longer time horizon. But generally, it holds that with lower availability of credit the economic agents will spend less. This will again lead to slowing down of the economy and decreasing inflation.

Asset price channel arises from the fact that interest hike or decrease has an impact on asset prices. Prices of stocks, real estate or commodities usually decrease in case of interest hike because higher interest rates mean lower yield relative to yield on fixed interest assets (e.g. bonds or deposits). Hence the value of assets in possesion of economic agents decreases and thus their wealth decreases. It can be assumed that wealth has partial impact on consumption and hence the consumption may decrease in response to interest hike also due to this transmission channel. Similarly, the decrease in wealth of firms may lead to lower investment. Both the decreased consumption and investment then cause lower aggregate demand, and thus lower inflation.

To sum up the monetary transmission mechanism, it is necessary to stress that the monetary policy decision about interest rates is transmitted through all these channels. Importantly, in all cases interest hike leads finally to the decrease in inflation, while interest decrease has the opposite effect.

In previous subchapters, there were introduced unconventional tools which were designed to complement the standard monetary policy toolkit in situation of ZLB in which the short-term rate can no longer be manipulated. The unconventional measures allow the central banks to influence the slope of the yield curve and thus the long-term rate, which can than through the above discussed channels influence the inflation.

But the decrease of interest rates and flattening of the yield curve does not have only the impact on inflation. Very likely, it will have also significant impact on the bank profitability. Bank profitability can be divided to few different categories. Borio *et al.* (2015) distinguish three categories - net interest income, non-interest income, and loan loss provisions.

Net interest income is the largest part of bank's profit and it is also the part most sensitive to the interest rate environment. Therefore, both the level of interest rate as well as the slope of the yield curve will play substantial role for the amount of net interest income. Borio *et al.* (2015) discuss four mechanisms relevant for influence of the level of interest rate. They include *retail deposits endowment effect*, *capital endowment effect*, *quantity effect*, and *dynamics of transition between equilibria*, i.e. the repricing lags and credit-loss accounting.

The *retail deposits endowment effect* is based on a fact that bank deposit rates are usually set as a markdown on market rates. The magnitude of the markdown depends e.g. on oligopolistic power and transaction costs. With interest rate decline and yield curve flattening the markdown likely becomes smaller. Hence in case of later monetary policy tightening there is space for net interest income increase due to the lag in increase of retail deposit rates, i.e. the banks postpone the increase to make the markdown higher again. As Borio *et al.* (2015) remind the endowment effect was big source of profits in times of high inflation and low market competition between banks as it was the case in many countries in late 1970s. On the other hand, in recent years after the crisis it has opposite impact as the interest rates became very low and the deposit rates cannot fall below zero, or at least not to some larger negative number. This suggests that the relationship between interest rates and net interest income is likely to be non-linear.

The *capital endowment effect* is in fact very similar to the retail deposit endowment effect. It comes from the fact, that equity capital does not pay interest. Thus with interest rates falling, the return on assets covered by equity mechanically declines. This effect is likely to be smaller due to the relatively small share of equity in banks' balance sheets. Moreover, this effect should not be a source of non-linearity in impact of interest rates on net interest income since the equity does not bear any interest cost.

Quantity effects arise due to the different interest rate elasticities of demand for loans and demand for deposits. The changes in interest rates influence the volumes of both, loans and deposits. However, demand for loans is more interest rate elastic than demand for deposits. This may lead to erosion of profitability at some higher level of interest rates. But on the other hand, it means that in the low interest rate environment, these effects should not have major impact.

The *dynamics of transition between equilibria*, i.e. the effects of transmission of the change in level of interest rates into the net interest income appear in two forms. *"The first relates to lags in price (rate) adjustments, possibly reflecting oligopolistic behaviour or views that the changes in market rates are only temporary. There is a vast literature documenting that if banks have oligopolistic power, deposit rates adjust more sluggishly than lending rates. This means that, all else equal, banks make profits when the monetary policy stance changes."* (Borio *et al.* 2015, p. 6-7) The second form arises from accounting practices. Theoretically, the interest margin of any new loan should include also the expected losses. However, the losses appear in accounting only when they are incurred. Hence the increase in new loans volume caused by lower interest rates may temporarily increase the profitability until the losses on some of the new loans materialize sometimes in the future.

The slope of the yield curve is also likely to have some impact on net interest income. Steeper yield curve should probably have positive effect because generally, the asset side of balance sheets of banks consists mainly of long-term assets (e.g. loans) while the liability side to large extent of short-term liabilities (e.g. demand deposits or interbank loans). That means that interest income comes mainly from long-term contracts bearing high term premium while interest cost is paid on short-term contracts without term premium. The term premium thus contributes more substantially to the net interest income when the yield curve is steeper.

Chapter 3

Literature Review

The aim of this thesis is to analyse the factors influencing the NIM of banks in the EU and the United States during years following the financial crisis of 2007-2009. This time period is characterized by quite specific and to large extent unprecedented macroeconomic conditions. The protracted period of very low interest rate environment and of unconventional monetary policy is among these conditions. The concerns about impact of very low, even negative interest rates on banks' profitability thus became prominent during this period. Therefore, the existing literature considering the impact of very low or negative interest rates on banks' profitabilty or other aspects of banks' business comes mainly from the very recent years.

Borio *et al.* (2015) studied the impact of monetary policy on bank profitability. They used annual data for 109 large international banks headquartered in 14 major advanced economies from Bankscope database. Their sample covered 18 years from 1995-2012. Hence the sample included both quite long pre-crisis period as well as the financial crisis and following years. On the other hand, this composition of the sample did not allow to consider the asymmetric effects of bank heterogeneity by size, because only large bank were included. They estimated using the system GMM method multiple models, each with certain income component, i.e. net interest income, non-interest income, loan loss provision, and the pre-tax profit, as dependent variable. Their set of independent variables included as monetary policy indicators three-month interbank rate and the difference between 10-year government bond and three-month interbank rate as a proxy for slope of the yield curve. Moreover, they included also quadratic form of these two variables to capture the assumed non-linearity discussed in Section 2.7. Other independent variables included various macroeconomic, bank specific or dummy variables to control for their impact. They found out that correlation of bank return on assets is positively correlated with both, the level of interest rate and the steepness of the yield curve. According to their findings this positive impact of higher short-term rate and steeper yield curve is driven by its positive impact on net interest margin. On the other hand, higher interest rates lead to higher loan loss provisions due to increased debt service cost of the borrowers, and they also compress the non-interest income because they have negative impact on securities' valuations. But this does not fully offset the impact of net interest income on the overall profitability.

The impact of "low-for-long" interest rates on banks' profitability, specifically on NIM, was analysed also by Claessens *et al.* (2017). Their study is also based on balance sheet and income statement annual data from Bankscope. The sample included 3385 banks from 47 countries for time period 2005-2013. In their model, they used NIM as a dependent variable and regress it on the three-month government bond yield, the spread between 10-year and three-month government bond yield, dummy variable detecting whether the country was in a "low rate environment" (defined as three-month rate below 1.25 percent), GDP growth of the country where the bank is based, and on a set of bank specific variables. Moreover, they assumed some bank fixed effects and time effects for which they included dummy variables. They ran the regression for the whole sample as well as for various subsamples, e.g. for low rate environment and high rate environment separetely, or they decomposed NIM to interest income margin and interest expense margin and used them as dependent variable instead. They found out that the impact of interest rates on NIM is higher in situation of low interest rates than of high interest rates. Also the impact is stronger on interest income margin than on interest expense margin. They on the other hand admit that there might be non-linearities in transmission from interest rate changes to NIM not captured by their methodology, specifically they mention differences between banking systems.

Bikker & Vervliet (2017) used similar approach in their paper considering the impact of low interest rates on banks' profitability and risk-taking. Their sample consisted of 3582 U.S. banks using data obtained mainly from Federal Deposit Insurance Corporation. Beside other analyses they also considered impact on NIM using similar model composed of independent variables capturing the effect of interest rate environment, other macroeconomic factors, and bank specific factors. Their results are similar to both Borio *et al.* (2015) and Claessens *et al.* (2017) since they found positive and concave impact of short-term interest rate. Moreover, they considered also size of the bank observing that larger banks tend to have somewhat lower margins which may be explained by assumption that larger banks' profitability includes larger portion of non-interest income, which is another finding of their estimation.

Altavilla *et al.* (2017) consider the impact of unconventional monetary policy and low interest rate environment on banks' profitability. They focus solely on Euro Area exploiting cross-section of European banks' accounting data with quarterly frequence from period June 2007 to January 2017. They estimate models using ROA (return on assets) as a profitability measure as well as models using individual profitability compononents, such as net interest income or non-interest income. They find rather insignificant short-run impact of monetary policy represented by the short-term rate and slope of the yield curve variables on the overall profitability (when treated for its endogeneity) using various settings of models including bank specific and country specific variables. In case of the net interest income itself they find positive impact of short-term rate, but insignificant impact of slope of the yield curve. However, they estimate both relationships only as linear.

Other similar studies aim at somewhat different aspects connected to impact of low interest rate environment on banking sector or they differ in methodology. Arseneau (2017) estimates the effect of possible introduction of negative policy rates on the profitability of U.S. banks. He uses data on various scenarios of CCAR stress testing. Hence this study is not based on observed data from real banking operation, but on expectations of central banks and the commercial banks themselves about their ability to cope with theoretical situation of negative policy rates. The sample includes only 22 bank holding companies, i.e. the largest banks which make up about 75 percent of total assets of U.S. banking sector. Their results show that some banks would in case of introduction of negative rates expect increase of NIM while others would expect compression, and some do not anticipate any effect. The number of those that would expect compression is little higher, but overall, there is quite strong heterogeneity in the observed sample.

Kerbl & Sigmund (2017) also study the impact of introduction of negative policy rate, but they use sample of data on Austrian banks from 1998-2016. They try to forecast the profitability using an ARIMA model on a bank-by-bank basis. They found link of NIM to the interest rate environment, especially in case the rates are near zero. However, they do not believe this conclusion can be easily extrapolated to the negative rate environment and hence they use the ARIMA simulation to address this issue, assuming the deposit rates being floored at zero. They conclude that negative rates are substantial risk for the profitability, especially for the smaller banks dependent on deposit financing.

Chapter 4

Influence of Low and Negative Interest Rate Environment on NIM in Bank Based and Capital Based Markets

In this chapter the impact of interest rates on banks' NIM using a unique panel dataset comprising of 629 banks from EU countries and 526 banks from United States in a time period 2011-2016 is analysed. This composition allows to test hypotheses about different response of NIM to low and even negative rates that may differ in bank based financial market and capital based financial market as well as impact of other factors including size of the bank or its business model.

4.1 Hypotheses

In this chapter, first three hypotheses of the thesis are tested. They are listed and further described in this section.

Hypothesis #1: Decrease of NIM was deeper in the EU (bank based financial market) than in the U.S. (capital market based financial market). The first hypothesis tested in this chapter is whether the decrease of NIM was deeper in EU member countries than in the United States. Except for United Kingdom, most EU countries are usually considered as bank based financial markets. It means that the banking sector plays substantial role in intermediation of loanable funds from surplus agents to deficit agents. Banks are thus the main risk carriers. On the contrary, United States and

United Kingdom are usually considered capital based financial markets. In this setting, the capital market has much more substantial role in financial intermadition and the risk is carried to large extent by investors themselves. Further description of characteristics of both types can be found e.g. in Mejstřík *et al.* (2014, p. 55 - 59). We have to be aware of the fact that in real world there do not exist countries that would perfectly fit the definition of either type. But for purpose of this thesis we stick to the assumption that capital based market is in our sample represented by United States and United Kingdom, while the rest of the EU countries will be considered as bank based.

We assume that the decrease of NIM should be bigger in EU countries, i.e. in bank based markets, than in the United States as capital based market. We can assume that in the bank based market the capital markets are rather underdeveloped. Hence the debtors in bank based can more easily enter the capital market to get favourable lending rate while seeking for funding or at least use it as a threat while negotiating with possible bank lenders to obtain lower rate. On the other hand, there are also arguments in favour of an opposite situation. Banks in bank based market may have generally higher monopolistic power over the interest they offer to their customers on both loans and deposits. Moreover, the decrease in NIM may indeed have been deeper in Europe, but for different reasons - the negative rates introduced in Eurozone and some other non-Eurozone member countries in 2015, while in the United States the rate had not go under zero during the observed period.

Hypothesis #2: NIM eroded most significantly in small banks in both the EU and the U.S. Second tested hypothesis is that NIM decreased most significantly in small banks in both EU and United States. In this thesis banks are divided into three size categories. *Large banks* are banks whose amount of total assets in 2016 was at least USD 30 billion. On the contrary, banks are considered as *small banks* when their total assets in 2016 were below USD 1 billion. The rest falls into category *medium banks*. The reason why NIM of smaller banks is likely to decrease more is that they rely more on funding from retail deposits as mentioned in Section 2.2 and hence they can not lower their interest costs so easily as the larger banks that rely on institutional deposits or interbank lending. This may become especially important in case of negative market rates that may not be easily transmitted into deposit rates as discussed in Section 2.5.

Hypothesis #3: Savings banks reported the highest NIM. Third hypothesis states that savings banks reported the highest NIM. In our dataset we follow the categorisation of banks in Orbis Bank Focus database, the main source of the data. Five types of banks are considered - *bank holdings* & *holding companies*, *commercial banks*, *cooperative banks*, *real estate* & *mortgage banks* and *savings banks*. The assumption for savings banks is that they generally tend to have a business model based on collecting longer maturity retail deposits and lending to retail clients and thus their profitability and especially net interest income is less sensitive to the changes in short-term interest rate than by other types of banks. On the other hand, these banks are rather of smaller size and hence it may apply for them the same arguments discussed in previous paragraph.

4.2 Dataset and Descriptive Analysis

Dataset used in this chapter includes 629 banks from 24 EU member countries and 526 banks from United States. Major source of the data was Orbis Bank Focus database. Data were obtained from it as two separate datasets. First was selected as active banks from EU28 countries whose specialisation was ranked either as bank holdings & holding companies, commercial banks, cooperative banks, real estate & mortgage banks, or savings banks. Second dataset as active banks from United States of same set of five specialisations belonging to "Classic US coverage" in the database. Data were then further filtered in order to achieve balanced panel for time period 2011-2016 with no missing observations for any of the bank specific variables used in the model.

Datasets were further extended by a set of country specific macroeconomic variables, i.e. GDP growth rate, inflation rate, unemployment rate, 3M interbank rate, and 10Y government bond yield. Due to the availability of GDP growth, inflation rate, and unemployment rate in Orbis Bank Focus only for time period 2013-2016 and due to unavailability of short-term and long-term interest rate variables in it at all, macroeconomic data for the whole observed time period were obtained from other sources.

For EU countries the source for all macroeconomic variables was Eurostat. Unfortunately, the 3M interbank rate for the whole observed period was available only for Euro Area, Denmark, Sweden, and United Kingdom. For other countries outside the Euro Area the last available year was 2014. For this reason the data for years 2015 and 2016 for the Czech Republic were obtained from the Czech National Bank, for Hungary and Poland from OECD. Banks from Bulgaria, Croatia and Romania were due to unavailability of reliable source of data for short-term rate in 2015 and 2016 removed from the sample (together 35 banks). For long-term rate EMU convergence criterion bond yields were used as a proxy. This yield is not available for Estonia because Estonian government has issued no such instrument. Therefore, the only one bank located in Estonia was also removed from the dataset.

Macroeconomic data for United States were obtained from FRED database of Federal Reserve Bank of St. Louis, Missourri. Except for the GDP growth rate, inflation rate, and unemployment rate, the proxies for short-term and for long-term interest rate were obtained. They are 3M LIBOR for USD denominated transactions and 10Y Treasury Constant Maturity Rate respectively.

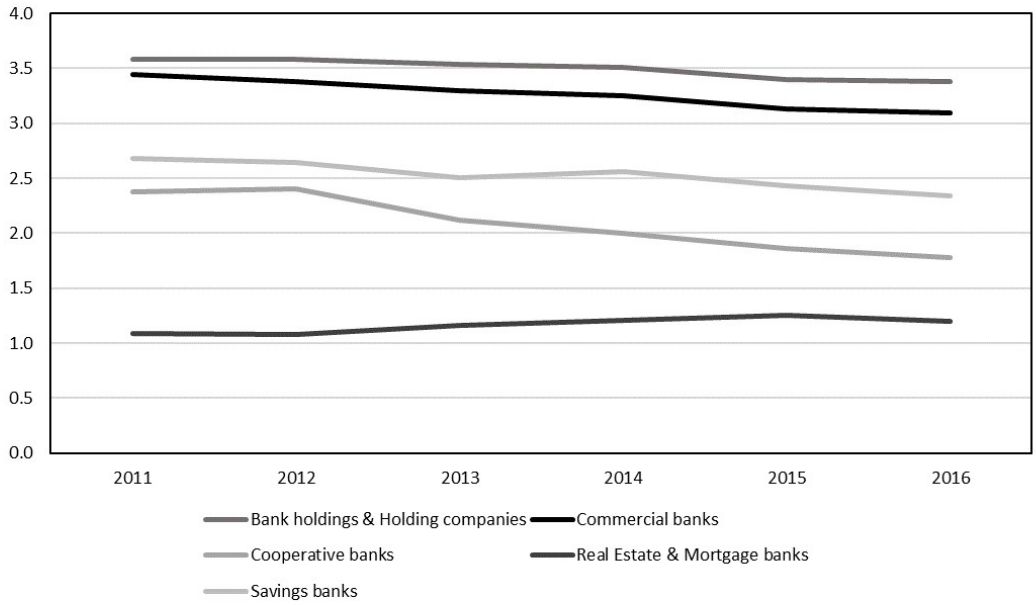
This two datasets were put together and made up a final balanced panel of 1155 cross-sectional units in 6 time periods. Other variables, i.e. various dummies, or logarithms and squares of certain variables were computed within this panel. Description of bank specific variables is provided in Table 4.1, description of bank specific dummy variables in Table 4.2, description of country specific variables in Table 4.3, and description of country specific dummy variables in Table 4.4.

Selection of variables is based on previous literature on the topics of banks' profitability and the impact of interest rate on it including Arseneau (2017), Borio *et al.* (2015), Borio *et al.* (2017), Claessens *et al.* (2017), and Fišerová *et al.* (2015). Summary statistics of all variables can be found in Table A.1. According to definitions in Table 4.2 there are 192 large banks, 732 medium banks, and 231 small banks in the sample. Split by specialisation there are 195 bank holdings & holding companies, 570 commercial banks, 272 cooperative banks, 45 real estate & mortgage banks, and 73 savings banks.

Figure 4.1 shows the development of average NIM by different bank specialisation. We can see that the highest average NIM through whole observed period reported bank holdings & holding companies, closely followed by commercial banks. In both cases, the NIM was slightly decreasing, in case of commercial banks the decrease was more significant, when during the observed period the average NIM fell from about 3.5 % to about 3 %. The lowest average NIM, just slightly above 1 % was observed by real estate & mortgage banks, but on the other hand this was the only type of banks which saw slight increase of NIM during the observed period. On the contrary, the sharpest decrease can be seen by cooperative banks. Finally, the figure contradicts the Hypothesis #3, that savings banks reported the highest NIM, as they appear to be the third.

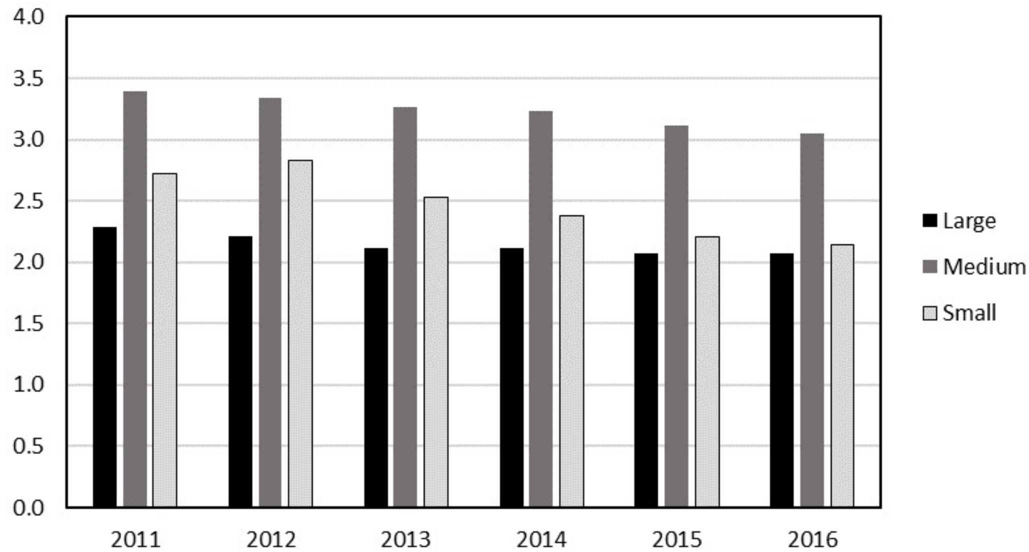
Figure 4.2 reveals that the highest average NIM was reported by banks

Figure 4.1: Average NIM by bank specialisation (%)



Source: Author based on Orbis Bank Focus, Eurostat and FRED.

Figure 4.2: Average NIM by bank size (%)



Source: Author based on Orbis Bank Focus, Eurostat and FRED.

Table 4.1: Bank Specific Variables

Natural logarithm of total assets of the bank	This variable serves commonly as an approximation of the size of the bank. Transformation by natural logarithm is used in order to smooth out large differences in size of individual banks.	*lta*
Net loans to total assets ratio	Indicates what portion of total assets is made up of loans. Hence it can be considered a credit risk ratio. Expected sign of the coefficient is ambiguous because higher ratios may lead to lack of liquidity while low ratios to decrease in net interest income.	*nl_ta*
Net loans to deposits and short term funding ratio	Reflects structure of the balance sheet and especially the liquidity of the bank.	*nl_dstf*
Loan loss reserves to gross loans ratio	Measures the quality of bank's assets by evaluating the part of loans put aside for potential charge-off.	*llr_gl*
Cost to income ratio	Indicator of bank's operational efficiency. Generally, the impact on profitability is supposed to be negative. It should hold for NIM as well since NIM is directly linked to the denominator of cost to income ratio.	*cir*
Liquid assets to deposits and short term funding ratio	Liquidity measure capturing the liquid part of asset side of the bank's balance sheet.	*la_dstf*
Equity to total assets ratio	Leverage ratio measuring the indebtedness of the bank and its ability to absorb potential losses. The expected sign of the coefficient is unclear since low ratio may indicate insufficient capital, while high ratio can be result of foregone investment opportunities.	*eq_ta*

Note: Source of all variables is Orbis Bank Focus database.

whose size is considered medium. Large banks reported the lowest average NIM. This is quite consistent with the theoretical assumption, that large banks rely less on retail deposits which are relatively cheaper source of funding in normal times, but rather on large institutional deposits that allows the bank to better steer the spread. We can also assume that they may often have larger portion of their income from other sources, e.g. net fee and commission income or off-balance sheet activities. The assumption about relative importance of retail

Table 4.2: Bank Specific Dummy Variables

Bank holdings & holding companies	Equals 1 for specialisation Bank holdings & holding companies.	*bhhc*
Cooperative banks	Equals 1 for specialisation Cooperative banks.	*coop*
Real estate & mortgage banks	Equals 1 for specialisation Real estate & mortgage banks.	*rem*
Savings banks	Equals 1 for specialisation Savings banks.	*saving*
Large banks	Equals 1 for banks whose total assets in 2016 were at least USD 30 billion.	*large*
Small banks	Equals 1 for banks whose total assets in 2016 were below USD 1 billion.	*small*

Note: Variables calculated by author based on Orbis Bank Focus data.

Table 4.3: Country Specific Variables

Real annual GDP growth rate	Annual growth rate of real GDP obtained either from Eurostat (EU countries) or FRED database (United States). The coefficient is likely to be positive.	*gdp*
Inflation rate	Annual inflation rate obtained either from Eurostat (EU countries) or FRED database (United States). The expected impact on NIM is negative.	$infl$
Unemployment rate	Annual unemployment rate obtained either from Eurostat (EU countries) or FRED database (United States). Higher unemployment should have negative impact on NIM.	*unem*
Short-term interest rate	For EU countries 3M interbank rate obtained from Eurostat, except for Czech Republic, Hungary and Poland in years 2015 and 2016 as described in the text. For United States 3M LIBOR in USD from FRED.	st_ir
Square of the short-term interest rate	Due to assumed non-linearity in impact of short-term rate its square is used.	st_ir^2
Slope of the yield curve	Approximated by spread between 3M interbank rate and 10Y government bond yield.	*spread*
Square of the slope of the yield curve	Similarly to short-term rate the square of the yield curve slope is included to capture assumed non-linearity.	$spread^2$

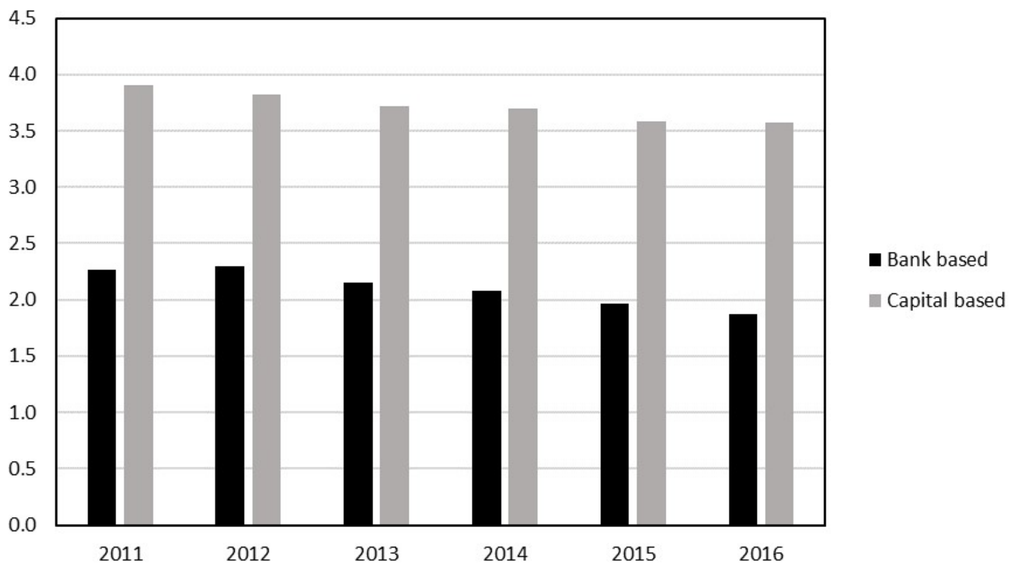
Note: Source of 3M interbank rate data in 2015 and 2016 for Czech Republic is CNB, for Hungary and Poland OECD.

Table 4.4: Country Specific Dummy Variables

Negative short-term interest rate	Equals 1 for country which had negative short-term interest rate in given year.	*negrate*
Capital based financial market	Equals 1 for country considered as capital based financial market, i.e. for the United Kingdom and the United States. (Rest of the countries considered bank based financial markets.)	*capbas*

deposit funding depending on size is further supported by the development of NIM by small banks which at the beginning was higher than in case of large banks, but throughout the period it fell to almost the same level. This decrease may have been caused by the factors that low or even negative short-term market rates could not have been fully transmitted into the deposit rates as discussed in Section 2.4.

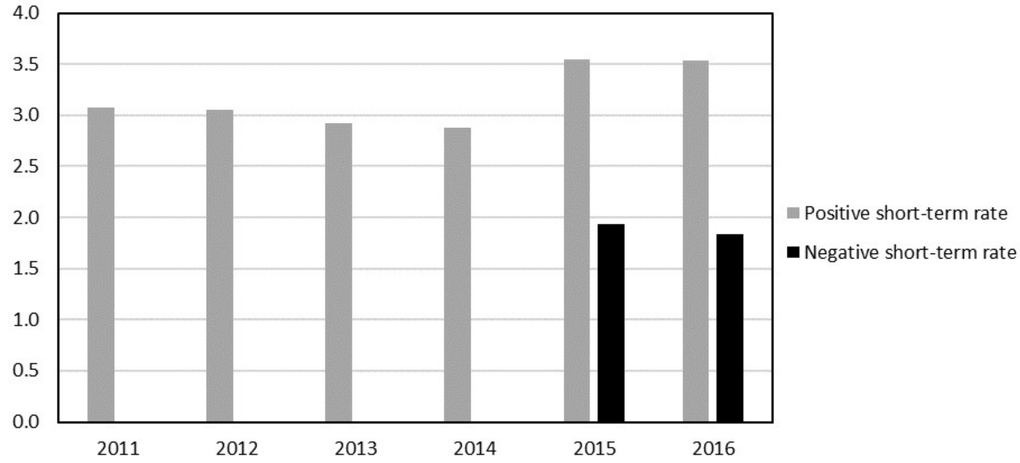
Figure 4.3: Average NIM on bank based/capital based markets (%)



Source: Author based on Orbis Bank Focus, Eurostat and FRED.

The difference in average NIM between bank based and capital based financial markets is depicted in Figure 4.3. We can see clearly that during the whole observed period there is substantial and relatively stable gap when the NIM of banks operating in capital based market is more than 50 % higher than of those operating on bank based. Furthermore, we see slight widening of the gap, but on the other hand this may be atributed to other factors, such as the negative short-term rate in most of the European countries.

Figure 4.4: Average NIM in situation of negative short-term interbank rate (%)



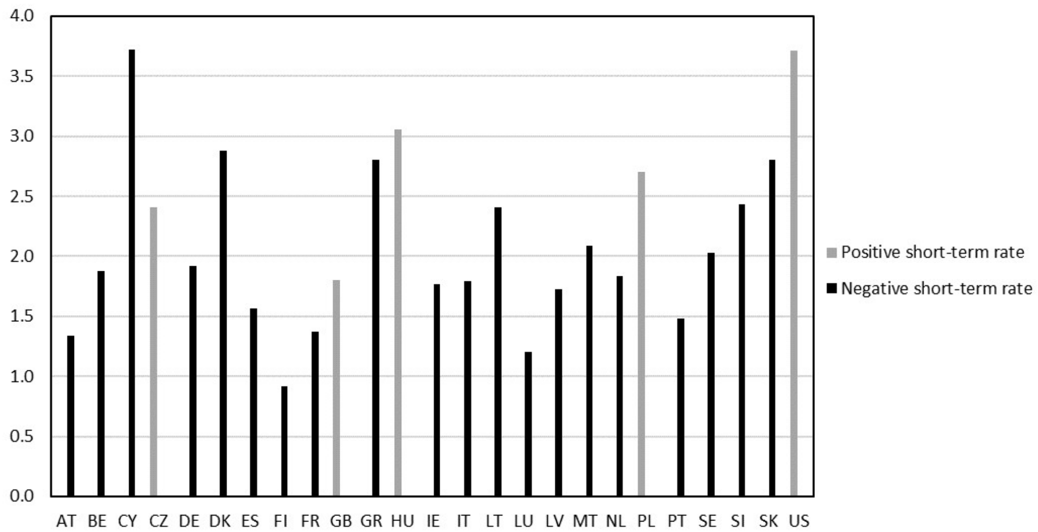
Source: Author based on Orbis Bank Focus, Eurostat and FRED.

The presence of negative short-term rates is visible in Figure 4.4 where the average NIM is divided for banks operating in country with or without negative short-term rate. Due to the fact, that negative rates first appeared in Euro Area and some other European countries in 2015 the picture shows average NIM for all banks in 2011-2014 while in 2015 and 2016 it separates them based on the simple rule of existence of the negative rate in a given country. In this aggregate view we can see clearly substantial difference of NIM which is about a half magnitude in countries with negative rate. On the other hand, looking at Figure 4.5 we can see that there are large differences between individual countries. Therefore, to make a qualified conclusion about the causality of negative rates' impact on NIM we need to perform a proper econometric analysis.

4.3 Methodology

While estimating a model using a panel dataset as in case of this thesis one can usually consider exploiting the most common panel data methods including pooled OLS, fixed effects (within estimator or least squares dummy variables estimator) or random effects (feasible generalized least squares). Advantage of

Figure 4.5: Average NIM in 2016 by countries (%)



Note: AT - Austria, BE - Belgium, CY - Cyprus, CZ - Czech Republic, DE - Germany, DK - Denmark, ES - Spain, FI - Finland, FR - France, GB - United Kingdom, GR - Greece, HU - Hungary, IE - Ireland, IT - Italy, LT - Lithuania, LU - Luxembourg, LV - Latvia, MT - Malta, NL - Netherlands, PL - Poland, PT - Portugal, SE - Sweden, SI - Slovenia, SK - Slovakia, US - United States of America
Source: Author based on Orbis Bank Focus, Eurostat and FRED.

all these methods is that they are relatively easily computable and understandable. On the other hand, they require quite strong assumptions that may be in some cases hard to fulfill. This is especially true for pooled OLS that requires explanatory variables to be uncorrelated with the error term which is certainly not true in case of presence of group specific fixed effects. In case of presence of group specific random effects, the model might be estimated by pooled OLS, but the estimates are inefficient and one should take the feasible GLS approach instead. The disadvantage of fixed effects model is then that all time invariant variables (e.g. group specific dummy variables) are cancelled out. More on the assumptions and (dis)advantages of each method can be found e.g. in Greene (2012).

Another disadvantage of the previously mentioned methods is that they offer a static view. Under certain assumptions they allow to estimate at least consistently model of the following form:

$$y_{it} = \alpha + \boldsymbol{x'_{it}}\boldsymbol{\beta} + c_i + \epsilon_{it} \tag{4.1}$$

where $i = 1, \dots, N$ (cross-sectional units) and $t = 1, \dots, T$ (time periods), c_i is the unobservable group specific fixed or random effect and $\epsilon_{it} \sim i.i.d.\, N(0, \sigma_\epsilon^2)$. However, if we need to estimate a dynamic panel data model of the form:

$$y_{it} = \alpha + \delta y_{i,t-1} + \boldsymbol{x'_{it}}\boldsymbol{\beta} + c_i + \epsilon_{it} \tag{4.2}$$

where $y_{i,t-1}$ is one period lagged dependent variable, we cannot use any of those methods because they would produce biased and inconsistent estimates due to the fact that $y_{i,t-1}$ is endogenous to the fixed effects component of the error term, i.e. $Cov(y_{i,t-1}, c_i) \neq 0$.

To overcome this problem two approaches using instrumental variables within generalized method of moments (GMM) framework were suggested. First is the difference GMM developed in Arellano & Bond (1991). Under this approach the model is estimated in first differences using the lags of dependent variable as instruments. However, using this approach we would still not be able to use the set of group specific dummy variables since they would be eliminated by differencing.

Fortunately, there is available another approach to apply for dynamic panel data model estimation - system GMM proposed by Arellano & Bover (1995) and Blundell & Bond (1998). This method is similar to difference GMM in using variables from inside the model as instruments, but in a somewhat different way. The model is estimated jointly in levels and differences and the instruments are lagged both differences and levels of dependent variable respectively. Hence it has another advantage that it allows to estimate model including set of dummy variables. System GMM method is used for example also in Borio *et al.* (2015) or Fišerová *et al.* (2015).

For these reasons system GMM is used as the main estimation methodology in this thesis. The estimated model will be:

$$\begin{aligned} nim_{it} = \alpha + \delta nim_{i,t-1} + \theta_1 st\_ir_{it} + \theta_2 st\_ir_{it}^2 + \theta_3 spread_{it} + \\ + \theta_4 spread_{it}^2 + \boldsymbol{x'_{it}}\boldsymbol{\beta} + \boldsymbol{d'_{it}}\gamma + \boldsymbol{z'_{it}}\boldsymbol{\phi} + \boldsymbol{D'_{it}}\boldsymbol{\zeta} + (c_i + \epsilon_{it}) \end{aligned} \tag{4.3}$$

where $\boldsymbol{x'_{it}}$ is a vector of bank specific variables listed in Table 4.1, $\boldsymbol{d'_{it}}$ is a vector of bank specific dummy variables listed in Table 4.2, $\boldsymbol{z'_{it}}$ is a vector of country specific variables listed in Table 4.3 except for short-term interest rate, slope of the yield curve and their squares which are pointed out as variables of main interest. Finally, $\boldsymbol{D'_{it}}$ is a vector of country specific dummy variables listed in Table 4.4. The error term consists of a fixed effects component c_i and an exogenous component ϵ_{it}. The other discussed methods such as fixed effects or pooled OLS will be performed as a robustness check and their results will be stated in appendix. The estimation will be performed in Stata. For system GMM the *xtabond2* command developed in Roodman (2009) will be used.

4.4 Results and Findings

This section presents the estimation results of the basic model using various estimation methods. Due to the nature of each of the method there are slight changes in the model setting. At first we impose an assumption of no dynamic effects and estimate the model using pooled OLS, fixed effects, and random effects methods without the lagged dependent variable. The estimation results are presented in Table A.3.

The estimation is performed using both normal, and heteroskedasticity and autocorrelation robust standard errors. We can see some common patterns in results of all three methods. First of all, we estimated a negative coefficient of short-term interest rate. (Although insignificant using the robust errors.) It seems quite counterintuitive to what we have expected because it would actually mean that the lower the short-term rate the higher the NIM. This suggests that these estimation approaches are not appropriate.

Looking at other coefficients we see ambiguous results for square of the short-term rate and slope of the yield curve and its square. They are generally insignificant and their signs differ with various methods. From this we would have to conclude that there is no clear impact of these factors. Considering the impact of macroeconomic variables, we can say that GDP growth probably does not have any significant impact, inflation has significant positive impact, and so does the unemployment rate. This seems also quite contradictory to what one could expect.

From bank specific variables probably the most interesting result is the coefficient for cost to income ratio which is significant negative for all methods. This result is consistent with our expectations as it reflects the link of NIM and cost to income ratio denominator. On the other hand, net loans to deposits and short-term funding ratio and liquid assets to deposits and short-term funding ratio seem to have minimum explanatory power as they appear insignificant in all or almost all methods respectively.

Coefficients on bank specific dummy variables are quite consistent with the patterns in Figure 4.1 and Figure 4.2. The difference between commercial banks (as a base group) and bank holdings & holding companies is quite small and hence the coefficient on *bhhc* dummy is insignificant. On the contrary, the other three types have significant negative coefficients indicating the generally lower level of NIM of these bank specialisations. The coefficient on size dummies are mostly insignificant. However, it may be caused by the fact that for example *small* dummy is significantly correlated with *coop* (as can be seen in Table A.2) and hence the impact of size may be captured to large extent by the specialisation dummies.

Regarding the country specific dummy variables we get quite expected results. Variable *negrate* indicating the existence of negative rate in a given country and year has significant and negative coefficient in all three methods. This result supports the hypothesis that existence of negative short-term rate on interbank market compresses the NIM. Moreover, it can also partly explain the lower significance of *st_ir* as it is somewhat negatively correlated with it. The coefficient at *capbas*, the dummy variable indicating the capital based market, is estimated only in RE and pooled OLS due to the collinearity. But still it gives us also quite expected results that the coefficient is significant and positive. It can be interpreted that the NIM in capital based markets is higher than in the bank based during the observed period as we have expected in the Hypothesis #1.

Now, let us relax the assumption of no dynamic effects. As discussed in Section 5.3, pooled OLS as well as fixed effects will produce biased and inconsistent results due to the endogeneity of lagged dependent variable. However, it is still useful to perform these two methods since they may serve as a good robustness check for system GMM estimation. As Roodman (2009) points out, the coefficient at lagged dependent variable estimated by pooled OLS suffers from an upward bias, whereas the coefficient at lag estimated by fixed effects is biased downwards. Therefore, the true coefficient should lie somewhere in between these two estimates, i.e. considering the model in Equation 4.2 it should hold $\hat{\delta}_{FE} \leq \hat{\delta}_{S-GMM} \leq \hat{\delta}_{OLS}$.

The system GMM estimation of the model presented in Equation 4.3 is performed using Stata command *xtabond2*. This command offers various estimation options, for our purpose we perform the estimation with four different

Table 4.5: System GMM estimation results

	One-step	Two-step	One-step (Robust option)	Two-step (Robust option)
	nim	nim	nim	nim
L.nim	0.837^{***}	0.846^{***}	0.837^{***}	0.846^{***}
	(0.0121)	(0.0160)	(0.0318)	(0.0286)
st_ir	0.0992^{***}	0.108^{***}	0.0992^{***}	0.108^{***}
	(0.0329)	(0.0293)	(0.0363)	(0.0325)
st_ir_sq	-0.0248^{***}	-0.0223^{***}	-0.0248^{***}	-0.0223^{***}
	(0.00568)	(0.00571)	(0.00708)	(0.00633)
spread	-0.0274^{**}	-0.00847	-0.0274	-0.00847
	(0.0130)	(0.0123)	(0.0169)	(0.0131)
spread_sq	-0.0000421	-0.000895	-0.0000421	-0.000895
	(0.000803)	(0.000731)	(0.000859)	(0.000822)
gdp	0.0143^{**}	0.0145^{***}	0.0143^{**}	0.0145^{***}
	(0.00622)	(0.00536)	(0.00712)	(0.00518)
infl	0.0802^{***}	0.0591^{***}	0.0802^{***}	0.0591^{***}
	(0.00919)	(0.0100)	(0.0172)	(0.0112)
unem	-0.00599^{*}	-0.00322	-0.00599	-0.00322
	(0.00317)	(0.00330)	(0.00373)	(0.00337)
lta	-0.0133^{*}	-0.0108	-0.0133	-0.0108
	(0.00688)	(0.00736)	(0.0123)	(0.00926)
llr_gl	0.0201^{***}	0.0128^{***}	0.0201^{***}	0.0128^{***}
	(0.00241)	(0.00378)	(0.00544)	(0.00403)
eq_ta	0.0251^{***}	0.0128^{**}	0.0251^{***}	0.0128^{**}
	(0.00220)	(0.00511)	(0.00771)	(0.00551)
cir	-0.00159^{***}	-0.00114^{**}	-0.00159^{***}	-0.00114^{**}
	(0.000371)	(0.000449)	(0.000614)	(0.000461)
nl_ta	0.00604^{***}	0.00535^{***}	0.00604^{***}	0.00535^{***}
	(0.000719)	(0.000835)	(0.00116)	(0.000920)
nl_dstf	0.000183	-0.0000578	0.000183	-0.0000578
	(0.000303)	(0.000305)	(0.000374)	(0.000301)
la_dstf	-0.000419	-0.000244	-0.000419	-0.000244
	(0.000419)	(0.000502)	(0.000553)	(0.000507)
bhhc	0.0351^{**}	0.0285	0.0351	0.0285
	(0.0177)	(0.0225)	(0.0424)	(0.0225)
coop	-0.151^{***}	-0.106^{***}	-0.151^{***}	-0.106^{***}
	(0.0242)	(0.0244)	(0.0336)	(0.0282)
rem	-0.213^{***}	-0.177^{***}	-0.213^{***}	-0.177^{***}
	(0.0416)	(0.0481)	(0.0619)	(0.0565)
savings	-0.100^{***}	-0.0608^{***}	-0.100^{***}	-0.0608^{***}
	(0.0271)	(0.0227)	(0.0263)	(0.0235)
large	0.0379	0.0261	0.0379	0.0261
	(0.0291)	(0.0353)	(0.0460)	(0.0380)
small	0.0134	0.0194	0.0134	0.0194
	(0.0271)	(0.0322)	(0.0419)	(0.0315)
negrate	-0.0203	-0.00686	-0.0203	-0.00686
	(0.0311)	(0.0203)	(0.0235)	(0.0227)
capbas	0.0673^{***}	0.0902^{***}	0.0673	0.0902^{**}
	(0.0252)	(0.0312)	(0.0755)	(0.0379)
Constant	-0.0181	0.0216	-0.0181	0.0216
	(0.131)	(0.130)	(0.224)	(0.170)
Number of observations	5775	5775	5775	5775
Number of groups	1155	1155	1155	1155
Number of instruments	32	32	32	32
Wald statistic	42280.4^{***}	33240.9^{***}	25992.5^{***}	26351.0^{***}
Arellano-Bond AR(1)	-28.39^{***}	-1.84^{*}	-1.77^{*}	-1.83^{*}
Arellano-Bond AR(2)	3.34^{***}	0.54	0.53	0.54
Sargan/Hansen test	85.76^{***}	13.26	13.26	13.26

Notes: Standard errors in parentheses. Sargan test used for one-step model without robust option, Hansen test for other models.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

settings: one-step GMM estimation, two-step GMM estimation, one-step GMM with robust option, and two-step GMM with robust option. More detailed description of the options is given in Roodman (2009). Robust option in case of one-step GMM requests the usage of heteroskedasticity and autocorrelation robust errors. In case of two-step GMM, the errors should be theoretically robust by definition and hence the option requests the Windmeijer correction for small samples. Although the two-step GMM with robust option is theoretically the superior option, we report results using all four options.

The system GMM estimations, whose results are reported in Table 4.5, are performed using second and further lags of dependent variable as instruments for equation in differences, and second and further lags of first differences of dependent variable as instruments for equation in levels due to assumed endogeneity of lagged dependent variable. At this setting we assume the rest of explanatory variables to be exogenous. However, we will have to confirm this assumption by performing either Sargan or Hansen test for overidentifying restrictions.

We can see that now all four estimations lead to significant and positive coefficient of st_ir and to significant and negative coefficient of st_ir^2. That is quite consistent with our expectations as well as with findings of Borio *et al.* (2015) that the impact of short-term rate on NIM (or net interest income) should be positive, but concave, i.e. that NIM is more interest rate sensitive in case the market rate is on a very low level. On the other hand, the slope of the yield curve is still insignificant as well as its square. The reason why this is the case are not clear, there exist multiple possible explanations. One of them is, that the observed period includes the sovereign debt crisis in Greece during which the yields on 10-year government bonds, used as proxy for the long-term rates, reached levels over 20 %. Due to this fact we have several outlying observations in the sample for the slope of the yield curve.

The impact of GDP growth is as expected significant and positive, whereas the coefficient on inflation is still contrary to the expectations significant and positive. It is worth noting that the inflation generally has been very low during the whole observed period which may have caused also quite little standard errors of the coefficients. The estimated coefficient suggests that the increase of one percentage point in inflation should cause about six basis points increase in NIM. The coefficient at unemployment rate is as expected negative, but insignificant. This may either be consequence of relatively short sample that does not allow to consider the impact of the whole business cycle, or of a

Table 4.6: Lagged dependent variable coefficients in FE, S-GMM, and Pooled OLS - robustness check

	FE	S-GMM	Pooled OLS
	nim	nim	nim
L.nim	0.238***	0.846***	0.941***
	(0.0708)	(0.0286)	(0.0270)

Notes: Robust standard errors in parentheses. All estimated coefficients are reported in Table A.4.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

relatively high negative correlation with GDP growth. (It is in fact a relation known in macroeconomics as Okun's law.)

Coefficients at bank specific variables show some patterns observed already in static panel methods. We can again see significant negative coefficient at cost to income ratio. Another common pattern is that the variables net loans to deposits and short-term funding ratio and liquid assets to deposits and short-term funding ratio are both insignificant. Coefficient at loan loss reserves to gross loans ratio is significant positive. This may be interpreted in a way that banks with higher level of credit risk tend to have higher NIM. Equity to total assets has also significant and positive coefficient. The same is true for net loans to total assets ratio. It might suggest that banks that were able to use larger portion of their funds to provide loans attain higher NIM because otherwise they would have to invest in other instruments such as government bonds that have lower yields than can be earned on the provided loans.

The coefficient on logarithm of total assets as well as coefficients on *large* and *small* dummy variables are all insignificant suggesting that there is no clear impact of the bank size. The specialisation dummy variables show very similar results as in case of the static methods when the *bhhc* is still insignificant while the other three are significant and negative.

The impact of negative short-term interest rate is still estimated as negative, but unlike in case of estimation by static methods it is insignificant. This may again be a consequence of relatively strong negative correlation between *negrate* and *st_ir*. The coefficient of *capbas* is significant except for one-step robust option, supporting the finding from static methods that the NIM in capital based markets is generally higher than in bank based markets.

In the bottom of the Table 4.5 estimation diagnostic results are reported.

The Wald statistics of all four options show overall significance of the model. In order to check that we have correctly specified the number of dependent variable lags, Arellano-Bond AR(1) and AR(2) tests are performed. Except for one-step GMM without robust option we see significance of first lag (but only at 10% significance level) and insignificance of the second lag. It suggests that the model with only the first lag is correct specification. Finally, the tests for overidentifying restrictions are performed. Due to the fact, that Stata reports only Sargan test for one-step GMM without robust option, this test is reported in this case. Unfortunately, this test is not robust contrary to the Hansen test which is reported for all other three options. Hansen test may be weakened by too many instruments, i.e. it would not be correct in case the number of instruments exceeds the number of groups in the panel (cross-sectional units). But this is not the case since we have only 32 instruments and 1155 groups. We do not reject the null hypothesis of the Hansen test that the instruments are exogenous.

Finally, we perform the robustness check by estimating the model using fixed effects and pooled OLS and compare the estimated coefficients at lagged dependent variable from these estimations with the coefficient from two-step system GMM estimation (with robust option). The coefficient are reported in Table 4.6. We can see that the condition $\hat{\delta}_{FE} \leq \hat{\delta}_{S-GMM} \leq \hat{\delta}_{OLS}$ is fulfilled. (All estimated coefficients are reported in Table A.4.) To sum up, we can conclude that the system GMM in this setting performs well in estimation of Equation 4.3.

But still there are some issues we have identified in the previous analysis that need to be adressed. For this purpose several modifications of the basic model will be estimated with some variables dropped. First issue to address is the insignificant impact of the slope of the yield curve. Following the previous literature, mainly Borio *et al.* (2015) it is rather unlikely that it would have no impact. Therefore, we test for the possibility that the relationship is not quadratic but just linear unlike in case of the short-term interest rate.

Second issue to address is the insignificance of *negrate* dummy variable. Due to the correlation with *st_ir* it is reasonable to have just one of these in the model. Third issue is the size effect. Due to the correlation with some of the bank types' dummy variables as well as with *lta*, it will be reestimated ommitting these five variables. Finally, the fourth issue is the insignificance of *nl_dstf* and *la_dstf* ratios which may be caused by quite strong correlation of these two variables with *nl_ta* ratio.

Table 4.7: Estimation results for modified models (two-step system GMM with robust option)

	(1) nim	(2) nim	(3) nim	(4) nim
L.nim	0.846***	0.836***	0.850***	0.844***
	(0.0283)	(0.0290)	(0.0269)	(0.0278)
st_ir	0.0984***	-	0.107***	0.101***
	(0.0292)		(0.0293)	(0.0290)
st_ir_sq	-0.0218***	-0.00852**	-0.0222***	-0.0219***
	(0.00620)	(0.00379)	(0.00624)	(0.00607)
spread	-0.0204***	-0.0255***	-0.0178**	-0.0184**
	(0.00729)	(0.00723)	(0.00736)	(0.00724)
gdp	0.0144***	0.0133***	0.0159***	0.0157***
	(0.00529)	(0.00493)	(0.00543)	(0.00513)
infl	0.0607***	0.0708***	0.0599***	0.0611***
	(0.0105)	(0.00946)	(0.0106)	(0.0102)
unem	-0.00255	-0.00306	-0.00198	-0.00472
	(0.00339)	(0.00346)	(0.00338)	(0.00359)
lta	-0.0103	-0.0129	-	-0.0126
	(0.00932)	(0.00943)		(0.00957)
llr_gl	0.0130***	0.0129***	0.0133***	0.0123***
	(0.00388)	(0.00406)	(0.00374)	(0.00374)
eq_ta	0.0130**	0.0126**	0.0138**	0.0125**
	(0.00536)	(0.00552)	(0.00538)	(0.00527)
cir	-0.00116**	-0.00123***	-0.00106**	-0.00123***
	(0.000459)	(0.000470)	(0.000434)	(0.000449)
nl_ta	0.00530***	0.00564***	0.00547***	-
	(0.000915)	(0.000945)	(0.000932)	
nl_dstf	0.00000289	-0.0000546	-0.000363	0.00141***
	(0.000296)	(0.000311)	(0.000277)	(0.000351)
la_dstf	-0.000292	-0.000317	-0.0000623	-0.00217***
	(0.000502)	(0.000511)	(0.000484)	(0.000564)
bhhc	0.0284	0.0246	-	0.0156
	(0.0225)	(0.0230)		(0.0228)
coop	-0.103***	-0.117***	-	-0.130***
	(0.0287)	(0.0291)		(0.0310)
rem	-0.183***	-0.206***	-	-0.203***
	(0.0553)	(0.0570)		(0.0593)
savings	-0.0613***	-0.0699***	-	-0.0456*
	(0.0234)	(0.0239)		(0.0234)
large	0.0228	0.0308	-0.00200	0.0123
	(0.0385)	(0.0388)	(0.0217)	(0.0385)
small	0.0223	0.0252	0.00978	0.0114
	(0.0317)	(0.0325)	(0.0246)	(0.0323)
negrate	-0.0182	-0.0560***	-0.0148	-0.0160
	(0.0191)	(0.0149)	(0.0188)	(0.0189)
capbas	0.0910**	0.0947**	0.139***	0.0939**
	(0.0377)	(0.0387)	(0.0420)	(0.0384)
Constant	0.0277	0.132	-0.202***	0.342*
	(0.167)	(0.170)	(0.0692)	(0.193)
Number of observations	5775	5775	5775	5775
Number of groups	1155	1155	1155	1155
Number of instruments	31	30	26	30
Wald statistic	26136.3***	24351.2***	25032.1***	23504.8***
Arellano-Bond AR(1)	-1.83*	-1.83*	-1.83*	-1.83*
Arellano-Bond AR(2)	0.53	0.53	0.53	0.53
Hansen test	12.77	13.00	13.28	12.05

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

Table 4.7 shows the estimation results for the modified models. All models are estimated using the two-step GMM with robust option (Windmeijer correction). In model (1) only the $spread^2$ is dropped. As we can see, it leads to a significant coefficient of *spread*. On the other hand, the coefficient remains negative which is in contradiction to expected positive impact of steeper yield curve on NIM. But this result may not be wrong following the results derived in Borio *et al.* (2015) who admits that *"Changes in the slope of the yield curve will also have quantity effects, notably influencing the volume of banks' fixed-rate mortgages. Similarly ... to the extent that, on balance, the demand for mortgages is more responsive (elastic) to changes in the slope than that for medium-term deposits, at some point a higher level of the slope would erode profitability."* (Borio *et al.* 2015, p. 8). Due to this result and due to the fact that by comparison of various specifications of the model we found that dropping of the $spread^2$ leads also to a better performance in terms of Hansen test, the other modifications are estimated using only the linear term of *spread*.

Model (2) is estimated without the short-term interest rate linear term. We can see that in this case *negrate* dummy becomes significant negative, i.e. it confirms the assumed impact of negative interest rate environment which was not visible in the original setting only due to the relatively strong correlation between these two variables. Moreover, the significance is not influenced by leaving the square of the short-term rate in the model. In model (3) we tried to address the issue of insignificance of size dummy variables by omitting *lta*, *bhhc*, *coop*, *rem*, and *savings*. However, we can see that even in this case the size dummies are still insignificant.

Model (4) is then estimated without net loans to total assets ratio. It leads to significance of the previously insignificant variables nl_dstf and la_dstf. It leads to a lowest Hansen test statistic among all four modified models. On the other hand, it leads to highest decrease of Wald statistic in comparison to the original model, but it is still significant at 1% level. Moreover, the omission of nl_ta leads to deterioration of significance of savings bank dummy. (It remains significant only at 10% significance level.)

Considering, all these results we conclude that the best model setting is the model (1). Although there are multiple insignificant variables, they still have their theoretical justification and they also help to some extent to keep the joint significance of the model on a high level. The only change that has brought some considerable change in overall results is the omission of quadratic term of the slope of the yield curve. The only question remains, why the estimated relationship is negative.

As mentioned above, the sample includes banks operating in Greece during the years of sovereign debt crisis. Therefore, the highest observed slopes of the yield curve are actually caused by this factor. On the other hand, the average NIM of included Greek banks during the most problematic two years - 2011 and 2012, is only slightly below average of the whole sample (2.73 in comparison to 2.9). Hence there may be other factors that would have to be more closely analysed, but this analysis would be beyond the scope of this thesis.

4.5 Summary of Results

In this section the estimation results are confronted with our three hypotheses whether they can be rejected or not and the results are also compared with results of previous studies.

Hypothesis #1 - not rejected: The results show that the NIM is generally lower in bank based financial markets than in capital based markets. This is further supported by the Figure 4.3 which shows that the decrease was slightly faster in bank based markets. (The decrease between 2011 and 2016 was about 6 basis points higher, between 2012 and 2016 about 16 basis points higher.)

Hypothesis #2 - not rejected: We have seen in Figure 4.2 the fastest decrease of NIM for small banks. However, the econometric models in various settings did not show a significant result for *small* dummy variable. Therefore, the general conclusion is that we fail to reject this hypothesis, but the result is not very robust.

Hypothesis #3 - rejected: We assumed that the savings banks reported highest NIM. But both Figure 4.1 and the econometric models show that bank holdings & holding companies and commercial bank have generally reported higher NIM during the observed period.

In Table 4.8 the estimation results are compared to results of other authors. The authors were using datasets of various size, geographic location, and type of banks included. The methodologies of each paper differ to certain extent. Therefore, we have chosen only some of the most common variables to compare. Additionally, we show whether the author considered the impact of bank specialisation, and size, and also whether the model included some kind of proxy for existence of low or even negative interest rate environment and proxy for differantiating between capital based and bank based financial market. As we

Table 4.8: Comparison of Estimated Signs and Significance Levels for the Coefficients of NIM Determinants in Previous Studies

Authors	Data	Methodology	nim_{t-1}	st_ir	st_ir^2	$spread$	$spread^2$	gdp	$infl$	eq_ta	specialisation	size[1]	low/negative rate	capital based/bank based
Borio *et al.* (2015) - BIS working paper	Bankscope (109 large banks, 14 advanced economies, 1995-2012)	System GMM	+	+	−	+	−	0	no	+	no	no	no	no
Claessens *et al.* (2017)	Bankscope (3385 banks, 47 countries, 2005-2013)	Fixed effects	+	+	no	0	no	0/−	no	+	no	no	yes[2]	no
Bikker & Vervliet (2017)	Federal Deposit Insurance Corporation (3582 U.S. banks)	System GMM & static methods	+	+	−	+[3]	no	+	−	−[4]	no	yes	no	no
Altavilla *et al.* (2017) - ECB working paper	ECB datasets (288 banks, Q1 2000 - Q4 2016)	OLS	+	+	no	0	no	+	0	0[5]	no	no	no	no
Arseneau (2017)	22 bank holdings (U.S. stress testing scenarios)	GLS	no	no	no	no	no	no	no	no	no	yes	yes[6]	no
Kerbl & Sigmund (2017)	OeNB (946 banks, Q1 1998 - Q1 2016)	Fixed effects	no	+	0	+	no	+	no	no	no	yes	yes[7]	no
This thesis - Chapter 4	Orbis Bank Focus (1155 banks, 2011-2016, EU & US)	System GMM	+	+	−	−	0	+	+	+	yes	yes	yes	yes

Notes: +/− - estimated positive/negative coefficient (at least at 10% significance level); 0 - insignificant estimate; no - variable not included in the model; yes - model includes variables/dummy variables for a given effect; [1] considered both (log of) total assets and size dummies; [2] low interest rate environment dummy; [3] long-term interest rate used instead of slope of the yield curve; [4] total capital ratio; [5] regulatory capital ratio; [6] negative interest rate environment dummy; [7] impact of negative rate considered as forecast in separate ARIMA model.

Source: Author based on individual papers and own results.

can see the comparison confirms similar results in case of the lagged dependent variable, short-term rate, GDP growth, and equity to total assets ratio. On the other hand, our results differ in case of the slope of the yield curve as discussed above.

Some of the authors measured the impact of size, usually by including total assets or their logarithm as an explanatory variable. Claessens *et al.* (2017) included dummy variable for low interest rate environment, but not for negative. Arseneau (2017) used dummy variable for negative environment, but his methodology was quite different from all the other papers including this thesis. Finally, Kerbl & Sigmund (2017) attempted to forecast impact of negative rate within different estimation framework than used for the panel dataset.

Hence the main contributions of the analysis in this chapter are usage of a unique dataset combining banks from EU countries with U.S. banks allowing to control for differences between bank based and capital based financial market, consideration of the difference in the NIM by bank specialisation, inclusion of dummy variable for negative interest rate environment, and the attempt to more closely analyse the impact of the bank size.

4.6 Further Research Opportunities

The results presented in Section 4.4 reveal some opportunities for further research. They can be divided into three categories: further analysis of the impact of the slope of the yield curve, more sophisticated approach to size effects, and usage of data from following years.

1) Analysis of the slope of the yield curve's impact: First of the further research opportunities is the influence of the slope of the yield curve which was found to be significant as linear and negative. This is somewhat contradictory to the theoretical assumptions as well as some previous results, e.g. Borio *et al.* (2015). On the other hand, it may be the case of reaching the certain point at which steeper yield curve lead to decrease in banks' profitability as suggested by Borio *et al.* (2015).

2) More sophisticated approach to the size effects: Another opportunity is to study in a more detailed way the impact of the size of the bank. As suggested by Figure 4.2, there are certainly differences between banks that can be attributed to their size. Unfortunately, the modelling approach applied in this thesis was unable to capture them. Therefore, future research should focus in finding a more powerful ways to consider the size effects in the analysis of NIM - interest rate relation.

3) Using data from following years: Most importantly, there is an opportunity in obtaining more data as they will come from following years to get more robust results. Moreover, it is likely that at least in some of the observed countries the interest rates will continue to rise for some time yet, and that there will eventually come an end to the period of negative interest rates in the Euro Area and other countries. Presence of these factors in an extended dataset may bring better understanding of the link between NIM and short-term interest rate.

Chapter 5

Impact of Low and Negative Interest Rate on NIM in the EU by Market Structure

This chapter uses somewhat different setting of the dataset and model to analyse the impact of low and negative interest rates on banks' NIM with special focus on the difference in their impact by market concentration. A panel of 629 banks form EU countries in time period 2011-2016 with Herfindahl index by total assets of credit institutions as a measure of market concentration is used.[1]

5.1 Hypotheses

The remaining two hypotheses, i.e. hypotheses #4 and #5, are tested in this chapter.

Hypothesis #4: Protracted period of low (and even negative) interest rates in the EU eroded all type of banks' NIM. First hypothesis states that protracted period of low and even negative interest rates in the EU eroded all type of banks' NIM. Although each bank has its own unique business model which can be to some extent similar within certain group of banks as they are distinguished in our sample, e.g. savings banks, real estate & mortgage banks, or cooperative banks will have generally different business models than

[1] The dataset was constructed in a similar way as in previous chapter using only the data for European banks. The estimation is conducted in a similar way as well. For this reason the description of data and methodology is to some extent a repetition of the description from previous chapter.

regular commercial banks, it is highly likely that such unprecedented situation of protracted period of very low interest rates, and since 2015 even negative short-term rates in Euro Area and few other EU member countries, will have negative impact on NIM of all those types of banks.

Hypothesis #5: Situation differs for each country based on specific market characteristics (bank ownership structure, market concentration etc.). Especially, it can be assumed that higher market concentration in general leads to lower decrease in NIM. Second hypothesis assumes that situation differs for each country based on specific market characteristics. These may include bank ownership structure, market concentration, etc. Due to the fact that the available dataset does not allow to properly consider the ownership structure, the main focus will be put on the market concentration. The assumption is that with higher market concentration the decrease of banks' NIM in a certain country will tend to be lower.

5.2 Dataset and Descriptive Analysis

Dataset used in this chapter includes 629 banks from 24 EU member countries. Major source of the data was Orbis Bank Focus database. Data were selected as active banks from EU28 countries whose specialisation was ranked either as bank holdings & holding companies, commercial banks, cooperative banks, real estate & mortgage banks, or savings banks. Data were then filtered by variables assumed for use in the model in order to achieve balanced panel for time period 2011-2016 with no missing observations.

Dataset was then extended by a set of country specific variables, i.e. GDP growth rate, inflation rate, unemployment rate, 3M interbank rate, 10Y government bond yield, and Herfindahl index of total assets of credit institutions. Due to the availability of GDP growth, inflation rate, and unemployment rate in Orbis Bank Focus only for time period 2013-2016 and due to unavailability of short-term interest rate, long-term interest rate and Herfindahl index variables in Orbis Bank Focus at all, country specific variables data for the whole observed time period were obtained from other sources.

The source for the country specific variables was Eurostat with exception of Herfindahl index data which were obtained from Statistical Data Warehouse of the European Central Bank. Due to the fact, that the 3M interbank rate data for the whole observed period were available only for Euro Area, Denmark, Sweden, and United Kingdom, but for other countries outside the Euro Area

Table 5.1: Bank Specific Variables

Natural logarithm of total assets of the bank	This variable serves commonly as an approximation of the size of the bank. Transformation by natural logarithm is used in order to smooth out large differences in size of individual banks.	lta
Net loans to total assets ratio	Indicates what portion of total assets is made up of loans. Hence it can be considered a credit risk ratio. Expected sign of the coefficient is ambiguous because higher ratios may lead to lack of liquidity while low ratios to decrease in net interest income.	nl_ta
Net loans to deposits and short term funding ratio	Reflects structure of the balance sheet and especially the liquidity of the bank.	nl_dstf
Loan loss reserves to gross loans ratio	Measures the quality of bank's assets by evaluating the part of loans put aside for potential charge-off.	llr_gl
Cost to income ratio	Indicator of bank's operational efficiency. Generally, the impact on profitability is supposed to be negative. It should hold for NIM as well since NIM is directly linked to the denominator of cost to income ratio.	cir
Liquid assets to deposits and short term funding ratio	Liquidity measure capturing the liquid part of asset side of the bank's balance sheet.	la_dstf
Equity to total assets ratio	Leverage ratio measuring the indebtedness of the bank and its ability to absorb potential losses. The expected sign of the coefficient is unclear since low ratio may indicate insufficient capital, while high ratio can be result of foregone investment opportunities.	eq_ta

Note: Source of all variables is Orbis Bank Focus database.

the last available year was 2014, the data for years 2015 and 2016 for the Czech Republic were obtained from the Czech National Bank, for Hungary and Poland from OECD. Banks from Bulgaria, Croatia and Romania were removed from the sample (together 35 banks) due to unavailability of reliable source of data for short-term rate in 2015 and 2016. Long-term rates were proxied by EMU convergence criterion bond yields. Unfortunately, this yield is not available for Estonia because Estonian government has issued no such instrument. Hence

Table 5.2: Bank Specific Dummy Variables

Bank holdings & holding companies	Equals 1 for specialisation Bank holdings & holding companies.	*bhhc*
Cooperative banks	Equals 1 for specialisation Cooperative banks.	*coop*
Real estate & mortgage banks	Equals 1 for specialisation Real estate & mortgage banks.	*rem*
Savings banks	Equals 1 for specialisation Savings banks.	*saving*
Large banks	Equals 1 for banks whose total assets in 2016 were at least USD 30 billion.	*large*
Small banks	Equals 1 for banks whose total assets in 2016 were below USD 1 billion.	*small*

Note: Variables calculated by author based on Orbis Bank Focus data.

Table 5.3: Country Specific Variables

Real annual GDP growth rate	Annual growth rate of real GDP obtained from Eurostat. The coefficient is likely to be positive.	gdp
Inflation rate	Annual inflation rate obtained from Eurostat. The expected impact on NIM is negative.	$infl$
Unemployment rate	Annual unemployment rate obtained from Eurostat. Higher unemployment should have negative impact on NIM.	$unem$
Short-term interest rate	For most observations 3M interbank rate obtained from Eurostat, except for Czech Republic, Hungary and Poland in years 2015 and 2016 as described in the text.	st_ir
Square of the short-term interest rate	Due to assumed non-linearity in impact of short-term rate its square is used.	st_ir^2
Slope of the yield curve	Approximated by spread between 3M interbank rate and 10Y government bond yield.	$spread$
Square of the slope of the yield curve	Similarly to short-term rate the square of the yield curve slope is included to capture assumed non-linearity.	$spread^2$
Herfindahl index	Measure of market concentration in terms of total assets of credit institutions as defined by EU legislation. Obtained from SDW of ECB.	hi

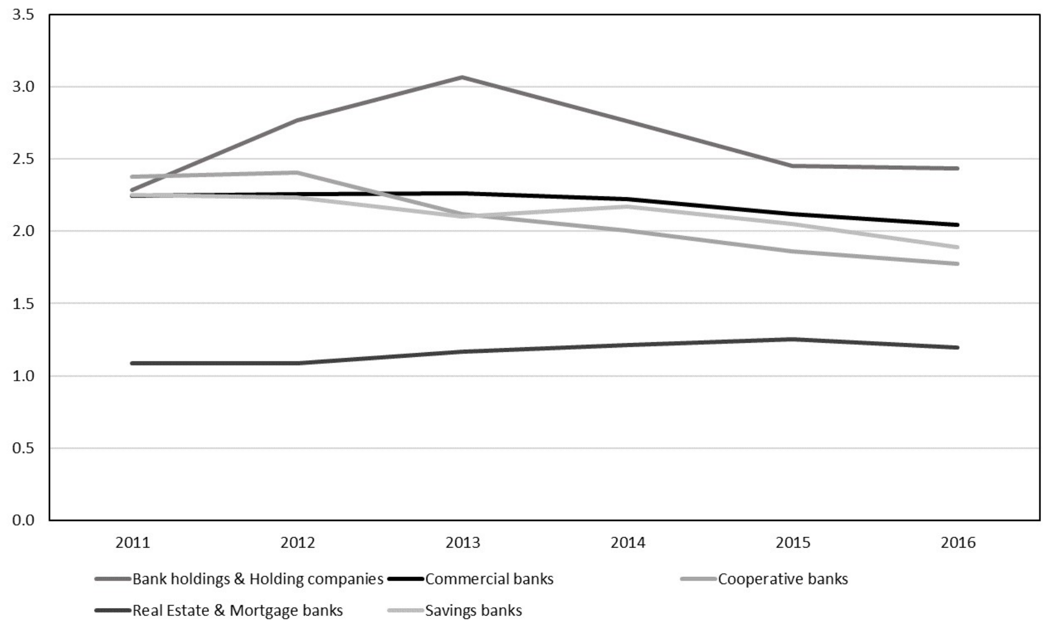
Note: Source of 3M interbank rate data in 2015 and 2016 for Czech Republic is CNB, for Hungary and Poland OECD.

the only one remaining bank located in Estonia was also removed from the dataset.

The final dataset is a balanced panel of 629 cross-sectional units in 6 time periods. Other variables, i.e. various dummies, or logarithms and squares of certain variables were computed within this panel. Description of bank specific variables is provided in Table 5.1, description of bank specific dummy variables in Table 5.2, and description of country specific variables in Table 5.3.

Selection of variables is based on previous literature on the topics of banks' profitability and the impact of interest rate on it including Arseneau (2017), Borio *et al.* (2015), Borio *et al.* (2017), Claessens *et al.* (2017), and Fišerová *et al.* (2015). Summary statistics of all variables are reported in Table B.1. Following the definitions in Table 5.2, the dataset includes 132 large banks, 268 medium size banks, and 229 small banks. In terms of specialisation then 26 bank holdings & holding companies, 235 commercial banks, 272 cooperative banks, 45 real estate & mortgage banks, and 51 savings banks.

Figure 5.1: Average NIM by bank specialisation (%)

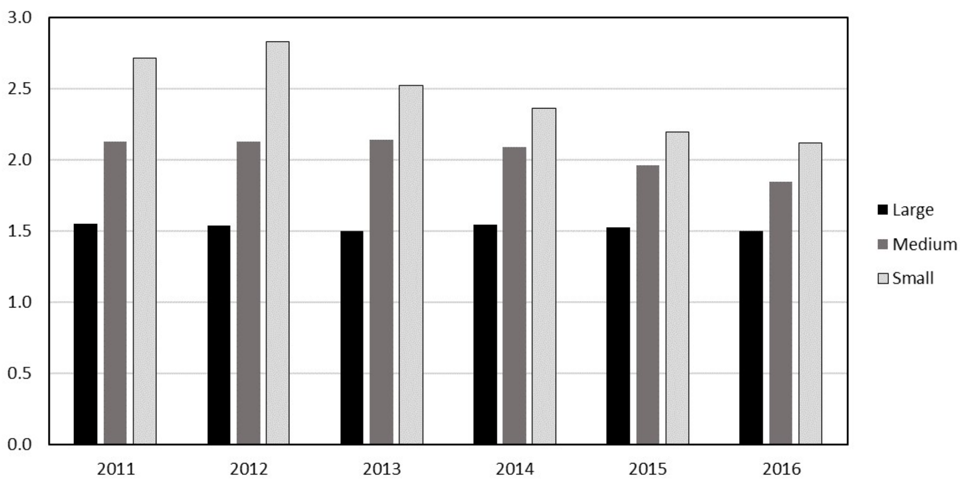


Source: Author based on Orbis Bank Focus, Eurostat and FRED.

Figure 5.1 pictures the development of average NIM for each of the bank specialisations. We can see that in case of bank holdings & holding companies the time series is relatively unstable. It may be caused by the fact that in the dataset restricted only to EU based banks there is a very low share of this type of a bank. Hence in such a small sample an irregularity, caused e.g. by repricing, may influence the time series' behaviour significantly. Therefore, the graph for bank holdings & holding companies is rather inconclusive.

For the other types of banks we can distinguish two cases. In case of cooperative and savings banks, we see quite sustained and relatively substantial decrease during the period 2011-2016 (about 60 basis points for cooperative and about 36 basis points for savings banks). On the other hand, in case of commercial and real estate & mortgage banks, we see more stable NIM (20 basis points decrease for commercial banks and 11 basis points increase for real estate & mortgage banks). Overall, these results suggest for the Hypothesis #4 to be rejected since we cannot conclude that the protracted period of low and later negative rates in the EU would erode profitability of all types of banks to the same extent.

Figure 5.2: Average NIM by bank size (%)



Source: Author based on Orbis Bank Focus, Eurostat and FRED.

In Figure 5.2 we can see that the large banks in the EU reported the lowest average NIM similarly as in case of the combined dataset in Chapter 4. But in case of the dataset for EU only, the highest NIM was reported by small banks while the medium sized banks came second. Another interesting result is that in case of the large banks, the average NIM is quite stable during the whole observed period, while on the other hand the small banks' average NIM between 2012 and 2016 dropped by almost 71 basis points. This is another source of evidence that there are likely to be differences in response to changing interest environment due to bank heterogeneity, in this case heterogeneity by size.

5.3 Methodology

The methodology is similar to the Chapter 4. We can consider using both the static and dynamic panel data methods. Static methods such as pooled OLS, fixed effects (within or LSDV estimator) or random effects (FGLS estimator) allow under certain assumptions to estimate at least consistently model of the following form:

$$y_{it} = \alpha + \boldsymbol{x'_{it}\beta} + c_i + \epsilon_{it} \tag{5.1}$$

where $i = 1, \ldots, N$ (cross-sectional units) and $t = 1, \ldots, T$ (time periods), c_i is the unobservable group specific fixed or random effect and $\epsilon_{it} \sim i.i.d.\, N(0, \sigma_\epsilon^2)$. To estimate a dynamic panel data model of the form:

$$y_{it} = \alpha + \delta y_{i,t-1} + \boldsymbol{x'_{it}\beta} + c_i + \epsilon_{it} \tag{5.2}$$

where $y_{i,t-1}$ is one period lagged dependent variable, we cannot use any of those methods because they would produce biased and inconsistent estimates as discussed in Chapter 4.

For dynamic panel data we have available two methods using instrumental variables within generalized method of moments (GMM) framework. The difference GMM developed in Arellano & Bond (1991) and system GMM proposed by Arellano & Bover (1995) and Blundell & Bond (1998). Due to the disadvantage of difference GMM, that we can get the model estimated only in first differences and using this approach we would not be able to use the set of group specific dummy variables, we use the other option - system GMM. In this method, the model is estimated in levels and differences jointly and instrumented by both lagged differences and lagged levels of the dependent variable respectively. Therefore, it allows us to estimate model including set of dummy variables.

The basic set up of estimated model will be:

$$\begin{aligned} nim_{it} = \alpha + \delta nim_{i,t-1} + \theta_1 st\_ir_{it} + \theta_2 st\_ir_{it}^2 + \theta_3 spread_{it} + \\ + \theta_4 spread_{it}^2 + \boldsymbol{x'_{it}\beta} + \boldsymbol{d'_{it}}\gamma + \boldsymbol{z'_{it}\phi} + (c_i + \epsilon_{it}) \end{aligned} \tag{5.3}$$

where $\boldsymbol{x}'_{it}$ is a vector of bank specific variables listed in Table 5.1, $\boldsymbol{d}'_{it}$ is a vector of bank specific dummy variables listed in Table 5.2, $\boldsymbol{z}'_{it}$ is a vector of country specific variables listed in Table 5.3 except for short-term interest rate, slope of the yield curve and their squares which are pointed out as variables of main interest. Finally, the error term consists of a fixed effects component c_i and an exogenous component ϵ_{it}.

System GMM will be used as the main estimation methodology in this chapter. But in order to get more robust evidence of validity of estimated relationships, we begin the analysis by imposing the assumption of no dynamic panel effects, estimate the model using the static methods, and put the estimation results in appendix.

5.4 Results and Findings

In this section estimation results from various estimation methods are presented. First, we impose the assumption of no dynamic effects and estimate the model without the lagged dependent variable using pooled OLS, fixed effects, and random effects. The results are reported in Table B.3.

Interestingly, we see the concave relationship between NIM and short-term interest rate, i.e. significant positive coefficient at linear term, and significant (at least at 10% level) negative coefficient at quadratic term, for all three methods. Moreover, we see also concave relationship for the slope of the yield curve for fixed effects and random effects models. From other macroeconomic variables we see significant impact only for unemployment and this impact is consistently with our expectations negative. On the contrary, GDP growth is insignificant for the theoretically superior methods, i.e. for fixed effects (with both normal and robust errors) and for random effects with robust errors, and inflation is insignificant at all.

Probably the most interesting result for Hypothesis #5 tested in this chapter is the coefficient of Herfindahl index which is significant at 10% level for fixed effects with robust standard errors. However, the sign is negative and that would practically mean that with higher market concentration the banks would tend to have lower NIM. This result is quite counterintuitive and because the level of significance is not that persuasive, we should probably wait for system GMM estimation results to make a certain conclusion.

In case of bank specific variables we see mainly significant negative coefficient of cost to income ratio and significant positive coefficient of net loans to total assets ratio. These results are both quite expected. Somewhat surprisingly we see also rather significant (at least at 10% level) positive coefficient of net loans to deposits and short-term funding ratio.

The coefficients of bank specific dummy variables could have been estimated only by random effects and pooled OLS. They show quite expected patterns. The *bhhc* is for most methods significant positive (except for random effects with robust errors), while the other three specialisation dummies are significant negative for most methods. These results are consistent with patterns in Figure 5.1. Considering the size dummies, we get also results expected based on Figure 5.2, i.e. that for small banks the NIM is generally higher and for large banks generally lower, but the significance is somewhat ambiguous when usually only one of the dummies is significant.

Finally, we should consider whether the estimates through the random effects are consistent or not. We compare the estimated coefficients from random effects and fixed effects estimations using the Hausman's specification test. The test statistic is reported in the bottom of Table B.3. We reject the null hypothesis of random effects consistency and hence we can conclude that should there be no dynamic effects we could get consistent estimates only through fixed effects. This would not allow us to use the time invariant bank specific dummy variables. Therefore, it still makes sense to stick to system GMM as the main estimation method.

We now again relax the assumption of no dynamic effects and continue with estimation by system GMM method. The estimation is performed using second and further lags of the dependent variable as instruments for the differenced equation and using second and further lags of differences of the dependent variable as instruments for equation in levels. For the estimation Stata command *xtabond2* developed in Roodman (2009) is used. Similarly as in Chapter 4, the model is estimated using one-step GMM, two-step GMM, one-step GMM with robust option, and two-step GMM option. Theoretically, two-step GMM with robust option (requesting the Windmeijer correction) should be the superior method, the others are reported for comparison as one of the robustness checks.

System GMM estimation results of the basic model setup are reported in Table 5.4. The results confirm that the relationship between NIM and short-term interest rate is concave as suggested by the static methods. On the other hand, in case of the slope of the yield curve, we see significant (at least on 10% level) negative coefficient at linear term, but for most estimation options insignificant coefficient of quadratic term. This suggests, similarly as in Chapter 4, for spec-

Table 5.4: System GMM estimation results

	One-step	Two-step	One-step (Robust option)	Two-step
	nim	nim	nim	nim
L.nim	0.862***	0.862***	0.862***	0.862***
	(0.0107)	(0.00499)	(0.0165)	(0.0159)
st_ir	0.198***	0.143***	0.198***	0.143***
	(0.0325)	(0.0217)	(0.0730)	(0.0231)
st_ir_sq	-0.0404***	-0.0268***	-0.0404***	-0.0268***
	(0.00627)	(0.00494)	(0.0120)	(0.00541)
spread	-0.0893***	-0.0226*	-0.0893**	-0.0226*
	(0.0169)	(0.0126)	(0.0429)	(0.0128)
spread_sq	0.00183**	-0.000912	0.00183	-0.000912
	(0.000922)	(0.000712)	(0.00171)	(0.000751)
gdp	0.00690	0.00848**	0.00690	0.00848**
	(0.00752)	(0.00419)	(0.00625)	(0.00418)
infl	0.104***	0.0547***	0.104***	0.0547***
	(0.0140)	(0.0108)	(0.0301)	(0.0106)
unem	0.0128***	0.00247	0.0128*	0.00247
	(0.00443)	(0.00289)	(0.00729)	(0.00301)
hi	0.359	0.490**	0.359	0.490**
	(0.239)	(0.208)	(0.247)	(0.208)
lta	-0.0270***	-0.0210***	-0.0270**	-0.0210**
	(0.0101)	(0.00685)	(0.0109)	(0.00819)
llr_gl	0.0108***	0.00746***	0.0108***	0.00746***
	(0.00252)	(0.00192)	(0.00293)	(0.00195)
eq_ta	0.0164***	0.00588**	0.0164**	0.00588**
	(0.00255)	(0.00266)	(0.00830)	(0.00262)
cir	-0.000811*	-0.000778**	-0.000811**	-0.000778**
	(0.000458)	(0.000328)	(0.000403)	(0.000309)
nl_ta	0.00469***	0.00436***	0.00469***	0.00436***
	(0.000990)	(0.000737)	(0.000981)	(0.000819)
nl_dstf	-0.000152	-0.000283	-0.000152	-0.000283
	(0.000354)	(0.000202)	(0.000255)	(0.000204)
la_dstf	-0.000366	-0.000109	-0.000366	-0.000109
	(0.000601)	(0.000485)	(0.000600)	(0.000505)
bhhc	0.154***	0.0274	0.154	0.0274
	(0.0497)	(0.0445)	(0.163)	(0.0462)
coop	-0.102***	-0.0835***	-0.102***	-0.0835***
	(0.0283)	(0.0183)	(0.0317)	(0.0190)
rem	-0.136***	-0.116***	-0.136***	-0.116***
	(0.0454)	(0.0307)	(0.0362)	(0.0373)
savings	-0.0683*	-0.0486**	-0.0683***	-0.0486**
	(0.0373)	(0.0236)	(0.0260)	(0.0230)
large	0.0746*	0.0603**	0.0746*	0.0603**
	(0.0413)	(0.0280)	(0.0442)	(0.0286)
small	-0.00269	0.00796	-0.00269	0.00796
	(0.0343)	(0.0223)	(0.0324)	(0.0230)
Constant	0.159	0.216*	0.159	0.216
	(0.182)	(0.118)	(0.195)	(0.148)
Number of observations	3145	3145	3145	3145
Number of groups	629	629	629	629
Number of instruments	31	31	31	31
Wald statistic	13618.3***	63767.3***	21120.7***	13576.7***
Arellano-Bond AR(1)	-22.76***	-1.31	-1.28	-1.31
Arellano-Bond AR(2)	3.13***	0.44	0.45	0.44
Sargan/Hansen test	170.83***	12.89	12.89	12.89

Notes: Standard errors in parentheses. Sargan test used for one-step model without robust option, Hansen test for other models.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

ification of the relationship as linear. For the other macroeconomic variables, we see significant positive impact of GDP growth and also for inflation. While the impact of GDP growth is consistent with the ex ante expectations, in case of inflation it is in contradiction with the expectations. Similarly, as stated in Section 4.4, this result may be attributed to the fact that we observe only period of low inflation with low volatility, which may cause the standard errors to be low. Finally, the coefficients of unemployment are mostly insignificant.

The most interesting country specific variable in this chapter is the Herfindahl index. We have estimated a significant positive coefficient of hi at least in case of two-step models. This is in line with the assumed relation that higher market concentration should lead to higher NIM in general.

Bank specific variables are mostly significant. The only two exceptions are variables nl_dstf and la_dstf. In this case, it may again be problem of the correlation with nl_ta, but as reported in Table B.2 the correlation is much weaker in this dataset than in dataset used in Chapter 4. We see significant negative coefficient of lta which probably captures most of the size effects, because the dummy variable $small$ is insignficant and while the dummy variable $large$ is significant, it has positive coefficient contradictory to the patterns in Figure 5.2.

Positive coefficient of llr_gl may signal that banks taking higher level of credit risk attain higher NIM. Positive coefficient eq_ta somewhat surprisingly suggests that lower leverage leads to higher NIM. Unsurprisingly, the coefficient of cost to income ratio is still negative. And finally, the positive coefficient of net loans to total assets suggests that the more the banks are able to lend to clients, the higher NIM they attain, because otherwise they would have to invest into government bonds and similar instruments that bore low yields during the observed period. For the specialisation bank specific dummy variables we observe behaviour consistent with the patterns in Figure 5.1. The coefficient at $bhhc$ is positive, but insignificant. On the contrary, the coefficient of other dummies are significant negative, suggesting generally lower NIM or faster decrease in NIM.

The bottom lines of Table 5.4 report the estimation diagnostic results. The Wald statistics show overall significance of the models. Arellano-Bond AR(1) and AR(2) tests both do not reject the null hypothesis. This result suggests, that we would have not make a big mistake, if we had estimated the model using static approach. On the other hand, as mentioned before, system GMM allows us to estimate the model using the time invariant dummy variables. Due to this

Table 5.5: Lagged dependent variable coefficients in S-GMM, FE, and Pooled OLS - robustness check

	FE	S-GMM	Pooled OLS
	nim	nim	nim
L.nim	0.110	0.862***	0.928***
	(0.0951)	(0.0159)	(0.0748)

Note: Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

fact and also due to the result of Hausman test that suggested inconsistency of random effects approach, it is still correct to use system GMM.

The results of Hansen test than lead to not rejecting the null hypothesis of exogennous instruments, i.e. to the desired outcome. We have to be aware of the fact that Hansen test could be weakened by too many instruments, especially if the number of instruments exceeds the number of groups. However, this is not the case, since we have only 31 instruments, but the number of groups is 629.

As another robustness check we compare the estimates of the coefficient at lagged dependent variable from fixed effects, system GMM, and pooled OLS estimation to verify the condition $\hat{\delta}_{FE} \leq \hat{\delta}_{S-GMM} \leq \hat{\delta}_{OLS}$. The estimated coefficient are presented in Table 5.5 confirming that this condition holds.

Finally, we try to estimate various modifications of the model dropping certain variables. Following the results in Table 5.4, it makes sense to consider dropping $spread^2$ as the results suggest rather linear than quadratic relationship. Another possibility is to estimate the model without logarithm of total assets and specialisation dummy variables to see whether it will change the significance of size dummy variables. Finally, due to some correlation between nl_ta, nl_dstf, and la_dstf, it is worth considering using just some of these three variables.

The estimation results for modified models are presented in Table 5.6 and Table 5.7. All models are estimated using only two-step GMM with robust option. Model (1) is estimated omitting only $spread^2$. As the estimation diagnostic shows, the performance is comparable to the original model. Models (2) and (3) aim at addressing the size effects dropping specialisation dummies and lta (the models differ in including/excluding $spread^2$). However, we can see that in this case Hansen test does not reject the null hypothesis at 10% sig-

Table 5.6: Estimation results for modified models (two-step system GMM with robust option)

	(1) nim	(2) nim	(3) nim
L.nim	0.859***	0.865***	0.862***
	(0.0156)	(0.0147)	(0.0145)
st_ir	0.147***	0.148***	0.152***
	(0.0232)	(0.0232)	(0.0233)
st_ir_sq	-0.0287***	-0.0268***	-0.0287***
	(0.00561)	(0.00532)	(0.00554)
spread	-0.0374***	-0.0218*	-0.0361***
	(0.00842)	(0.0128)	(0.00863)
spread_sq	-	-0.000832	-
		(0.000772)	
gdp	0.00769*	0.00939**	0.00855**
	(0.00429)	(0.00410)	(0.00428)
infl	0.0598***	0.0543***	0.0594***
	(0.00963)	(0.0105)	(0.00960)
unem	0.00410	0.00236	0.00417
	(0.00288)	(0.00280)	(0.00276)
hi	0.478**	0.726***	0.714***
	(0.197)	(0.213)	(0.200)
lta	-0.0221***	-	-
	(0.00806)		
llr_gl	0.00760***	0.00764***	0.00777***
	(0.00187)	(0.00195)	(0.00188)
eq_ta	0.00619**	0.00748***	0.00780***
	(0.00255)	(0.00253)	(0.00246)
cir	-0.000790**	-0.000677**	-0.000680**
	(0.000318)	(0.000305)	(0.000313)
nl_ta	0.00431***	0.00432***	0.00425***
	(0.000802)	(0.000784)	(0.000769)
nl_dstf	-0.000255	-0.000517**	-0.000498**
	(0.000203)	(0.000202)	(0.000201)
la_dstf	-0.000138	0.0000292	-0.00000172
	(0.000494)	(0.000483)	(0.000469)
bhhc	0.0269	-	-
	(0.0455)		
coop	-0.0824***	-	-
	(0.0189)		
rem	-0.121***	-	-
	(0.0359)		
savings	-0.0488**	-	-
	(0.0232)		
large	0.0583**	0.0105	0.00458
	(0.0285)	(0.0176)	(0.0181)
small	0.00878	0.0383**	0.0419**
	(0.0229)	(0.0176)	(0.0170)
Constant	0.243*	-0.178***	-0.170***
	(0.145)	(0.0649)	(0.0622)
Observations	3145	3145	3145
Wald statistic	13364.4***	11805.1***	11484.7***
Arellano-Bond AR(1)	-1.31	-1.31	-1.31
Arellano-Bond AR(2)	0.45	0.44	0.44
Hansen test	12.67	13.77*	13.46*

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

Table 5.7: Estimation results for modified models (two-step system GMM with robust option)

	(4) nim	(5) nim	(6) nim	(7) nim	(8) nim
L.nim	0.866***	0.863***	0.859***	0.865***	0.864***
	(0.0152)	(0.0149)	(0.0157)	(0.0148)	(0.0153)
st_ir	0.144***	0.147***	0.147***	0.150***	0.152***
	(0.0231)	(0.0231)	(0.0233)	(0.0228)	(0.0228)
st_ir_sq	-0.0276***	-0.0290***	-0.0285***	-0.0292***	-0.0284***
	(0.00522)	(0.00535)	(0.00559)	(0.00529)	(0.00526)
spread	-0.0258**	-0.0365***	-0.0373***	-0.0357***	-0.0347***
	(0.0130)	(0.00844)	(0.00841)	(0.00824)	(0.00842)
spread_sq	-0.000636	-	-	-	-
	(0.000751)				
gdp	0.00973**	0.00918**	0.00820*	0.00835*	0.0100**
	(0.00429)	(0.00442)	(0.00433)	(0.00443)	(0.00468)
infl	0.0593***	0.0632***	0.0596***	0.0635***	0.0606***
	(0.0108)	(0.00976)	(0.00971)	(0.00980)	(0.00981)
unem	0.00131	0.00247	0.00426	0.00261	0.00408
	(0.00304)	(0.00294)	(0.00278)	(0.00297)	(0.00288)
hi	0.472**	0.464**	0.456**	0.548**	0.500**
	(0.224)	(0.214)	(0.195)	(0.214)	(0.217)
lta	-0.0199**	-0.0210***	-0.0232***	-0.0203***	-0.0263***
	(0.00802)	(0.00791)	(0.00795)	(0.00756)	(0.00766)
llr_gl	0.00741***	0.00760***	0.00775***	0.00704***	0.00718***
	(0.00192)	(0.00185)	(0.00189)	(0.00184)	(0.00192)
eq_ta	0.00674**	0.00704***	0.00583**	0.00742***	0.00489*
	(0.00269)	(0.00262)	(0.00260)	(0.00262)	(0.00285)
cir	-0.000776**	-0.000787**	-0.000766**	-0.000896***	-0.000807***
	(0.000304)	(0.000311)	(0.000316)	(0.000309)	(0.000306)
nl_ta	-	-	0.00408***	-	-
			(0.000556)		
nl_dstf	0.000688***	0.000704***	-	-	0.000622***
	(0.000177)	(0.000174)			(0.000200)
la_dstf	-0.00174***	-0.00175***	-	-0.00162***	-
	(0.000441)	(0.000434)		(0.000535)	
bhhc	0.00126	0.00145	0.0270	0.00309	0.00669
	(0.0470)	(0.0467)	(0.0452)	(0.0472)	(0.0502)
coop	-0.103***	-0.103***	-0.0842***	-0.0906***	-0.0812***
	(0.0203)	(0.0203)	(0.0191)	(0.0205)	(0.0192)
rem	-0.117***	-0.122***	-0.136***	-0.0684**	-0.104***
	(0.0396)	(0.0384)	(0.0358)	(0.0349)	(0.0384)
savings	-0.0384	-0.0389*	-0.0482**	-0.0306	-0.0198
	(0.0234)	(0.0237)	(0.0233)	(0.0240)	(0.0234)
large	0.0461	0.0456	0.0562**	0.0508*	0.0461*
	(0.0288)	(0.0287)	(0.0282)	(0.0277)	(0.0279)
small	-0.00396	-0.00394	0.00607	-0.00589	-0.0153
	(0.0242)	(0.0242)	(0.0227)	(0.0244)	(0.0238)
Constant	0.420***	0.443***	0.251*	0.474***	0.483***
	(0.152)	(0.150)	(0.147)	(0.144)	(0.148)
Observations	3145	3145	3145	3145	3145
Wald statistic	13175.6***	13018.6***	12904.7***	12936.8***	12316.5***
Arellano-Bond AR(1)	-1.31	-1.31	-1.31	-1.31	-1.31
Arellano-Bond AR(2)	0.44	0.44	0.45	0.44	0.44
Hansen test	10.19	10.22	12.72	9.57	10.14

Note: Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

nificance level. Moreover, the estimated coefficients of size dummies again give ambiguous results. Consistently with our expectations, the *small* coefficient is significant positive. On the other hand, coefficient at *large* is insignificant now.

Models (4)-(8) presented in Table 5.7 are various specifications omitting certain variables of the balance sheet structure, i.e. nl_ta, nl_dstf, and la_dstf. As we can see, dropping of nl_ta generally leads to decrease in Hansen test statistic and to increase of significance of both nl_dstf, and la_dstf. On the other hand, dropping any of the variables reduces the Wald statistic. Hence we are facing kind of a trade-off. But generally, the results suggest to use either only nl_ta, or nl_dstf and/or la_dstf. To sum up the analysis of models (1)-(8), we should modify the original model in two ways - model the impact of *spread* only as linear, and use only some of the bank specific variables reflecting the balance sheet structure and liquidity. In other words, the best model would be probably either the model (5), or (7).

5.5 Summary of Results

This section confronts the estimation results with the two hypotheses tested in this chapter in order to reject or not reject them. The estimation results are then compared to the results of previous papers and results of Chapter 4.

Hypothesis #4 - rejected: The estimation results as well as Figure 5.1 do not confirm that the NIM of all bank types would respond to the situation of low and later negative short-term rates, present during the observed period 2011-2016 in the EU, in the same way. The figure shows differences in both the pace and the direction of the average NIM for each bank type. Similarly, the significance of most of the bank specialisation dummies is in favour of differences in NIM.

Hypothesis #5 - not rejected: The models estimated in this chapter included the variable Herfindahl index as a measure of market concentration. Since the estimated coefficient was significant and positive, it supports the claim that higher market concentration leads to higher NIM. Therefore, this hypothesis cannot be rejected.

Table 5.8 presents the comparison of estimation results with results in other papers. The papers differ in using datasets of various size, geographic location, as well as bank types' variety. Moreover, different estimation approaches are employed in each of the paper. For this reason, only some of the most commonly

Table 5.8: Comparison of Estimated Signs and Significance Levels for the Coefficients of NIM Determinants in Previous Studies

Authors	Data	Methodology	nim_{t-1}	st_ir	st_ir^2	$spread$	$spread^2$	gdp	$infl$	hi	eq_ta	specialisation	size[1]	low/negative rate
Borio *et al.* (2015) - BIS working paper	Bankscope (109 large banks, 14 advanced economies, 1995-2012)	System GMM	+	+	-	+	-	0	no	no	+	no	no	no
Claessens *et al.* (2017)	Bankscope (3385 banks, 47 countries, 2005-2013)	Fixed effects	+	+	no	0	no	0/-	no	no	+	no	no	yes[2]
Bikker & Vervliet (2017)	Federal Deposit Insurance Corporation (3582 U.S. banks)	System GMM & static methods	+	+	-	+[3]	no	+	-	no	−[4]	no	yes	no
Altavilla *et al.* (2017) - ECB working paper	ECB datasets (288 banks, Q1 2000 - Q4 2016)	OLS	+	+	no	0	no	+	0	no	0[5]	no	no	no
Arseneau (2017)	22 bank holdings (U.S. stress testing scenarios)	GLS	no	no	no	no	no	no	no	no	no	no	yes	yes[6]
Kerbl & Sigmund (2017)	OeNB (946 banks, Q1 1998 - Q1 2016)	Fixed effects	no	+	0	+	no	+	no	no	no	no	yes	yes[7]
This thesis - Chapter 4	Orbis Bank Focus (1155 banks, 2011-2016, EU & US)	System GMM	+	+	-	-	0	+	+	no	+	yes	yes	yes
This thesis - Chapter 5	Orbis Bank Focus (629 banks, 2011-2016, EU)	System GMM	+	+	-	-	0	+	+	+	+	yes	yes	no

Notes: +/− - estimated positive/negative coefficient (at least at 10% significance level); 0 - insignificant estimate; no - variable not included in the model; yes - model includes variables/dummy variables for a given effect; [1] Considered both (log of) total assets and size dummies; [2] low interest rate environment dummy; [3] long-term interest rate used instead of slope of the yield curve; [4] total capital ratio; [5] regulatory capital ratio; [6] negative interest rate environment dummy; [7] impact of negative rate considered as forecast in separate ARIMA model.

Source: Author based on individual papers and own results.

included variables are considered in the table. We can found similar results for certain variables. Our estimation in both chapters brings similar results for the coefficients of lagged dependent variable, for short-term rate and its square, GDP growth, and equity to total assets ratio.

On the contrary, our results differ especially for the coeffients of the slope of the yield curve. Some of the authors considered the impact of the size of the bank, at least by including total assets or their logarithm as an explanatory variable. However, our estimation is unique in including the specialisation dummies, as well as in including the Herfindahl index as another explanatory variable.

To sum up, the main contribution of the analysis in this chapter is consideration of the impact of the market concentration on NIM together with controlling for the differences between various bank specialisations and for different size categories as well as exploiting of a unique dataset of EU banks of various size and specialisation.

5.6 Further Research Opportunities

To conclude this chapter, let us briefly discuss opportunities for further research. They can be summarized into three points: further analysis of the impact of the slope of the yield curve, assessment of other market characteristics besides market concentration, and obtaining more data, e.g. from following years.

1) Further analysis of the influence of the slope of the yield curve: Similarly, as in case of Section 4.4, the results in Section 5.4 for the impact of slope of the yield curve, that suggest the impact to be negative and linear, seem in contradiction with the theoretical assumptions and previous results. But they may on the other hand mean reaching of a certain point at which steeper yield curve may cause decreasing profitability as predicted in Borio *et al.* (2015).

2) Assessment of other market characteristics: Another research opportunity would be to collect data for more variables reflecting the specific market characteristics. In this thesis we used Herfindahl index as a measure of market concentration. However, we were not able to consider other important characteristics such as ownership structure within our dataset. It is not an easy task to find good proxy for modelling its impact, but it would clearly help in better understanding of the determinants of NIM.

3) Obtaining data from following years: Finally, it would be desirable to do the analysis with more data available, i.e. use longer time period as data from following years become available. The negative interest rate environment in the Euro Area is still present, but eventually it will end. Hence we could have more observations on both the negative rate period as well as "normal" times. Moreover, it will be interesting how exactly will the banks cope with the end of negative rate era.

Chapter 6

Conclusion

The low or even negative interest rate environment, that appeared during the last decade around the world, has brought serious concerns about its impact on bank profitability, and especially on net interest margin (NIM). But still, this impact has not been yet fully analysed. Although some analyses were done by Borio *et al.* (2015), Claessens *et al.* (2017), or Bikker & Vervliet (2017), there still remain questions to be answered.

This thesis aimed at assesment of the impact while controlling for the differences between bank based and capital based financial markets, for the existence of negative short-term rate, for the various bank specialisations, for the market concentration, as well as for the size effects.

Using the annual data on 629 banks from EU countries and 526 banks from United States from period 2011-2016, we found positive, but concave relationship with short-term rate. On the other hand, the impact of the slope of the yield curve was found to be linear and negative. This result is in contradiction with previous studies, but not necessarily in contradiction with theoretical explanations in Borio *et al.* (2015). We also found that generally the average NIM was higher in the capital based financial markets than in bank based financial market. Moreover, the decrease of NIM during the observed period was somewhat deeper in case of bank based market. This finding can be interpreted also in a way that institutional factors matter for the general level of NIM.

The analysis also revealed that the decrease of NIM was fastest in case of small banks. On the other hand, generally the lowest average NIM during the whole period was observed for the large banks. However, the results for size effects were somewhat mixed and hence not so robust. By bank specialisation, the highest average NIM reported the bank holdings & holding companies together with commercial banks, followed by savings banks and cooperative banks, while the real estate & mortgage banks have reported the lowest average NIM during the whole observed period.

With restriction on the EU banks only we conducted an analysis controlling for the impact of the market concentration proxied by Herfindahl index of total assets. We found positive relationship between the NIM and Herfindahl index suggesting that with higher concentration and hence higher oligopolistic power the banks can attain higher NIM. The fact that market concentration matters may have also certain policy implications, i.e. how to cope with financial stability vs. protection of market competition trade-off.

Considering our hypotheses, we arrived at following results:

Hypothesis #1 - not rejected: We found out that the NIM is generally lower in bank based financial markets than in capital based markets and that the decrease between 2011 and 2016 was slightly faster in bank based markets.

Hypothesis #2 - not rejected: The figures showed fastest decrease of NIM for small banks. However, the econometric models in did not show a significant result for size. Hence the conclusion is that we fail to reject this hypothesis, but the result is not very robust.

Hypothesis #3 - rejected: We assumed that the savings banks reported highest NIM. But both the figures and the econometric models show that bank holdings & holding companies and commercial bank have generally reported higher NIM during the observed period.

Hypothesis #4 - rejected: Our findings do not confirm that the NIM of all bank types would respond to the low or negative rate environment during in the same way. There are differences in both the pace and the direction of the average NIM for each bank type.

Hypothesis #5 - not rejected: In with Herfindahl index as a proxy for market concentration, the estimated coefficient was significant and positive. It supports the expectation that higher market concentration leads to higher NIM. Therefore, this hypothesis cannot be rejected.

To sum up, the main contribution of the thesis is usage of a unique dataset of relatively large geographical variety allowing to consider the differences between bank based and capital based market, between different bank specialisations, the size effects, as well as the impact of market concentration. Contrary to Borio *et al.* (2015), who used most similar methodology, we used larger sample of banks with larger heterogeneity by size, and specialisation. Contrary to some other authors, we used more advanced econometric approach - system GMM.

Bibliography

Akerlof, G. A. (1970): "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *The Quarterly Journal of Economics* **84(3)**: pp. 488–500.

Altavilla, C., M. Boucinha, & J.-L. Peydró (2017): "Monetary policy and bank profitability in a low interest rate environment." *Working Paper Series 2105*, European Central Bank.

Arellano, M. & S. Bond (1991): "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* **58(2)**: pp. 277–297.

Arellano, M. & O. Bover (1995): "Another look at the instrumental variable estimation of error-components models." *Journal of Econometrics* **68(1)**: pp. 29–51.

Arseneau, D. M. (2017): "How would US banks fare in a negative interest rate environment?" *Finance and Economics Discussion Series* **2017(030)**.

Bernanke, B. S. & V. R. Reinhart (2004): "Conducting monetary policy at very low short-term interest rates." *American Economic Review* **94(2)**: pp. 85–90.

Bikker, J. & T. Vervliet (2017): "Bank profitability and risk-taking under low interest rates." *DNB Working Papers 560*, Netherlands Central Bank, Research Department.

Blundell, R. & S. Bond (1998): "Initial conditions and moment restrictions in dynamic panel data models." *Journal of Econometrics* **87(1)**: pp. 115–143.

Borio, C., L. Gambacorta, & B. Hofmann (2015): "The influence of monetary policy on bank profitability." *BIS Working Papers 514*, Bank for International Settlements.

Borio, C., L. Gambacorta, & B. Hofmann (2017): "The influence of monetary policy on bank profitability." *International Finance* **20(1)**: pp. 48–63.

Černohorský, J. & P. Teplý (2011): *Základy financí.* 1. vyd. Praha: Grada, 2011, 304 s.

Claessens, S., N. Coleman, & M. S. Donnelly (2017): "'Low-For-Long' Interest Rates and Banks' Interest Margins and Profitability : Cross-Country Evidence." *International Finance Discussion Papers 1197*, Board of Governors of the Federal Reserve System (U.S.).

Cúrdia, V. & M. Woodford (2011): "The central-bank balance sheet as an instrument of monetary policy." *Journal of Monetary Economics* **1(58)**: pp. 54–79.

Fišerová, T., P. Teplý, & D. Tripe (2015): "The performance of foreign-owned banks in host country economies." *Prague Economic Papers* **24(5)**: pp. 538–561.

Franta, M., T. Holub, P. Kral, I. Kubicova, K. Smidkova, & B. Vasicek (2014): "The Exchange Rate as an Instrument at Zero Interest Rates: The Case of the Czech Republic." *Research and Policy Notes 2014/03*, Czech National Bank, Research Department.

Golin, J. & P. Delhaise (2013): *The Bank Credit Analysis Handbook: A Guide for Analysts, Bankers and Investors.* Wiley.

Greene, W. H. (2012): *Econometric Analysis.* Pearson.

Jung, T., Y. Teranishi, & T. Watanabe (2005): "Optimal monetary policy at the zero-interest-rate bound." *Journal of Money, Credit, and Banking* **37(5)**: pp. 813–835.

Kerbl, S. & M. Sigmund (2017): "Negative interest rates: Forecasting banks' profitability in a new environment." *SSRN Electronic Journal* .

McCallum, B. T. (2000): "Theoretical analysis regarding a zero lower bound on nominal interest rates." *Journal of Money, Credit and Banking* **32(4)**: p. 870.

Mejstřík, M., M. Pečená, & P. Teplý (2014): *Bankovnictví v teorii a praxi/Banking in Theory and Practice.* Charles University in Prague, Karolinum Press.

Roodman, D. (2009): "How to do xtabond2: An introduction to difference and system GMM in Stata." *Stata Journal* **9(1)**: pp. 86–136.

Svensson, L. (2006): "Monetary policy and japan's liquidity trap." *Working Papers 76*, Princeton University, Department of Economics, Center for Economic Policy Studies.

Svensson, L. E. (2003): "Escaping from a liquidity trap and deflation: The foolproof way and others." *Journal of Economic Perspectives* **17(4)**: pp. 145–166.

Appendix A

Additional Analyses for Models in Chapter 4

Table A.1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
nim	2.9	2.11	-0.53	31.65
st_ir	0.43	0.59	-0.49	8.05
spread	2.15	1.38	-0.41	21.93
gdp	1.33	1.73	-9.1	25.6
infl	1.44	1.16	-1.5	5.7
unem	8.4	3.18	4	27.5
lta	15.31	2.1	10.31	21.75
llr_gl	3.26	3.73	-2.2	46.41
eq_ta	10.34	4.49	-3.93	63.57
cir	65.22	24.66	0.03	851.20
nl_ta	61.61	16.39	1.8	98.73
nl_dstf	84.54	38.09	2.4	827.06
la_dstf	16.83	22.31	0.01	391.32
bhhc	0.17	0.37	0	1
coop	0.24	0.42	0	1
rem	0.04	0.19	0	1
savings	0.06	0.24	0	1
large	0.17	0.37	0	1
small	0.2	0.4	0	1
negrate	0.16	0.37	0	1
capbas	0.49	0.5	0	1
Number of observations		6930		
Number of groups		1155		
Observations per group		6		

Source: Author's calculation in Stata 11.2.

Table A.2: Cross-correlation table

Variables	nim	st_ir	spread	gdp	infl	unem	lta	llr_gl	eq_ta	cir	nl_ta	nl_dstf	la_dstf	bhhc	coop	rem	savings	large	small	negrate	capbas
nim	1.00																				
st_ir	0.03	1.00																			
	(0.00)																				
spread	-0.05	0.06	1.00																		
	(0.00)	(0.00)																			
gdp	0.14	-0.01	-0.59	1.00																	
	(0.00)	(0.51)	(0.00)																		
infl	0.11	0.47	0.31	-0.22	1.00																
	(0.00)	(0.00)	(0.00)	(0.00)																	
unem	-0.19	-0.10	0.55	-0.46	-0.06	1.00															
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)																
lta	-0.13	0.08	-0.20	0.22	-0.00	-0.13	1.00														
	(0.00)	(0.00)	(0.00)	(0.00)	(0.86)	(0.00)															
llr_gl	-0.02	-0.06	0.24	-0.22	-0.21	0.48	-0.13	1.00													
	(0.19)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)														
eq_ta	0.35	-0.03	-0.01	0.06	0.01	-0.07	-0.32	-0.01	1.00												
	(0.00)	(0.01)	(0.47)	(0.00)	(0.28)	(0.00)	(0.00)	(0.42)													
cir	-0.11	0.01	0.02	-0.00	0.06	-0.05	-0.08	0.01	0.02	1.00											
	(0.00)	(0.43)	(0.14)	(0.70)	(0.00)	(0.00)	(0.00)	(0.27)	(0.10)												
nl_ta	0.23	0.09	0.02	0.05	0.03	-0.11	-0.06	-0.13	-0.02	-0.14	1.00										
	(0.00)	(0.00)	(0.11)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.12)	(0.00)											
nl_dstf	0.01	0.13	0.08	-0.12	0.04	0.04	0.01	-0.03	-0.02	-0.17	0.59	1.00									
	(0.64)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.29)	(0.01)	(0.07)	(0.00)	(0.00)										
la_dstf	-0.21	0.02	-0.07	-0.04	0.01	0.00	0.20	0.08	0.04	0.08	-0.50	0.01	1.00								
	(0.00)	(0.04)	(0.00)	(0.00)	(0.21)	(0.87)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.59)									
bhhc	0.13	-0.01	-0.11	0.18	0.06	-0.21	0.10	-0.18	0.03	0.03	-0.02	-0.10	-0.06	1.00							
	(0.00)	(0.33)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.18)	(0.00)	(0.00)								
coop	-0.21	-0.07	0.31	-0.46	-0.08	0.41	-0.43	0.27	0.05	-0.01	-0.08	0.12	-0.02	-0.25	1.00						
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.26)	(0.00)	(0.00)	(0.04)	(0.00)							
rem	-0.17	0.04	-0.13	0.06	-0.01	-0.11	0.10	-0.10	-0.17	-0.07	0.17	0.36	0.08	-0.09	-0.11	1.00					
	(0.00)	(0.00)	(0.00)	(0.00)	(0.54)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)						
savings	-0.05	-0.01	-0.03	-0.02	-0.02	0.01	0.05	0.03	-0.04	0.02	0.10	0.02	-0.03	-0.12	-0.14	-0.05	1.00				
	(0.00)	(0.67)	(0.01)	(0.19)	(0.08)	(0.50)	(0.00)	(0.00)	(0.00)	(0.17)	(0.00)	(0.15)	(0.01)	(0.00)	(0.00)	(0.00)					
large	-0.16	0.05	-0.04	0.05	-0.02	0.09	0.75	-0.05	-0.22	-0.06	-0.12	0.06	0.23	0.00	-0.17	0.09	-0.03	1.00			
	(0.00)	(0.00)	(0.00)	(0.00)	(0.12)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.76)	(0.00)	(0.00)	(0.01)				
small	-0.10	-0.07	0.29	-0.39	-0.08	0.35	-0.62	0.26	0.19	0.05	-0.10	0.08	0.03	-0.22	0.65	-0.03	-0.11	-0.22	1.00		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)			
negrate	-0.21	-0.43	-0.24	0.06	-0.51	0.24	-0.09	0.31	-0.06	0.01	-0.10	0.01	0.08	-0.17	0.26	0.05	0.04	0.02	0.23	1.00	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.41)	(0.00)	(0.38)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.14)	(0.00)		
capbas	0.38	-0.05	-0.24	0.43	0.17	-0.50	0.14	-0.43	0.16	-0.01	0.11	-0.21	-0.22	0.38	-0.55	-0.13	-0.09	-0.06	-0.48	-0.43	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.30)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	

Note: p-values in parentheses.

Source: Author's calculation in Stata 11.2.

Table A.3: Static panel methods estimation results

	RE	FE	Pooled OLS	RE	FE	Pooled OLS
	(Normal standard errors)			(Robust standard errors)		
	nim			nim		
st_ir	-0.0698**	-0.0611*	-0.186**	-0.0698	-0.0611	-0.186*
	(0.0321)	(0.0324)	(0.0855)	(0.0512)	(0.0501)	(0.0973)
st_ir_sq	-0.00763	-0.00920*	0.0182	-0.00763	-0.00920	0.0182
	(0.00510)	(0.00507)	(0.0158)	(0.00662)	(0.00661)	(0.0174)
spread	0.000270	0.00962	-0.191***	0.000270	0.00962	-0.191***
	(0.0158)	(0.0160)	(0.0388)	(0.0177)	(0.0176)	(0.0449)
spread_sq	-0.000000132	-0.000757	0.0113***	-0.000000132	-0.000757	0.0113***
	(0.000878)	(0.000873)	(0.00252)	(0.000906)	(0.000915)	(0.00223)
gdp	0.0100*	0.0107*	-0.000520	0.0100	0.0107	-0.000520
	(0.00584)	(0.00581)	(0.0172)	(0.00698)	(0.00721)	(0.0149)
infl	0.105***	0.0997***	0.171***	0.105***	0.0997***	0.171***
	(0.00986)	(0.0101)	(0.0248)	(0.0141)	(0.0139)	(0.0288)
unem	0.0208**	0.0273***	-0.0510***	0.0208**	0.0273**	-0.0510***
	(0.00594)	(0.00620)	(0.0100)	(0.00899)	(0.00993)	(0.00952)
lta	-0.135***	-0.127***	-0.160***	-0.135**	-0.127	-0.160***
	(0.0275)	(0.0319)	(0.0219)	(0.0605)	(0.0837)	(0.0211)
llr_gl	0.0188***	0.0111**	0.120***	0.0188**	0.0111	0.120***
	(0.00418)	(0.00425)	(0.00681)	(0.00820)	(0.00837)	(0.0138)
eq_ta	0.0236***	0.0139**	0.123***	0.0236**	0.0139	0.123***
	(0.00370)	(0.00384)	(0.00515)	(0.00892)	(0.0101)	(0.0143)
cir	-0.00304***	-0.00272***	-0.00977***	-0.00304***	-0.00272***	-0.00977***
	(0.000352)	(0.000351)	(0.000860)	(0.000693)	(0.000668)	(0.00130)
nl_ta	0.0249***	0.0250***	0.0233***	0.0249***	0.0250***	0.0233***
	(0.00158)	(0.00165)	(0.00210)	(0.00395)	(0.00449)	(0.00194)
nl_dstf	-0.000660	-0.000793	0.000963	-0.000660	-0.000793	0.000963
	(0.000518)	(0.000526)	(0.000836)	(0.000628)	(0.000634)	(0.000901)
la_dstf	0.00125	0.00222**	-0.00584***	0.00125	0.00222	-0.00584***
	(0.000835)	(0.000855)	(0.00127)	(0.00142)	(0.00153)	(0.00148)
bhhc	-0.0821	-	-0.0168	-0.0821	-	-0.0168
	(0.142)		(0.0601)	(0.208)		(0.0793)
coop	-0.851***	-	-0.748***	-0.851***	-	-0.748***
	(0.169)		(0.0756)	(0.191)		(0.0733)
rem	-1.632***	-	-1.480***	-1.632***	-	-1.480***
	(0.265)		(0.123)	(0.163)		(0.0945)
savings	-0.500**	-	-0.509***	-0.500**	-	-0.509***
	(0.211)		(0.0900)	(0.130)		(0.0562)
large	-0.0938	-	0.310**	-0.0938	-	0.310**
	(0.168)		(0.0967)	(0.259)		(0.0865)
small	0.248	-	-0.0373	0.248	-	-0.0373
	(0.181)		(0.0910)	(0.251)		(0.0980)
negrate	-0.158***	-0.139***	-0.494***	-0.158***	-0.139**	-0.494***
	(0.0324)	(0.0326)	(0.0959)	(0.0359)	(0.0365)	(0.0826)
capbas	1.193***	-	0.896***	1.193***	-	0.896***
	(0.136)		(0.0741)	(0.160)		(0.104)
Constant	2.773***	2.971***	3.361***	2.773**	2.971**	3.361***
	(0.493)	(0.547)	(0.402)	(0.954)	(1.363)	(0.390)
Number of observations	6930	6930	6930	6930	6930	6930
F/Wald statistic	1498.46***	69.02***	167.6***	1215.09***	44.42***	195.0***
R-squared	0.276	0.152	0.348	0.276	0.152	0.348
Hausman test	265.62***	-	-	-	-	-

Note: Standard errors in parentheses. Wald statistic used for random effects models.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

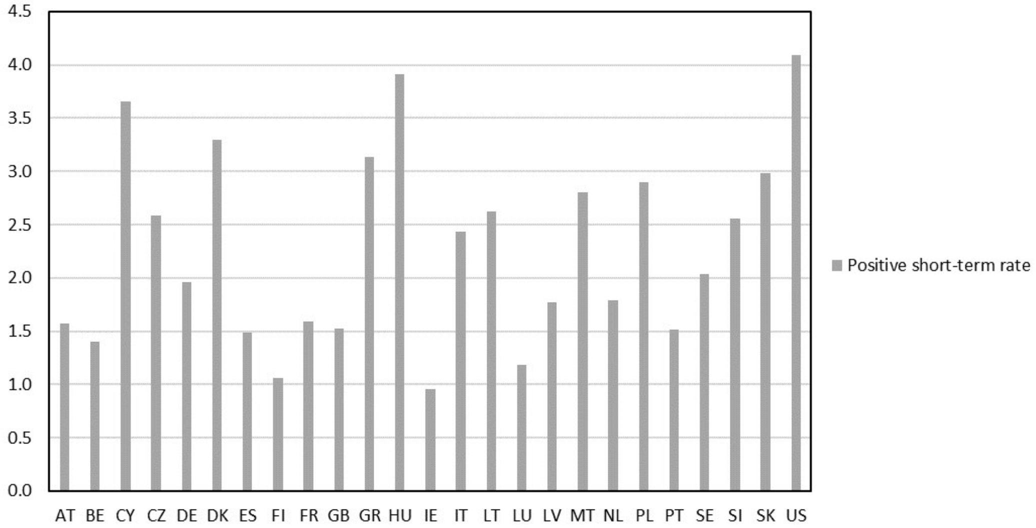
Table A.4: Comparison of S-GMM, FE, and Pooled OLS with lagged dependent variable

	FE nim	S-GMM nim	Pooled OLS nim
L.nim	0.238***	0.846***	0.941***
	(0.0708)	(0.0286)	(0.0270)
st_ir	0.162**	0.108***	0.132**
	(0.0793)	(0.0325)	(0.0524)
st_ir_sq	-0.0259***	-0.0223***	-0.0258***
	(0.00831)	(0.00633)	(0.00823)
spread	0.0366	-0.00847	-0.0163
	(0.0229)	(0.0131)	(0.0139)
spread_sq	-0.00196*	-0.000895	-0.000514
	(0.00104)	(0.000822)	(0.000710)
gdp	0.0196***	0.0145***	0.00934**
	(0.00616)	(0.00518)	(0.00425)
infl	0.0674***	0.0591***	0.0513***
	(0.0149)	(0.0112)	(0.0118)
unem	0.0188*	-0.00322	0.000736
	(0.0113)	(0.00337)	(0.00293)
lta	-0.229***	-0.0108	-0.00388
	(0.0839)	(0.00926)	(0.00716)
llr_gl	0.00309	0.0128***	0.00821**
	(0.00676)	(0.00403)	(0.00335)
eq_ta	0.0232**	0.0128**	0.00984**
	(0.0105)	(0.00551)	(0.00447)
cir	-0.00266***	-0.00114**	-0.000547
	(0.000706)	(0.000461)	(0.000601)
nl_ta	0.0141***	0.00535***	0.00337***
	(0.00334)	(0.000920)	(0.00101)
nl_dstf	-0.000711	-0.0000578	0.0000360
	(0.000586)	(0.000301)	(0.000183)
la_dstf	0.000756	-0.000244	0.000376
	(0.00104)	(0.000507)	(0.000377)
bhhc	-	0.0285	0.0382
		(0.0225)	(0.0287)
coop	-	-0.106***	-0.0758***
		(0.0282)	(0.0207)
rem	-	-0.177***	-0.0462
		(0.0565)	(0.0354)
savings	-	-0.0608***	-0.0425**
		(0.0235)	(0.0191)
large	-	0.0261	0.0217
		(0.0380)	(0.0291)
small	-	0.0194	-0.00109
		(0.0315)	(0.0305)
negrate	-0.0339	-0.00686	0.0425*
	(0.0366)	(0.0227)	(0.0246)
capbas	-	0.0902**	0.00190
		(0.0379)	(0.0639)
Constant	4.426***	0.0216	-0.223*
	(1.442)	(0.170)	(0.124)
Number of observations	5775	5775	5775
F/Wald statistic	58.41***	26351.05***	2345.8***
R-squared	0.208	-	0.941

Note: Robust standard errors in parentheses. Wald statistic for system GMM.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

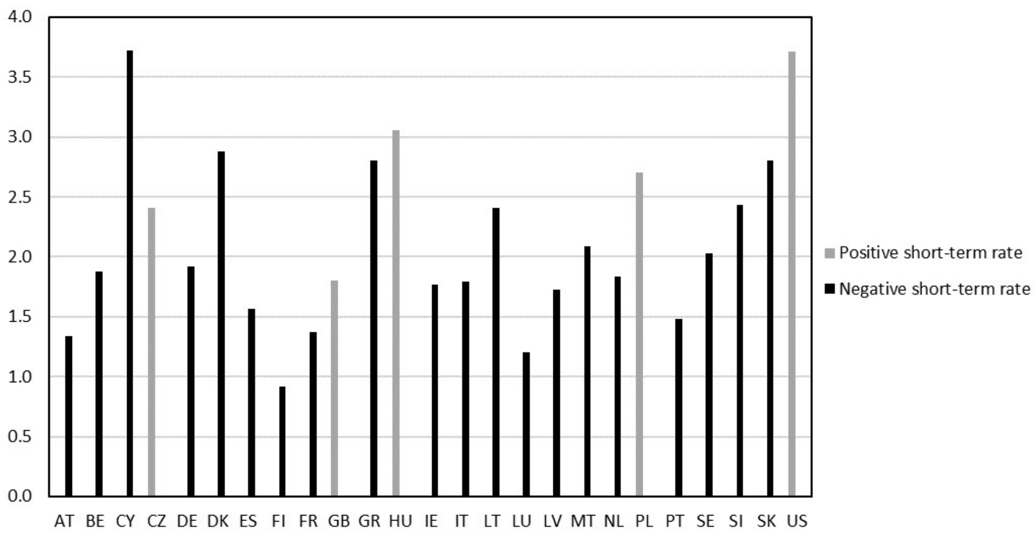
Figure A.1: Average NIM in 2011 by countries (%)



Note: AT - Austria, BE - Belgium, CY - Cyprus, CZ - Czech Republic, DE - Germany, DK - Denmark, ES - Spain, FI - Finland, FR - France, GB - United Kingdom, GR - Greece, HU - Hungary, IE - Ireland, IT - Italy, LT - Lithuania, LU - Luxembourg, LV - Latvia, MT - Malta, NL - Netherlands, PL - Poland, PT - Portugal, SE - Sweden, SI - Slovenia, SK - Slovakia, US - United States of America

Source: Author based on Orbis Bank Focus, Eurostat and FRED.

Figure A.2: Average NIM in 2016 by countries (%)



Note: AT - Austria, BE - Belgium, CY - Cyprus, CZ - Czech Republic, DE - Germany, DK - Denmark, ES - Spain, FI - Finland, FR - France, GB - United Kingdom, GR - Greece, HU - Hungary, IE - Ireland, IT - Italy, LT - Lithuania, LU - Luxembourg, LV - Latvia, MT - Malta, NL - Netherlands, PL - Poland, PT - Portugal, SE - Sweden, SI - Slovenia, SK - Slovakia, US - United States of America

Source: Author based on Orbis Bank Focus, Eurostat and FRED.

Appendix B

Additional Analyses for Models in Chapter 5

Table B.1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
nim	2.09	1.55	-0.53	31.65
st_ir	0.47	0.79	-0.49	8.05
spread	2.4	1.78	-0.41	21.93
gdp	0.70	2.09	-9.1	25.6
infl	1.3	1.32	-1.5	5.7
unem	9.74	3.59	4	27.5
hi	0.06	0.04	0.03	0.37
lta	15.19	2.51	10.31	21.75
llr_gl	4.69	4.45	-2.2	46.41
eq_ta	9.56	5.03	-3.93	63.57
cir	66.55	29.28	0.03	851.20
nl_ta	59.47	17.57	1.8	97.57
nl_dstf	91.37	47.68	3.78	827.06
bhhc	0.04	0.2	0	1
coop	0.43	0.5	0	1
rem	0.07	0.26	0	1
savings	0.08	0.27	0	1
large	0.21	0.41	0	1
small	0.36	0.48	0	1
Number of observations		3774		
Number of groups		629		
Observations per group		6		

Source: Author's calculation in Stata 11.2.

Table B.2: Cross-correlation table

Variables	nim	st_ir	spread	gdp	infl	unem	hi	lta	llr_gl	eq_ta	cir	nl_ta	nl_dstf	bhhc	coop	rem	savings	large	small
nim	1.00																		
st_ir	0.13	1.00																	
	(0.00)																		
spread	0.06	0.09	1.00																
	(0.00)	(0.00)																	
gdp	-0.04	0.05	-0.61	1.00															
	(0.01)	(0.00)	(0.00)																
infl	0.06	0.59	0.36	-0.28	1.00														
	(0.00)	(0.00)	(0.00)	(0.00)															
unem	-0.02	-0.14	0.54	-0.35	-0.20	1.00													
	(0.13)	(0.00)	(0.00)	(0.00)	(0.00)														
hi	0.04	0.02	-0.02	0.13	-0.05	0.05	1.00												
	(0.01)	(0.30)	(0.33)	(0.00)	(0.00)	(0.00)													
lta	-0.26	0.09	-0.21	0.24	0.02	-0.12	0.23	1.00											
	(0.00)	(0.00)	(0.00)	(0.00)	(0.26)	(0.00)	(0.00)												
llr_gl	0.14	-0.10	0.18	-0.06	-0.24	0.37	0.11	-0.14	1.00										
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)											
eq_ta	0.29	-0.02	0.03	-0.03	-0.02	0.02	-0.09	-0.49	0.04	1.00									
	(0.00)	(0.27)	(0.03)	(0.07)	(0.26)	(0.22)	(0.00)	(0.00)	(0.01)										
cir	-0.02	0.01	-0.00	0.02	0.08	-0.12	-0.09	-0.07	-0.01	0.08	1.00								
	(0.19)	(0.44)	(0.93)	(0.14)	(0.00)	(0.00)	(0.00)	(0.00)	(0.38)	(0.00)									
nl_ta	0.14	0.12	0.08	-0.02	0.09	-0.02	0.06	-0.01	-0.08	-0.10	-0.15	1.00							
	(0.00)	(0.00)	(0.00)	(0.14)	(0.00)	(0.34)	(0.00)	(0.41)	(0.00)	(0.00)	(0.00)								
nl_dstf	-0.01	0.13	0.05	-0.06	0.11	-0.04	0.05	0.05	-0.15	-0.04	-0.19	0.59	1.00						
	(0.40)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)							
bhhc	0.07	0.04	-0.09	0.09	0.03	-0.12	0.03	0.23	-0.11	0.00	0.03	-0.11	-0.03	1.00					
	(0.00)	(0.02)	(0.00)	(0.00)	(0.03)	(0.00)	(0.04)	(0.00)	(0.00)	(0.92)	(0.08)	(0.00)	(0.10)						
coop	0.00	-0.12	0.26	-0.33	-0.02	0.25	-0.34	-0.52	0.08	0.20	-0.06	-0.01	0.03	-0.18	1.00				
	(0.87)	(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.54)	(0.11)	(0.00)					
rem	-0.17	0.03	-0.17	0.16	0.02	-0.23	-0.00	0.13	-0.20	-0.16	-0.09	0.25	0.36	-0.06	-0.24	1.00			
	(0.00)	(0.07)	(0.00)	(0.00)	(0.20)	(0.00)	(0.98)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)				
savings	0.01	-0.01	-0.06	0.02	-0.02	-0.04	-0.03	0.06	0.01	-0.04	0.01	0.12	-0.02	-0.06	-0.26	-0.08	1.00		
	(0.71)	(0.41)	(0.00)	(0.17)	(0.35)	(0.01)	(0.05)	(0.00)	(0.41)	(0.01)	(0.50)	(0.00)	(0.14)	(0.00)	(0.00)	(0.00)			
large	-0.19	0.06	-0.08	0.14	-0.00	0.04	0.18	0.77	-0.14	-0.33	-0.07	-0.06	0.07	0.21	-0.33	0.08	-0.05	1.00	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.91)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
small	0.18	-0.11	0.24	-0.27	-0.02	0.20	-0.24	-0.75	0.09	0.38	0.02	-0.05	-0.00	-0.14	0.55	-0.13	-0.20	-0.39	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.22)	(0.00)	(0.85)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	

Note: p-values in parentheses.

Source: Author's calculation in Stata 11.2.

Table B.3: Static panel methods estimation results

	RE	FE	Pooled OLS	RE	FE	Pooled OLS
	(Normal standard errors)			(Robust standard errors)		
	nim	nim	nim	nim	nim	nim
st_ir	0.113***	0.0936**	0.395***	0.113**	0.0936**	0.395**
	(0.0275)	(0.0274)	(0.0656)	(0.0463)	(0.0472)	(0.111)
st_ir_sq	-0.0114**	-0.0116**	-0.0385**	-0.0114*	-0.0116*	-0.0385*
	(0.00500)	(0.00498)	(0.0126)	(0.00632)	(0.00638)	(0.0197)
spread	0.0891***	0.0844***	-0.0917**	0.0891***	0.0844***	-0.0917**
	(0.0179)	(0.0184)	(0.0359)	(0.0169)	(0.0185)	(0.0464)
spread_sq	-0.00374***	-0.00394***	0.00558**	-0.00374***	-0.00394**	0.00558**
	(0.000890)	(0.000908)	(0.00209)	(0.000953)	(0.00106)	(0.00223)
gdp	-0.0142**	-0.00936	-0.0524**	-0.0142	-0.00936	-0.0524**
	(0.00641)	(0.00645)	(0.0145)	(0.0102)	(0.00972)	(0.0173)
infl	-0.000859	0.00689	-0.00438	-0.000859	0.00689	-0.00438
	(0.0124)	(0.0125)	(0.0290)	(0.0198)	(0.0191)	(0.0325)
unem	-0.0283***	-0.0245**	-0.0475***	-0.0283**	-0.0245**	-0.0475***
	(0.00697)	(0.00749)	(0.00959)	(0.00854)	(0.00981)	(0.00870)
hi	-0.279	-1.474	1.020*	-0.279	-1.474*	1.020**
	(0.805)	(1.033)	(0.551)	(0.702)	(0.824)	(0.501)
lta	-0.0400	0.104**	-0.192***	-0.0400	0.104	-0.192***
	(0.0359)	(0.0489)	(0.0230)	(0.0692)	(0.128)	(0.0245)
llr_gl	0.0104**	0.00747*	0.0566***	0.0104*	0.00747	0.0566***
	(0.00413)	(0.00429)	(0.00569)	(0.00559)	(0.00613)	(0.00560)
eq_ta	0.0167**	0.0154**	0.0639***	0.0167	0.0154	0.0639***
	(0.00436)	(0.00471)	(0.00529)	(0.0102)	(0.0144)	(0.0133)
cir	-0.00235***	-0.00197***	-0.00377***	-0.00235**	-0.00197**	-0.00377***
	(0.000374)	(0.000378)	(0.000783)	(0.000646)	(0.000685)	(0.000593)
nl_ta	0.0209***	0.0220***	0.0208***	0.0209***	0.0220***	0.0208***
	(0.00190)	(0.00206)	(0.00214)	(0.00318)	(0.00353)	(0.00196)
nl_dstf	-0.00130**	-0.00121**	-0.00281***	-0.00130**	-0.00121*	-0.00281***
	(0.000510)	(0.000527)	(0.000695)	(0.000656)	(0.000653)	(0.000625)
la_dstf	0.000498	0.00135	-0.00266**	0.000498	0.00135	-0.00266*
	(0.000885)	(0.000912)	(0.00128)	(0.00128)	(0.00151)	(0.00149)
bhhc	0.807**	-	0.841***	0.807	-	0.841**
	(0.270)		(0.117)	(0.911)		(0.338)
coop	-0.716***	-	-0.597***	-0.716***	-	-0.597***
	(0.138)		(0.0648)	(0.160)		(0.0738)
rem	-1.276***	-	-1.020***	-1.276***	-	-1.020***
	(0.213)		(0.102)	(0.139)		(0.0756)
savings	-0.311	-	-0.286**	-0.311*	-	-0.286***
	(0.203)		(0.0890)	(0.161)		(0.0720)
large	-0.385**	-	0.354**	-0.385	-	0.354***
	(0.182)		(0.0974)	(0.308)		(0.0792)
small	0.557**	-	0.0902	0.557**	-	0.0902
	(0.162)		(0.0814)	(0.246)		(0.0937)
Constant	1.857**	-0.656	4.125***	1.857*	-0.656	4.125***
	(0.612)	(0.789)	(0.407)	(1.045)	(2.038)	(0.478)
Number of observations	3774	3774	3774	3774	3774	3774
F/Wald statistic	811.11***	45.67***	60.00***	888.68***	43.46***	96.83***
R-squared	0.188	0.180	0.251	0.188	0.180	0.251
Hausman test	91.83***	-	-	-	-	-

Note: Standard errors in parentheses. Wald statistic used for random effects models.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.

Table B.4: Comparison of S-GMM, FE, and Pooled OLS with lagged dependent variable

	FE nim	S-GMM nim	Pooled OLS nim
L.nim	0.110	0.862***	0.928***
	(0.0951)	(0.0159)	(0.0748)
st_ir	0.328***	0.143***	0.110**
	(0.0971)	(0.0231)	(0.0442)
st_ir_sq	-0.0332***	-0.0268***	-0.0256***
	(0.00834)	(0.00541)	(0.00774)
spread	0.0820***	-0.0226*	-0.0545***
	(0.0236)	(0.0128)	(0.0206)
spread_sq	-0.00391***	-0.000912	0.000805
	(0.00109)	(0.000751)	(0.000868)
gdp	0.0156**	0.00848**	0.00801
	(0.00701)	(0.00418)	(0.00520)
infl	0.0134	0.0547***	0.0735***
	(0.0295)	(0.0106)	(0.0168)
unem	-0.0289	0.00247	0.0112*
	(0.0194)	(0.00301)	(0.00592)
hi	-1.116	0.490**	0.206
	(1.053)	(0.208)	(0.199)
lta	-0.240	-0.0210**	-0.0145
	(0.195)	(0.00819)	(0.0149)
llr_gl	-0.000603	0.00746***	0.00535
	(0.00667)	(0.00195)	(0.00401)
eq_ta	0.0174	0.00588**	0.00850
	(0.0168)	(0.00262)	(0.00595)
cir	-0.00258***	-0.000778**	-0.000298
	(0.000747)	(0.000309)	(0.000562)
nl_ta	0.0157***	0.00436***	0.00334*
	(0.00422)	(0.000819)	(0.00195)
nl_dstf	-0.00102	-0.000283	-0.000188
	(0.000653)	(0.000204)	(0.000396)
la_dstf	0.000760	-0.000109	0.0000810
	(0.00106)	(0.000505)	(0.000492)
bhhc	-	0.0274	0.110
		(0.0462)	(0.136)
coop	-	-0.0835***	-0.0745***
		(0.0190)	(0.0271)
rem	-	-0.116***	-0.0493
		(0.0373)	(0.0692)
savings	-	-0.0486**	-0.0533**
		(0.0230)	(0.0227)
large	-	0.0603**	0.0501
		(0.0286)	(0.0404)
small	-	0.00796	-0.0139
		(0.0230)	(0.0368)
Constant	4.744	0.216	-0.0360
	(3.028)	(0.148)	(0.316)
Observations	3145	3145	3145
F/Wald statistic	58.12***	13576.7***	619.46***
R-squared	0.209	-	0.887

Note: Robust standard errors in parentheses. Wald statistic for system GMM.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculation in Stata 11.2.