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Linkages between financial sector and real output - empirical evidence from the Czech Republic

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Abstract

This thesis studies various ways in which the financial sector may affect the real economy. Particular attention is devoted to the bank lending channel of monetary transmission which amplifies monetary policy through changes in the supply of bank loans. We analyze the theoretical foundations of this channel, review international empirical literature and identify characteristic features of Czech financial system. Due to the important role of bank loans in the Czech Republic and the limited availability of alternative sources of finance, we hypothesize that the channel should be operative in the Czech Republic. Using a VEC model we analyze aggregate data for 2001-2011. Impulse response functions are then used to identify responses of the lending rate and the amount of loans to a monetary shock. Based on these responses we conclude the bank lending channel was operative.

JEL Classification	E44, E51, E52, G21
Keywords	credit channel, bank lending channel, bank loans, real output, financial sector

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Abstrakt

Tato práce se zabývá způsoby, jakými finanční sektor ovlivňuje reálnou ekonomiku. Zvláštní pozornost je věnována bankovnímu kanálu transmisního mechanismu měnové politiky, který může zesilovat účinky měnové politiky prostřednictvím změn v nabídce bankovních úvěrů. V práci jsou rozebrány teoretické základy bankovního kanálu, jsou vyhodnoceny empirické studie týkající se bankovního kanálu a také jsou popsány charakteristické znaky českého finančního systému. S ohledem na důležité postavení bankovních úvěrů a omezenou dostupnost alternativních zdrojů financování je vyslovena hypotéza o existenci bankovního kanálu v České republice. S využitím VEC modelu analyzujeme data z let 2001-2011 a s pomocí funkcí odezev na impuls jsou zkoumány reakce výpůjční sazby a objemů úvěrů na měnové šoky. Na základě těchto reakcí je přijat závěr, že bankovní kanál v České republice ve zkoumaném období českou ekonomiku ovlivňoval.

Klasifikace JEL	E44, E51, E52, G21
Klíčová slova	úvěrový kanál, bankovní kanál, bankovní úvěry, reálný výstup, finanční sektor

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Acronyms

ADF Augmented Dickey-Fuller test

AIC Akaike Information Criterion

CCI Cost of Credit Intermediation

CZK Czech koruna

ECB European Central Bank

GDP Gross domestic product

GDP Generalized least squares

HQC Hannan-Quinn Criterion

MAIC Modified Akaike Information Criterion

PRIBOR Prague Interbank Offered Rate

SBIC Schwarz/Bayes Information Criterion

USD United States dollar

VAR Vector autoregression

VEC Vector error correction

VECM Vector error correction model

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Garant studijního programu Vám dle zákona č. 111/1998 Sb. o vysokých školách a Studijního a zkušebního řádu UK v Praze určuje následující bakalářskou práci

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Charakteristika tématu, současný stav poznání, případné zvláštní metody zpracování tématu:

The goal of the thesis is to explore the effects a financial system has on the real economic activity. Particular attention will be paid to the bank lending channel - a mechanism that under some assumptions magnifies the effect of monetary policy. The underlying economic theory as well as foreign empirical research about the effects of credit availability will be discussed. Based on this theory, a hypothesis about the existence of the bank lending channel in the Czech Republic will be tested in an econometric model. The model will use publicly available data, especially data on monetary aggregates from Czech National Bank and on inflation and GDP growth from Czech Statistical Office. The data will most likely cover period 2002-2011.

Economic literature will be surveyed in order to identify the prevalent theory on the effect of bank lending on real output. Empirical papers from foreign countries will be discussed and their results compared to the theory. Possible conflicting results will be explained. In the second half of the thesis, a hypothesis concerning the Czech Republic will be formed, based on an analysis of characteristics of Czech economy. To test the hypothesis, an econometric model will be used.

Struktura BP:

I would like to confirm or refute the following hypothesis: (i) Current economic theory is unified in predicting that bank lending shall have a significant effect on real output. (ii) The effect of bank lending on output is stronger in Europe than in the USA, because of different

practices of corporate financing. (iii) Given the structure of Czech financial system, macro-financial linkages are very important in the Czech Republic and this hypothesis can be tested by an econometric model.

Osnova

1. Introduction – theory of macro-financial linkages
2. Empirical evidence from other countries. Discussion of possible inconsistencies
3. Outline of Czech financial an banking system and the hypothesis about the bank lending channel in the Czech Republic
4. Econometric model, testing the hypothesis
5. Conclusion

Seznam základních pramenů a odborné literatury:

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Chapter 1

Introduction

When the financial crises developed into a global recession in 2008, it was a reminder of how important has a financial system become in a modern economy. But apart from occasionally destabilizing it, the financial system has many other effects on the real economy. This thesis is devoted to studying these effects, particularly the effect a structure of the financial system has on the transmission of monetary policy. The rest of the thesis is divided into six parts.

In Chapter Two we outline some important effects a financial sector may have on an economy. We firstly discuss important theories of how development of a financial sector contributes to an economic growth and then we proceed to describe the so-called credit channel - a mechanism which affects the impact of monetary policy through the availability of bank loans. The credit channel itself operates through affecting the balance sheet of both borrowers and banks: the former conduit is called the balance sheet channel, the latter is known as the bank lending channel.

The third chapter covers the more controversial of the two sub-channels – the bank lending channel. The rationale behind the bank lending channel is that under certain conditions the outcomes of monetary policy of a central bank are magnified through a change of the amount of loans provided by banks. The intensity of this magnifying mechanism is not constant; it changes in time but also across different countries. What matters is chiefly the availability of alternative sources of finance. We discuss the validity of the assumptions of the bank lending channel, as well as the microeconomic logic behind it.

Chapter Four is an overview of empirical findings about the existence of the bank lending channel in the World. We will use these findings in Chapter Five, where we identify aspects of the Czech financial and banking system that could be relevant to the existence of an operating bank lending channel. Combining our knowledge about these aspects with results from the reviewed theoretical and empirical literature, we make a hypothesis that the bank lending channel should be operating in the Czech Republic.

This hypothesis will be tested in Chapter Six. Due to cointegration among our variables, we estimate a Vector error correction model and derive impulse response functions, from whose behaviour we infer that the bank lending channel was probably operative in 2001-2011. Our findings are then summarized in Chapter Seven.

Chapter 2

Different effects of the financial sector on the real economy

However surprising it might seem today, the important economic theories in the 20th Century often underestimated or downright ignored the importance of a financial system for a real economy. Some dominant macroeconomic schools of thought, such as Keynesianism or Monetarism, did not study credit markets, instead studying only the market in money; others, such as proponents of the Real business cycle theory, considered the financial structure downright irrelevant (Gertler 1988). In this chapter we first give a very brief and necessarily selective overview of the important theories that changed how economists viewed the financial sector. We then proceed to describe some basic links through which the financial sector influences the real economy. The rest of the thesis is then primarily devoted to studying one of those links - the bank lending channel.

2.1 The role of financial system in economic thought

The perception that the link between financial sector and economic output should be important is not new – in fact it was noted not later than in 1904 by Thorstein Veblen (Gertler 1988). This issue naturally received much attention during the Great Depression which followed the Stock market crash of 1929 and more than 9,000 banks suspended their operations during the period 1930-1933 when the Depression hit the United States the hardest (Mankiw 2010). This led some economists, including the most cited pre-Depression economist Irving Fisher to suspect that the troubles of the financial system contributed to

the collapse of the real economy (Snowdon & Vane 2005). Fisher argued that the direct cause of the economic slowdown were excessive debts; the indirect and more significant effect then was, Fisher argued, that the declining prices increased the real debt burden by roughly 40 percent, deteriorating borrowers' balance sheet (Gertler 1988).

But Fisher's ideas did not remain influential for long because, following the publication of The General Theory of Employment, Interest and Money in 1936, economics were for many decades dominated by Keynesianism. Though Keynes himself believed that some elements of financial system matter, his followers focused more on money, rather than on credit, in line with the liquidity preference theory (Gertler 1988). Some of the Keynes's ideas could in fact be characterized as reflecting modern economic thinking: for example Keynes argued that lenders' confidence was necessary for the return to prosperity and that this "confidence depended on lenders' perceptions of how well borrowers' incentives were aligned with their own" (Gertler 1988)– echoing modern notions of asymmetric information and principal-agent problem.

Gurley & Shaw (1955) discussed how the financial sector was important for economic development (their work is discussed in more detail in section 2.2) but their results were overshadowed by Modigliani and Miller who proved in their influential papers that under certain conditions the financial structure of a company did not affect the company's value. Since this "irrelevance theorem" meant that it did not matter whether a firm financed its investments through loans or securities, it largely eliminated the special role of banks. As will be explained below, the special role of banks is a necessary condition for the existence of a credit channel and the Miller-Modigliani theorem thus implied that monetary policy can have only a transitory effect on real variables (Freixas & Rochet 2008).

Another important moment in the development of the economic theory was the publication of a study of U.S. monetary history by Milton Friedman and Anna Schwartz. They offered an explanation of the Great Recession in which the problems of banks led to the troubled state of the economy - through the reduction of money supply and the wealth of banks' shareholders (Bernanke 1983). Their view remained influential to these days, but since they focused on the role of money in the economy, Friedman & Schwartz de-emphasized the

role of other aspects of the financial sector (Gertler 1988).

The crucial contributions that set the tone of research up to these days are due to Ben Bernanke. Drawing on Friedman & Schwartz but incorporating the theory of incomplete markets, Bernanke (1983) argued that the market incompleteness could explain both the unusual length and the depth of the Depression. Bernanke's paper has become the basis for future discussions of the links between financial system and real output, and it therefore deserves some attention.

Bernanke (1983) describes a simple but sensible model of an economy in which the real service of banks is differentiating between "good" and "bad" borrowers. The cost of channeling funds from the depositors to the good borrowers is what Bernanke calls "the cost of credit intermediation" (CCI). He then goes on to explain the effect that the banking crises and the company bankruptcies had on the CCI during years 1930-1933. Firstly, the fear of bank runs led banks to increase reserves and seek more liquid assets then before. The following contraction of credit was partly offset by non-bank institutions, but Bernanke notes that this switch from banks increased the CCI because of the banks' expertise and existing customer relationships. Secondly, Bernanke discusses the impact of widespread company bankruptcies in the period between years 1930-1933: in his opinion the "debtor insolvency necessarily raised the CCI for banks". He argues that the banks' potential response -– increasing interest rates – could be counter-productive, since it would increase a risk of default. The banks thus resorted to not making loans to borrowers they might have lent to in better times. Importantly, Bernanke then identified two channels in which the constrained credit could have affected the real output: firstly through "effects on aggregate supply" and secondly through "a more reduced feasibility of effective risk sharing and greater difficulties in funding large, indivisible projects" (Bernanke 1983).

Following the publication of Bernanke's seminal paper, many important studies have been published that further developed the notions of the credit channel. Since this thesis is mostly concerned with the credit channel, the influential literature is discussed in the following chapters. For now we only briefly describe two general links between the financial sector and the economic output.

2.2 Financial sector and economic development

The issue of whether the development of financial services if beneficial for the whole economy is certainly crucial, particularly for developing countries (Freixas & Rochet 2008). The "Great Recession" of recent years has however provided a ground for this debate even in developed countries, though, to my knowledge, the debate has been waged at a popular, non-academic level (e.g. Chang 2011, Shiller 2012).

The importance of financial system for economic development has been stressed for example by Joseph Schumpeter but the link was treated more systematically by Gurley & Shaw (1955) who, after criticizing shortcomings of Keynesian liquidity-preference model, described how financial intermediaries serve a useful function (at macro level) in aligning the mismatch between preferences of agents with a surplus and preferences of agents with a deficit of financial assets. Financial intermediaries thus help to keep the interest rates at a lower levels then would be a result of direct lending between the two groups of agents. This smoothing of the access to funds stimulates aggregate demand.

Gurley and Shaw were well aware of the problems of reverse causality and they were careful to stress that the "development of financial intermediaries [...] is both a determined and a determining variable in the growth process" (Gurley & Shaw 1955). Though they focused only on the American economy, their result that the development of financial markets contributes to general economic growth was soon confirmed for other countries as well and Freixas & Rochet (2008) concludes that there is plenty of evidence to the claim that development in financial sector *causes* economic growth.

Besides facilitating access to funds at better price and in larger quantity, financial intermediaries may contribute to economic growth in other ways. Freixas & Rochet (2008) lists the following functions:

- *Providing ex ante information.* This could include providing forecasts and ratings but also offering instruments such as futures.
- *Monitoring investment.* This service is provided for example by mutual funds that allow individual investors to share the costs of professional investment management.

- *Better risk management.* Besides the obvious role of insurance companies, other financial intermediaries facilitate risk management as well. For example mutual funds enable small investors to enjoy benefits of diversified portfolio which would otherwise not be possible, for example due to minimal required amounts of trades. Finally, modern financial engineering has considerably facilitated allocation of risk.

- *Mobilization of savings.* This function has many facets: from providing security to one's funds to stimulating savings through the development of specialized investment instruments.

- *Facilitating the exchange of goods and services.* A bank may for example provide a letter of credit, guaranteeing the seller of goods that he will receive a payment for the goods sold.

- *Financing technological development.* It has been suggested that countries without a developed financial system may not be able to obtain modern technologies (Freixas & Rochet 2008). This may cause economic divergence.

Special attention was paid to the issue whether market-based financial is superior to the bank-based financial system in terms of contributing to economic growth. Though some authors argued that this superiority depended on the stage of economic development (Freixas & Rochet 2008), Levine (2002) found there was no significant difference between the two afore-mentioned structures and the growth rather depended on the overall development of the financial system. As will be shown below, the distinction between the two types of financial structure is crucial for an existence of the transmission mechanism of monetary policy called the bank lending channel.

2.3 Financial system and the transmission of monetary policy

In past 50 years most economists have acknowledged the view once held only by monetarists that monetary policy has a short term effect on real economic activity. The mechanism is such that a monetary restriction increases short term interest rates, which in turn increases costs of credit, leading to reduced

investments and a decline in output. This mechanism has been called the interest rate channel (Mishkin 2004). The change of the amount of bank loans is due to the decreased demand for loans, and banks influence the effects of the change in monetary policy through the speed with which they adjust their own rates in reaction to a policy change (Cappiello *et al.* 2010).

Subsequent research however found that the interest rate channel is not able to explain certain observed effects of a change in a monetary policy. Bernanke & Gertler (1995) summarize these observed deviations from the behaviour predicted by the interest rate channel:

1. *Magnitude puzzle*: a change in monetary policy has a large effect on a real output but only a small effect on market interest rates.

2. *Timing puzzle*: the important components of GDP started to react only after the effects of a change in monetary policy on interest rates subsided.

3. *Composition puzzle*: Although monetary policy is thought to have effect mostly at short term rates, the component of spending that had the fastest and strongest reaction to a change in monetary policy was residential investment.

The effort to explain these puzzles has led to developing other possible channels of the transmission mechanism. One of them is the so-called risk-taking channel - a change of monetary policy changes the values of assets used as a collateral. This may change how banks perceive risks and subsequently even their lending practices (ECB 2008).

More attention was paid to the possibility to explain the observed deviations through the role of credit market imperfections. The mechanism which operates alongside the interest rate channel and which is based on those imperfections has been called the credit channel. Unlike the interest rate channel which predicts a change in demand, the credit channel implies that banks reduce a supply of loans after a monetary tightening.

The credit market imperfections such as incomplete information or costly enforcement of contracts insert a "wedge between the cost of funds raised externally [...] and the opportunity cost of internal funds" (Bernanke & Gertler 1995). This wedge is often called the external finance premium. The crucial

idea behind the credit channel is that the monetary policy affects not only market interest rates, but also the external finance premium (Bernanke & Gertler 1995). It can do so through two mechanisms - the balance sheet channel and the bank lending channel.

2.3.1 Balance sheet channel

The balance sheet channel stresses the effects the monetary policy has on the external finance premium through the change of borrowers' financial position (Gallegati 2005). Unlike the bank lending channel, this channel does not focus specifically on banks, but rather on the supply of funds from all intermediaries.

Bernanke & Gertler (1995) distinguish two direct effects of a financial tightening on borrowers' financial position. Firstly, rising interest rates increase the interest expenses, reducing cash flow and profits of the borrower – Bernanke and Gertler found in their study that the increase of interest payments accounted for 40 percent of the short-term decline in corporate profits. Secondly, "rising interest rates are also typically associated with declining asset values", reducing the value of borrowers' assets and the value of potential collateral (Bernanke & Gertler 1995). The higher is the proportional value of collateral to the amount of borrowed money, the lower is the risk assumed by the lender, which reduces the external finance premium. Furthermore a decline in the value of a company increases the moral hazard, because it implies the owner has a lower stake in the company (Mishkin 2004). For the balance sheet channel to have an effect on the real output, it is further necessary that the external finance premium rises for some borrowers to a degree that they may not be able to borrow at the market rate, but his is not a particularly restrictive assumptions.

Furthermore a company is affected by a change in monetary policy indirectly, because similar effects occur to the borrowers themselves as well as to their customers: the indirect effect of monetary tightening is then the borrowers' lower revenue (Bernanke & Gertler 1995).

2.3.2 Introduction to bank lending channel

Unlike the balance sheet channel which is thought to be well established, the existence of the bank lending channel seems "controversial" (Bernanke & Gertler 1995). It is based on the notion that for some classes of borrowers, especially

small firms and households, it is very hard to substitute bank loans for other source of external finance. A reduction of a supply of bank loans thus rises the external finance premium, because the bank-dependent borrowers have to incur extra costs to replace the bank loans, for example through trade credit.

For the bank lending channel to operate in an economy, it is necessary that banks change the supply of loans in response to a change of monetary policy and that some borrowers who rely on bank loans modify the level of investment in response to the change of supply. As both these conditions and the workings of the bank lending channel warrant a special discussion, we will cover the bank lending channel in greater detail in the following chapter.

We will conclude this chapter with a description of how the credit channel may explain the three puzzles mentioned above:

1. The magnitude puzzle can be explained for example by the bank lending channel. In the extreme case of credit rationing, the interest rates for large borrowers may actually decrease, but the production of bank-dependent credit-deprived borrowers decreases considerably.

2. The timing puzzle can be explained through the balance sheet channel. Even a transitory increase of interest rates raises the interest payments, reduces cash flows and the firm may borrow to smooth the cash flow reduction. But the worsening of cash flow and of the balance sheet could result in a non-transitory increase in the external finance premium which could explain the decline in the components of GDP long after the transitory increase in the short-term interest rate (Bernanke & Gertler 1995).

3. The sharp decrease in residential investment is linked both to the bank lending channel and balance sheet channel. A decrease in the value of assets that could serve as a collateral obviously leads to lower spending on housing. An important role of banks in financing housing investments and the absence of alternative sources, such as trade credit, results in lower residential investment if banks reduce loans supply after a monetary tightening.

Chapter 3

Bank lending channel

The bank lending channel focuses on the effects that monetary policy has on the supply of bank loans, and subsequently on the firms' (borrowers') business activity. Traditionally the channel rested on certain conditions which needed to be fulfilled for the channel to be present: (i) firstly, banks are not able to perfectly insulate themselves from a restrictive monetary policy which decreases their reserves and deposits; if the banks could readily rearrange their balance sheets, for example by replacing their squeezed deposits through other sources of funds, the bank lending channel would not occur, (ii) secondly, bank customers must not be able to replace credit with other sources of external finance (e.g. Oliner & Rudebusch 1996).[1] Under these assumptions, a restrictive monetary policy decreases bank deposits, which in turn leads to a decrease in the supply of loans. The result is a decrease in investment and total output. The mechanism can be expressed in the following scheme (based on Mishkin 2004):

$$M \downarrow \Longrightarrow Deposits \downarrow \Longrightarrow Loans \downarrow \Longrightarrow I \downarrow \Longrightarrow Y \downarrow$$

Since this mechanism works alongside the interest rate channel, the result of a monetary tightening is a larger decline in bank lending then would occur under interest channel alone.

In the following parts we describe the basic model of bank lending channel of Bernanke & Blinder (1988) with its implications, then go on to discuss the validity of assumptions of the traditional model, as well as recent developments in the theory of the bank lending channel.

[1] Freixas & Rochet adds a third condition which is probably implicitly assumed by other authors as well – price stickiness.

3.1 CC-LM model

The traditional IS-LM model gives a special role to a bank liability – money, while including bank asset (loans) in the bond market. Bernanke & Blinder (1988) noted this asymmetry as well as another shortcoming of the classical IS-LM model which does not distinguish between bank credit and bonds, despite theoretical and empirical arguments about special role of credit intermediaries.

Bernanke & Blinder assume that bank assets are composed of three assets: bonds (B_b), reserves (R) and loans (L_s) and that the only bank liability is deposits (D). Four markets are then modeled. Money market is represented by the standard LM curve. Equilibrium in the loan market is achieved when demand equals supply and the equilibrium loan rate ρ is expressed as a function of bond rate r, income y and bank reserves:

$$\rho = \Phi(r, y, R).$$

Once these two markets reach equilibrium, Walras law secures that bond market is in equilibrium as well. The remaining goods market is represented by the IS curve $y = Y(r, \rho)$. After substituting for ρ into IS curve, Bernanke and Blinder obtained a new curve

$$y = Y(r, \Phi(r, y, R))$$

which they called CC (commodities and credit) and which had the same negative slope as IS curve. Their paper summarizes results of comparative statics analysis - the most important implication being that a monetary expansion not only causes rightward shift of LM curve, but also a shift of CC curve in the same direction, amplifying the effects of monetary policy.

3.2 First assumption of the bank lending channel

As noted above, two conditions must be satisfied for the channel to operate: (i) the central bank must be able to shift loan supply schedule of banks and (ii) bank loans and other sources of finance are not perfect substitutes.

The first assumptions, called availability doctrine by Freixas & Rochet (2008), has been widely accepted to be reasonable in the United States until 1980's. The most important reason was wide applicability of so-called Regulation Q,

which put a cap on interest rates banks paid on their deposits. A tightening of monetary policy which reduced bank reserves typically led to a contraction of deposits as well, because banks could not offset declines in deposits by offering higher interest rates (Bernanke 2007). This led to so-called disintermediation as assets moved away from the banking sector to other areas of financial system – thus deteriorating access to funds for bank-dependent entities, such as small firms and households (Bernanke 2007). Bernanke moreover notes that in 1960's and 1970's banks had only limited alternative sources of funding besides deposits, and thus had a problem overcoming their decrease.

Deregulation of banking system and developments in financial innovation in 1980's led some to question the availability assumption. With the regulatory restrictions abandoned for most types of deposits in 1986, banks were suddenly able to attract new deposits by offering a higher interest rates. Some authors, most importantly Romer & Romer (1990), further noted banks' ability to easily replace deposits with alternative funds, particularly through issuance of certificates of deposit. Moreover, financial innovation in turn reduces the impact of disintermediation, particularly in the area of financing of housing (Bernanke & Gertler 1995). These developments even led one of the pioneers of the bank lending channel theory to call the availability assumption "controversial" (Bernanke & Gertler 1995) and to question the quantitative importance of lending channel in the United States itself (Bernanke 2007).

A strong argument against the presence of bank lending channel was proposed by Milne & Wood (2009). They suggest that the traditional bank lending channel is present only when, following monetary tightening, outflow of deposits exceeds the decline in lending. Their analysis of G8 countries however showed that in the economies observed this was not common as deposits were rather inelastic and did not respond strongly to the changes in monetary policy – only the structure of deposits changed, with monetary tightening leading to a decrease of sight deposits and an increase of time deposits. Their argument is however controversial as it contradicts theoretical results achieved by economists in this area of interest in past 20 years. While not discussing the econometric results in Milne and Wood's paper, Ahtik (2010) questions some of their theoretical conclusions; in his opinion the behavior of banks described by Milne and Wood would be irrational, as maintaining excessive resources would represent a cost to the banks.

Despite the noted skepticism of Ben Bernanke and contribution of Milne and Wood, the empirical evidence against the availability doctrine remains quite limited, as even the authors who question the effect of (potential) lending channel on real output found that monetary policy can affect bank's lending decisions (Driscoll 2004, Ashcraft 2006).

3.3 Second assumption of the bank lending channel

The second assumption for a long time seemed less controversial as it was understood that banks play a special role in financial markets which makes their services hard to substitute (Bernanke & Gertler 1995, Freixas & Rochet 2008). Evidence from the Great Depression showed that households, farmers and unincorporated businesses was the group with highest reliance on bank credit and also the group hardest hit by the recession (Bernanke 1983). Even though many small businesses switched to the trade credit during the Great Recession, this was not an argument against the assumption of bank dependence, as the assumption allows some degree of substitutability.

The special role of banks and their services is related to their better ability to deal with marker imperfections arising mostly from information asymmetries between borrowers and lenders. Banks have a special expertise in *ex ante* evaluation of loan applicants as well as in *ex post* monitoring of the borrowers' compliance with the loan terms. Though there are many models describing how banks deal with imperfect information (e.g. Freixas & Rochet 2008), Holmstrom & Tirole (1997) developed a model unifying the macroeconomic role of banks with their special role in dealing with imperfect information. It was later used by Tirole (2006) to explain bank lending channel.

3.3.1 Holmstrom-Tirole model of the bank lending channel

Tirole (2006) interprets bank lending channel as a mechanism describing the impact of banks' balance sheet on firms' real activity. Since we concluded that current economic theory is unified on the issue of the validity of the first assumption, Tirole's simplification does not reduce the usefulness of his analysis

which does not explicitly include the link between the policy of the central bank and the banks' balance sheet. The following discussion is based on Holmstrom & Tirole (1997) and Tirole (2006), unless stated otherwise. Only a simplified version of the model is discussed here, with some assumptions omitted for the sake of space and simplicity.

The formal model due to Holstrom and Tirole identifies three groups of risk-neutral economic agents: uninformed individual investors, banks (monitors) and firms (entrepreneurs). Investors and banks expect rates γ and χ respectively. The special nature of bank services is reflected in the fact that $\chi > \gamma$. If it did not hold, a bank could become an uninformed investor.

An entrepreneur wants to realize a project of size I and his net worth is A. The net worth is distributed according to a cumulative distribution function with domain $[0, \infty)$. The profit of the project could be R in case of success and 0 in case of failure. The real outcome depends on the effort of the entrepreneur. With a lot of effort, the probability of success is P_M while with less effort the probability is P_L ($P_L < P_H$, $P_H - P_L = \Delta P$) but the entrepreneur obtains a private benefit B (this benefit might include for example free time or kickbacks to a friend).

Usually, $A < I$ and the entrepreneur requires external funding. There are two basic ways of external financing: (i) indirect where the monitoring bank is involved or (ii) direct, when the entrepreneur borrows solely from the investor.

In the direct financing, profit R is distributed between entrepreneur and investor: $R = R_E + R_I$. Two conditions must be satisfied: firstly the "incentive compatibility condition" that the entrepreneur will work hard on the project: his utility from increased effort must be higher then his private benefit from not working hard: $\Delta P \cdot R_E > B$, and secondly "financing condition" $R_I > \gamma \cdot (I - A)$, where the right side represents income the investor would receive on the market and left side represents his expected income from the project. From these two inequalities, it is easy to obtain a level of net worth of the entrepreneur necessary for obtaining direct finance. This level is denoted $\bar{A}(\gamma)$ and the condition for direct financing is thus $A \geqq \bar{A}(\gamma)$.

For entrepreneurs whose net worth is below $\bar{A}(\gamma)$, indirect finance might be

available. Besides analogous financing condition and the condition related to entrepreneur's incentives, another conditions must be fulfilled, namely incentive compatibility condition of the bank monitor, whose benefit from better monitoring must not be lower then the costs associated with preventing entrepreneur's private benefit. As in the case of direct finance, a threshold net worth $\underline{A}(\gamma, \chi)$ may be identified, such that the entrepreneur may not obtain indirect finance if his net worth is less then the threshold: $A < \underline{A}(\gamma, \chi)$.

The crucial result is that in case of a credit crunch, defined by Holstrom & Tirole as a reduction in aggregate capital of intermediaries, aggregate investment decreases and the threshold $\underline{A}(\gamma, \chi)$ increases, leaving the marginal firms without access to external finance. At the same time at least one of the rates γ and χ also increases, hurting other weaker entrepreneurs as well. Tirole (2006) mentions that under some circumstances, financially stronger firms may even benefit from a credit crunch; indeed, this was exactly the situation in the United States during the Great Depression.

3.4 Recent developments in bank lending channel

As noted above, the deregulation and innovations in American financial sector have led to the validity of traditional bank lending channel being questioned, particularly in the United States. Bernanke (2007) proposed to focus on the bank capital and its determinants and how they influence the transmission mechanism - which is sometimes called the bank capital channel. As was mentioned above, the traditional explanation of bank lending channel is based on the ability of the central bank to influence bank's reserves. It has been noted that central banks, which use the interest rate as the principal policy instrument in inflation targeting, may not be able to influence banks' reserves (Egert & MacDonald 2009). Even in these situations a loan supply may be affected by a tight monetary policy through the bank capital channel. The following discussion of the bank capital channel is based on Egert & MacDonald (2009), unless stated otherwise.

There are three assumptions for the existence of such a channel: (i) banks incur costs in raising equity. This is probably a sensible assumption: legal rules impose significant transaction costs on raising additional equity, as special majorities of shareholders often have to approve such changes. Moreover

issuing shares in a stock market involves significant legal fees and related costs, especially in markets where liquid stock markets are not developed. Last but not least, since banks are in general assumed to have a privileged access to liquid financial markets, their effort to obtain financing via issuing shares may be interpreted as a signal that other well-informed institutions do not trust in the bank's financial health. In such a case the price of shares would probably reflect this concern. (ii) Second, also plausible, assumption is that bank assets (credit) and liabilities (deposits) have different maturities. (iii) The final and crucial assumption is that capital regulation influences banks' supply of credit. Under these assumptions, an increase in the interest rate increases the cost of deposits without changing the income from credit, due to the discrepancy in their maturities. This leads to a loss of the bank's capital. If the bank's capital is close to the minimum capital requirements, the bank has to reduce the supply of loans, because issuing new shares is assumed to be costly.

Indeed, many studies confirmed that bank capitalization is an important determinant for the intensity of the bank lending channel - less capitalized banks react more strongly to shocks in monetary policy (e.g. Gambacorta 2005 or Van den Heuvel 2006). With the onset of financial crisis in 2007 there is however some evidence that even the criterion of capitalization is not able to fully capture the workings of the bank lending channel (Gambacorta & Marques-Ibanez 2011). Gambacorta & Marques-Ibanez argue that a good model should include the changes in bank income during a crises, when fees from investment banking are significantly reduced - they observe that banks with a higher proportion of profitable but volatile non-interest income react to the monetary shocks more intensively.

Chapter 4

Bank lending channel - literature survey

The necessary conditions for the bank lending channel suggest that its presence depends of the structure of the financial system in given countries. In particular countries where banks are an important source of finance and where securities markets are not developed, the second condition for the bank lending channel is likely fulfilled. But the structure of the financial system might determine whether banks have enough possibilities to restructure their balance sheets in response to a monetary shock, and thus determine even the first assumption (Freixas & Rochet 2008).

But even in countries where banks play very large role in the economy, bank lending channel might be mitigated by the existence of banking networks (Egert & MacDonald 2009). What matters is then not the strength of a balance sheet of an individual bank, but the strength of the consolidated balance sheet of the whole group. The mitigation of the effects of monetary policy due to an affiliation with a banking group has been shown by Ashcraft (2006) in the United States and by Gambacorta (2005) in Italy.

Furthermore, bank dependency goes in some cases hand in hand with the existence of a relationship banking (i.e. dealing repeatedly with the same customer for long time). This can mean that banks try to provide an access to funds to their customers even if the monetary policy is tight (Ehrmann *et al.* 2001). On the other hand it should be noted that a bank-dominated financial sector does not necessarily imply relationship lending – Ehrmann and others identify

a number of European countries where banks are a very important source of company financing, but relationship banking is not important: for example Greece and Spain.

4.1 United States

The theory of credit channel was developed in the United States and many empirical studies were then carried out using U.S. data. The results are somehow conflicting, but in many ways instructive even for the rest of the world.

We will first briefly outline some features of American financial system. Compared to the Euro area, American system is considerably more "market-based" as American agents may obtain substantial funds from issuing debt securities and from the stock market and bank loans are not as dominant source as in Europe. ECB (2008) reported that the ratio of debt securities issued by non-financial firms to GDP in 2007 was 26 %, compared to 8 % in Euro area. The ratio of these debt securities to bank loans for non-financial institutions was was over 150 %, compared to 16 % in the Euro area (ECB 2008).[1] Finally, American stock markets are more capitalized then Euro area stock markets: the ratio of stock market capitalization to the GDP in the United States and Euro area was 112 % and 75 %, respectively (ECB 2008). It therefore seems that there exist available substitutes to bank loans. Furthermore, as noted above, financial innovation has led some to question the first assumption of the bank lending channel. It is therefore possible that the structure of U.S. financial system prevents the bank lending channel from operating. Now, we will survey the literature which studied the channel in the United States.

As described above, Bernanke (1983) argued that bank lending channel contributed to the severity and duration of the Great Depression. Bernanke & Gertler (1995) suggested how observed deviations from traditional economic theory could be explained by the bank lending channel even in an ordinary economic environment. Using firm-level data, Gertler & Gilchrist (1993) found that following monetary tightening the lending to small firms declines while the lending to large firms actually increases - this again confirmed some hypothesis of the bank lending channel, particularly that the external finance premium

[1] We are however slightly suspicious of this figure, as Hartman *et al.* (2003) puts the U.S. ratio at roughly 70 %.

is larger for smaller firms. On the other hand they did not find that the size of banks should determine the bank's response to a shock in monetary policy. By contrast Kashyap & Stein (1995) found that the size of the bank mattered in the response to the monetary tightening - they argue that it is harder for smaller banks to obtain nondeposit sources of external finance to substitute deposits. Hendricks & Kempa (2011) used Markov switching model to identify a bank lending channel in U.S. history. Their approach was original in that it assumed that the intensity of the bank lending channel is not constant in time, but changes. We nevertheless found their results inconclusive and discuss them in greater detail in Chapter Six. Brissimis & Delis (2009) attempted to identify loan supply functions of individual banks. They found that bonds and bank loans were perfect substitutes, both for banks and firms, and concluded that the bank lending channel must therefore be inoperative in the United States.

The main goal of the studies cited above was to test a certain assumption or a component of the theory of the bank lending channel, instead of its impact on the real output. On the other hand Driscoll (2004) and Ashcraft (2006) relied on a reduced-form model but did not find a significant effect on the real output.

While Vector autoregressions were the most popular method used by the previously mentioned studies, Driscoll (2004) used panel data, exploiting the fact that U.S. states are small open economies with a fixed exchange rate. To avoid the problem of reverse causality, he uses a two stage regression: in the first stage he regresses loans on money demand shocks, in the second he regresses output on loans. As an instrument for shocks to loan supply, he uses state-specific money demand shocks. In his first stage regression Driscoll showed that bank lending increases in response to an increase in bank reserves, which is the first assumption of the bank lending channel. But the second stage regression did not show any significant positive effect of increased lending on output. Driscoll thus concluded that U.S. firms are not bank-dependent and the second assumption of the bank lending channel is not fulfilled.

Ashcraft (2006) in contrast found that banks have a somewhat special function in the economy – but not special enough to cause a macroeconomic changes in economic output. He however also found that monetary policy affected the banks' lending.

Finally Bayoumi & Melander (2008) found that a decline of a capital/assets ratio of banks by one percent leads to a 1.5 percent decrease of the real GDP. Nevertheless it should be noted that they did not study separate bank lending channel as a mechanism magnifying a change in monetary policy, but instead described an overall framework of what happens after a tightening of lending practices.

Our conclusion from the survey of the literature concerning the United States is that the existence of a bank lending channel magnifying monetary policy is doubtful. This should not be surprising, since bank loans play a less important role in financing of firms in the United States than in Europe, and on the other hand bonds are more important as a source of funds in the U.S. then in Europe. An important result from the recent American literature is that the central bank is able to affect the supply of bank loans.

4.2 Europe

The literature concerning Europe is very extensive, even though it usually does not present new theoretical insights, but rather focuses on empirical studies in individual European countries. We will therefore discuss only studies that found conflicting results or studies that on the other hand confirmed previously mentioned notions. Given the different degree of importance of bank loans, we expect that bank lending channel is more likely to operate in Europe than in the United States.

Some of the most interesting results are presented by Čihák & Koeva Brooks (2009) and by Cappiello *et al.* (2010). Employing the same approach as Driscoll to a panel of Euro-area countries, both groups of researchers concluded that increases of supply of bank loans have a significant effect on real output. Though Cappiello et al. considered the possibility that the different results could stem from studying data from a different time period, they concluded that the principal explanation of different results is the strong position of the banking sector in Euro-zone.

Brissimis & Delis (2009) came with some surprising results that indicate that bank lending channel is not present in the United Kingdom or Germany but is operative in Greece. This result is surprising particularly in the German

case where banks are very important. The authors suggest that this is due to early liberalization of German banking system and a good access to interbank markets for funds. Other arguments against the existence of the credit channel could stem from the habit of relationship banking, which is very important in Germany but unimportant in Greece (Ehrmann *et al.* 2001). One should be however careful in interpreting the results of Brissimis & Delis, because a number of researchers obtained conflicting results for the countries mentioned: Huang (2003) and Alevizopoulou & Apergis (2012) found the bank lending channel operating in the United Kingdom and Hülsewig *et al.* (2004) observed it in Germany. It should however be noted that Brissimis and Delis study covered the period 1996-2003, while Huang's data came from 1975-1999 and Hülsewig et al. focused on the period 1975-1998. It is thus possible that one reason for the different findings are a gradual liberalization of banking and development of financial innovation (the latter reason is relevant particularly in the case of the United Kingdom) along with a change in economic climate, which was arguably more hostile in both countries in 1975-1985 then in 1996-2003. On the other hand Alevizopoulu & Apergis studied years 1999-2009.

A Euro-zone country where multiple studies confirmed the bank lending channel is Italy (Gambacorta 2005, Altunbas *et al.* 2002), which is in fact a country with important relationship lending (Ehrmann *et al.* 2001).

4.3 The rest of the world

Numerous other studies have studied the bank lending channel outside of Europe and the United States. We present only the results which provide some theoretical insight.

It is perhaps not surprising that the bank lending channel has been confirmed in many developing countries where markets with equities do not exist or are very limited. These countries include e.g. Kenya (Buigut 2010) and some countries of the South African Development Community (Botswana, Malawi, Namibia, South Africa and Zambia) (Lungu 2007).

The channel has been also confirmed in China using data from 1996-2006 (Dickinson *et al.* 2010). This result should not be taken for granted: Chinese banking system was dominated in the covered period by 4 major state-owned banks and

foreign banks were not allowed into the market until December 2006; Egert & MacDonald (2009) suggested that strong role of the state in banking sector might be a factor mitigating the existence of the bank lending channel.

Chapter 5

Relevant features of the Czech financial system

Before proceeding to the empirical part in Chapter Six we attempt to briefly identify some aspects of the Czech financial system that could be important to the existence of the bank lending channel in the Czech Republic.

Firstly we will try to assess the importance bank loans as the source of finance in the Czech Republic, using the criteria set out in Ehrmann *et al.* (2001). Their first criterion is a ratio of corporate debt securities to GDP. ARAD reports the outstanding debt securities of non-financial corporations to be CZK 199 bil. at the end of 2011 and GDP to be roughly CZK 3,800 bil., which puts the ratio at slightly more then 5 %. The authors set the criterion so that countries with "very important" banks had the ratio lower then 4 percent. It should however be noted that Ehrmann et al. used the data from 1997 and the ratio has in general increased over time, e.g. for Germany more than 20 times, from 0.4 percent in 1997 to more than 12 percent in 2011. The ratio is around 20% in Italy, a country in which the bank lending channel was confirmed by multiple studies.

The second criterion used by Ehrmann *et al.* (2001) is the ratio of corporate debt securities to corporate bank loans, and they consider countries with the ratio under 10 percent to have "very important banks". Czech loans to corporate sector were around CZK 828 bil. at the end of 2011, so the ratio is quite high, over 20 %. For Italy and Germany, the ratio is 27 % and 30 %, respectively.[1] Even though this ratio might suggest that there is a substitute

[1]We used Euro denominated data on loans for non-financial companies from the ECB database, USD-denominated data on corporate debt securities from the BIS database and

for loans, the aggregate data probably overstate the importance of bonds financing in the Czech Republic. Firstly the total amount of bonds more than doubled between 2006-2011 (older data are not available in ARAD). The reason could be a legislative change, since issuing bonds was not available for newly established companies until 2006, which significantly limited the use of "special purpose vehicles". Second reason why the ratio in our opinion exaggerates the importance of bonds is that only larger companies considered bonds as an available source of finance (Körner 2008). Moreover bond emissions have to be approved by the Czech National Bank, which creates an administrative burden not present in the case of bank loans. In this regard it should be noted that the Czech Parliament in May 2012 passed an amendment to the Czech Bonds Act (Act no. 190/2004 Coll., on bonds) which abolishes the duty to have the bonds emission approved by the Czech National Bank beforehand. These legislative changes could further increase the substitutability of bank loans and bonds.

Finally the market capitalization of Czech stock market is around CZK 1 trillion, around 25 percent of GDP. This is considerably less then the threshold of 60 % used by Ehrmann *et al.* (2001). Again, this ratio overstates the true importance of Czech stock market, because the market capitalization of ČEZ, a.s., an energy giant, accounts for more than one third of the total market capitalization of Prague Stock Exchange and altogether only 27 companies are listed.

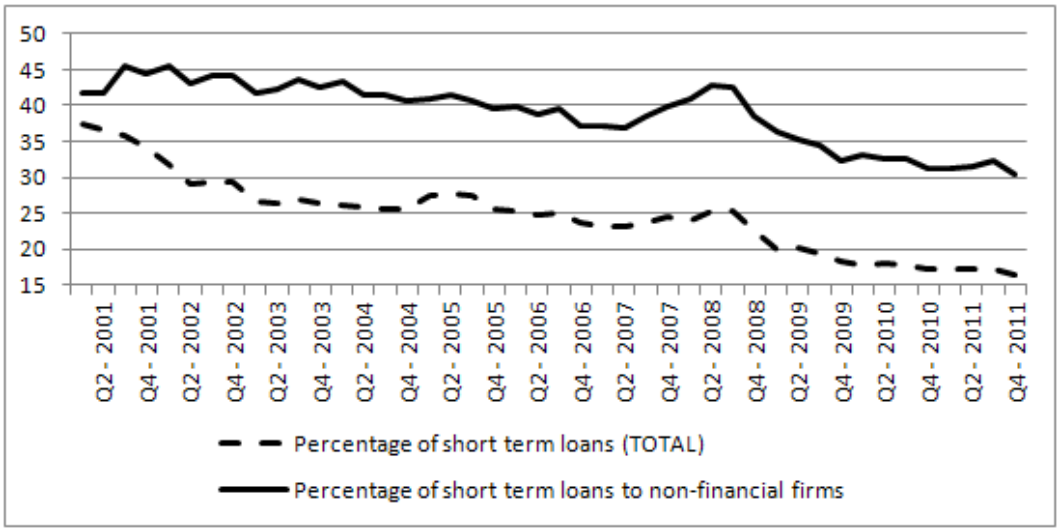
Based on the ratios and a comparison with some European countries in which the bank lending channel has been found operating, we conclude that bank loans are a very important source of finance for companies in the Czech Republic.

Ehrmann *et al.* (2001) further suggest that term structure of the loans is important, as a high share of short term loans implies that the loans have to be renewed more often, which makes the bank lending more responsive to changes in monetary policy. As we can see in Figure 5.1, for most of the period under study the ratio of short term loans (with a maturity no more than 1 year) was below 35 %, which is the threshold suggested by Ehrmann and others. The ratio was however significantly higher for loans to non-financial corporations,

USD/EUR exchange rate 1.377, which was the average in September 2011, the latest month recorded in the BIS database.

but previous studies (e.g. Pruteanu-Podpiera 2007) used the ratio with total loans in the denominator. Secondly, we discuss some of the characteristics of

Figure 5.1: Short term loans as a percent of total loans.



Source: ARAD, author's own calculations.

banking sector mentioned in previous chapters and other studies that could have a mitigating effect on the existence of the bank lending channel. For most of the period we study (2001-2011), the role of Czech government as an owner was not important, as the last major state-controlled bank was privatized in summer 2001. On the other hand the bank lending channel could be mitigated by good capitalization of Czech banks, that remained strong even during the recent financial crises (Report of the Czech National Bank on financial stability, 2010-2011). Finally Geršl & Jakubík (2009) found that a vast majority of Czech non-financial corporations borrow from only one lender; as discussed above this relationship lending could moderate the response of bank lending to changes in monetary policy.

A particular feature of Czech economy that could mitigate the bank lending channel is the importance of intra-group lending. This has been shown to be particularly high for German-owned companies in early stages of development (Geršl & Hlaváček 2007), and Körner (2008) confirmed that intra-group loans are not available to Czech firms without foreign ownership. The former study finds that intra group financing is more typical for smaller German-owned companies, which could mean that even smaller firms have a substitute to bank loans. Körner (2008) further finds that the share of intra-group loans in total

bank loans in a large sample of Czech companies (both foreign and domestic-owned) was substantial (24 % in 2004) and was increasing in 2000-2004 (form 18 % in 2000). This could mitigate the dependency on bank loans.

Finally we will evaluate the concentration in Czech banking sector. Comparing only concentrations is likely to miss the information about other more important conditions of banks, such as the absolute size or capitalization, but even the *ceteris* paribus effect of high market concentration is ambiguous. Pruteanu-Podpiera (2007) hypothesises that high concentration might bring additional rigidities via strengthening the supply side of loans, magnifying the bank lending channel. On the other hand Egert & MacDonald (2009) suggest that higher concentration implies larger banks with a better access to credit. This latter view was confirmed empirically by for example by Olivero *et al.* (2011). Both the Herfindahl-Hirschman index and the share of five biggest Czech banks suggest that Czech banking market in years 2004-2008 was more concentrated then the weighted averages of Eurozone and EU countries (ECB 2010). Both criteria for the Czech Republic are comparable to those of Greece, a country where the bank lending channel was identified (Brissimis & Delis 2009).

The previous discussion of Czech banking sector gives a conflicting clues about the existence of the bank lending channel. On one hand bank loans have been a very important source of funds, stock market is not greatly capitalized and bonds are only recently becoming an important source of finance. On the other hand relationship banking and the maturity structure of loans are factors that could mitigate the bank lending channel. Buchtíková (2001) studied firm-level data from 1995-1999 and found the channel operating. Pruteanu-Podpiera (2007) studied bank-level data and concluded that the bank lending channel existed in 1996-1998, but could not confirm it in 1999-2001. It could be argued that compared to the past, bank lending channel is more likely to occur in 2001-2011 due to the more market-oriented bank sector,[2] even though the importance of bank loans, as a source of funds, has probably decreased slightly, as has the share of short term loans.

Nevertheless as bonds and stock market remain less important in the Czech Republic then in many other countries with an operating bank lending chan-

[2]Previous studies cover periods of "banking socialism" and of company groups affiliated with banks.

nel, we propose that the bank lending channel operated in the Czech Republic in 2001-2011 and we will test this hypothesis in the following chapter.

Chapter 6

Empirical part

The principal goal of this chapter is an econometric study of the bank lending channel in the Czech Republic. Before proceeding to specifying and testing our model we briefly describe empirical methods used by others.

Probably the most popular method of studying linkages between aggregate financial and real variables has been Vector autoregression, when researches have used the fact that VAR models do not require distinguishing between endogenous and exogenous variables (Cipra 2008). Hülsewig *et al.* (2004), Gallegati (2005), Lungu (2007) and Buigut (2010), among others, use Vector error correction model (VECM) as variables they used were cointegrated.

A unique method was used by Hendrics and Kempa in their two papers (Hendricks & Kempa 2009, Hendricks & Kempa 2011). Relying on the theoretical insight that credit channel should be more active in times of financial distress and its intensity is hence not linear in time, they used a Markov switching model to identify periods when the respective channel was present. Their independent variables were a spread between long term bonds and Federal funds rate (FB) and industrial production (IP). Their dependent variable was defined as a ration of treasury and agency securities to consumer and industrial loans (SEC/CIL). They then estimated a model with two regimes, all parameters switching and two sets of errors that have the same mean but a state-dependent variance:

$$SEC_t/CIL_t = \begin{cases} c_1 + \alpha_1 \cdot IP_t + \beta_1 \cdot FB_t + \epsilon_{t,1} \\ c_2 + \alpha_2 \cdot IP_t + \beta_2 \cdot FB_t + \epsilon_{t,2} \end{cases}$$

Though this approach is sensible due to non-linearity of credit channel, our objection to their results is that Hendricks & Kempa (2011) did not use the coefficients on monetary policy for identification of the two regimes of the Markov switching model. Their estimation yielded non-significant coefficients on both β coefficients. The authors then focused on the absolute values of the other coefficients and identified the regime with larger absolute values as a regime with operative credit channel. In our opinion, this is hardly an evidence for monetary channel as both regimes proved that monetary policy had no significant impact on lending behaviour of banks.

We initially intended to include Markov switching model into this thesis, with some forms of GDP and PRIBOR as explanatory variables and a ratio of private bank loans to some aggregate as the dependent variable. Most of the models we estimated had only one switch in May 2002. The regime after switch was extremely persistent and the estimated coefficients did not provide any clue as to the identification of the two regimes. We used MATLAB with `MS_REGRESS` package. After a failure to estimate a MS model, we proceeded to estimate a VAR model in Stata.

6.1 Data

We utilize quarterly data from Q1:2001 to Q4:2011, there are thus 44 observations. The first quarter of 2001 is the first period with a recorded average interest on bank loans; the fourth quarter of 2011 was the last period for which the GDP was available. The data were obtained from ARAD database. We use

Table 6.1: **Description of time series**

Variable	*Denotation*
Real seasonaly adjusted gross domestic product	GDP
Natural logarithm of GDP	logGDP
Real total loans to households and non-financial firms	LOANS
Real monetary base	MB
Average interest rate on loans	IR
Average interest rate on deposits	DR
3M PRIBOR	PRIBOR

Source: ARAD, author's own calculations.

3M PRIBOR as an indicator of Czech National Bank's monetary policy even

though its main policy instrument is 2W REPO. 3M PRIBOR is used as a policy rate e.g. by Morgese Borys *et al.* (2009), who also provide few arguments why it is preferred to 2W REPO. IR is an average interest rate on loans in Czech korunas provided by banks to households. Since the bank lending channel should affect mostly smaller firms and households and ARAD database does not provide data based on interest rates on loans for non-financial companies differenced by the company size, we opted for the interest rate for households as a proxy for the interest rate paid on loans to bank-dependent creditors. The same applies to DR by analogy. GDP, LOANS and MB is used in CZK billions and are in real terms, in 2005 prices. PRIBOR, IR and DR are in percentage points.

6.2 Introduction to Vector autoregressions

As we wanted to study macroeconomic effects in a small country and Markov switching model did not produce satisfactory results, Vector autoregression (or its variant) was a natural choice. It was developed by Christopher Sims in 1980 as an alternative to simultaneous equations model (Kirchgässner & Wolters 2007). Its main advantage is that it is not necessary to specify which variables are endogenous and which are exogenous - in traditional VAR models it is assumed that "everything depends on everything" and that all variables are endogenous (Kirchgässner & Wolters 2007). k-dimensional VAR model of order p VAR(p) has the form:

$$\boldsymbol{y}_t = \boldsymbol{\varphi}_0 + \boldsymbol{\Phi}_1 \boldsymbol{y}_{t-1} + \cdots + \boldsymbol{\Phi}_p \boldsymbol{y}_{t-p} + \boldsymbol{\epsilon}_t \tag{6.1}$$

where $\boldsymbol{\epsilon}_t$ is a k-dimensional vector of disturbances at time t and $\boldsymbol{\Phi}_i$ is a $k \times k$ matrix of coefficients. Each component of the $\boldsymbol{y}_t$ hence depends linearly on its own lagged values up to p periods as well as on the lagged values of all other variables up to order p (Kirchgässner & Wolters 2007). Besides normally distributed residuals the model as a whole has to be stationary and residuals must not be serially correlated (Cipra 2008).

6.3 Model

We estimated models with different combinations of variables and various lag structures. In many cases diagnostic tests during and after estimation revealed

violations of basic assumptions for inference. Of particular problem was autocorrelation and extreme non-normality of residuals.[1] We therefore present only one model which has a very useful economic interpretation and, compared to most other models, sound statistical properties, even though one assumption is unfortunately partially violated.

Before we proceed to the final model, we briefly discuss a model where all assumptions were fulfilled perfectly: a VECM with PRIBOR, LOANS and logGDP, cointegration rank $r = 1$ and underlying VAR(4). As predicted, this model indicated a decline in LOANS and logGDP following a monetary restriction. The graph of a response of logGDP to a shock in PRIBOR very closely resembled IRFs estimated in literature which relied on VECM, particularly in Hülsewig *et al.* (2004) – both found an short increase in GDP immediately after the monetary shock - Bernanke & Gertler (1995) suggested this is mostly due to an increase in inventories. The timing is remarkably similar to the one found by Hulsewig et al. - with the response curve reaching the minimum after slightly less then 10 quarters.

This model however does not indicate whether a decrease in loans after a monetary tightening is a result of a lower demand (suggested by the interest rate channel) or a decreased supply (suggested by the bank lending channel). A way to solve this "supply vs. demand puzzle" is described by Buigut (2010), who used a simple VEC model and formulated three conditions for accepting the bank lending channel: (i) the amount of loans decreases, (ii) the price of loans increases and (iii) the output declines. Hoping this appropriately solves the puzzle, we will use this approach and estimate a similar model as Buigut. Combining the information on the equilibrium price and equilibrium quantity could help us determine whether the reduction of LOANS was a result of decreased demand or supply.

Our model thus contains four variables: PRIBOR, LOANS, IR and logGDP. We start with testing the four time series for unit roots - one of the important sources of non-stationarity. Determining stationarity is very important in VAR models: though there are dissenting voices, it is generally understood

[1] p-value of normality tests was often reported as 0.0000. Though Jarque-Bera test may produce significant Type I and Type II errors from small samples, we took the extremely low values as evidence for rejecting the null hypothesis of normality.

that VAR model requires all time series to be stationary (Cipra 2008, Enders 1994, Kirchgässner & Wolters 2007). We include trends in tests of logGDP and LOANS - for example technological development and population growth tend to increase both over time. On the other hand we do not include a trend in a test of PRIBOR and IR, as there is no economic reason to believe there is a trend in interest rate. This argument is supported by Hamilton (1994). We used Augmented Dickey-Fuller test and GLS Dickey-Fuller. Based on the ADF test, with the number of lagged differences determined by MAIC, the Schwartz criteria and the Ng-Perron methods, we could not reject unit roots for logGDP, IR and PRIBOR. ADF test suggested that LOANS is stationary when the ADF test regression is run with 1 lagged difference, but unit root cannot be rejected at four lagged differences selected both by the Ng-Perron method and the Schwartz criteria. Results of the Augmented Dickey-Fuller test are reported in Table A.1 in Appendix. Based on GLS Dickey-Fuller we could not reject the null hypothesis of the unit root up to lag 9 (the lag was determined by Stata through Schwert formula $p_{max} = \lfloor 12 \cdot \sqrt[4]{\frac{T}{100}} \rfloor$, where T is the number of observations) for any of the time series. We thus concluded that we cannot reject unit roots for all four time series.

A simple solution of the unit root issue is first differencing. This procedure however leads to a loss of important information, particularly if we are interested in the long term relationship in the equilibrium between variables, because in the equilibrium the increments are almost zero (Cipra 2008). Moreover, if the variables are cointegrated, applying VAR to the first-differences would result in a misspecification error (Murray 1994). On the other hand, cointegration allows us to *correct* the equation with first differences if we are able to include a new element into the model: a non-trivial linear combination of levels of the non-stationary variables (Cipra (2008)). The *corrected* model from equation (6.1) would then look like:

$$\Delta \boldsymbol{y}_t = \boldsymbol{v} + \boldsymbol{\alpha}\boldsymbol{\beta}^{\intercal}\boldsymbol{y}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma_i}\Delta \boldsymbol{y_{t-i}} + \boldsymbol{u}_t \tag{6.2}$$

where $\boldsymbol{v}$ is a constant $(k \times 1)$ vector, $\boldsymbol{\alpha}$ is a $(k \times r)$ matrix called adjustment matrix, $\boldsymbol{\beta}$ is a $(k \times r)$ matrix of cointegrating coefficients and r is the number of the linear non-trivial combinations mentioned above (based on Stata 2009).

Proper test for cointegration requires a correct determination of a number of

lags in the underlying VAR model. Many methods have been developed to help with the choice of the lag. Ivanov & Kilian (2005) mention six methods: Schwarz/Bayes Information Criterion (SBIC), Hannan-Quinn Criterion (HQC), Akaike Information Criterion (AIC), the general-to-specific sequential Likelihood Ratio test, a small-sample correction to that test and the specific-to-general sequential Portmanteau test. Some of these methods can be implemented in Stata. The information criteria are sensitive to the choice of p_{max}, the maximal lag. The choice of p_{max} was not discussed in the literature we have reviewed but the study with quarterly data presented in Hülsewig *et al.* (2004) used at least 5 lags. Since some lags were significant even in a VAR model with eights lags, we set $p_{max} = 8$. The SBIC recommends lag 1 while AIC and HQIC suggested lag 7 (see Table A.2 in Appendix). Ivanov & Kilian (2005) discuss and compare the lag selection criteria and conclude that Schwartz identification criterion is the most appropriate for VEC models as well as for models with quarterly data with small samples. But diagnostic tests suggested that VAR(1) and VAR(2) had autocorrelated residuals at multiple lags of low orders and the tests for normality suggested the residuals showed extreme non-normality (joint p-value of Jarque-Bera test was 0.00082 for VAR(2), 0.0000 for VAR(1)). We could not reject the null hypothesis of normal distribution of residuals from VAR(3) but there was unfortunately evidence against a non-autocorrelation, since the null hypothesis of no autocorrelation at lag 4 was rejected at 5% at lag of order 4 (p-value 0.02233). VAR(3) was nevertheless stable and at least two of three information criteria favoured it over models with four, five and six lags. We are aware that inference is sensitive to autocorrelation. On the other hand this model had much better statistical properties than vast majority of other models we estimated and had a crucial economic interpretation. Moreover, we would not even detect the autocorrelation if we relied at the default setting in Stata.[2] Keeping all this in mind, we proceed with the VAR(3) model.

Once we determined the number of lags, we conducted a test for cointegration using methodology developed by Johansen, which can be implemented in Stata. The results can be seen in Table A.3 in Appendix and Johansen's multiple-trace test selected number two as the rank of cointegration matrix, which means that there are two cointegrating equations (rank is the number r mentioned above). Given the linear trend in LOANS and logGDP, we used the default setting in Stata `trend(constant)` which allows for a trend in data,

[2]Obviously, this does not alleviate the autocorrelation problem.

and for a non-zero constant and no trend in the cointegrating equations.

We then proceed to estimate VEC model. The precise results of the estimation are reported in Table A.4 in Appendix. The model satisfies assumptions of stability and no serial correlation and normally distributed, and therefore homoskedastic, residuals (Wooldridge 2002). The results of respective tests are reported in Tables A.5, A.6 and A.7 and Figure A.1 in Appendix. Since we estimated a model with four variables and rank $r = 2$, the companion matrix of our VEC model has two unit eigenvalues (see Table A.7 in Appendix) but the remaining eigenvalues are strictly less than one.

Using the notation from above, the key parameters of the model may be expressed in the following manner :

$$\boldsymbol{\Delta y_t} = \begin{pmatrix} \Delta logGDP_t \\ \Delta LOANS_t \\ \Delta PRIBOR_t \\ \Delta IR_t \end{pmatrix} \quad \boldsymbol{\alpha} = \begin{pmatrix} -0.22 & -0.0000007 \\ 1231.33 & -0.32 \\ -2.47 & -0.0007 \\ 1.9 & -0.003 \end{pmatrix}$$

$$\boldsymbol{\beta} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0.014 & 82.1 \\ 0.15 & 495.4 \end{pmatrix}$$

with $r = 2$ and cointegrating equations:

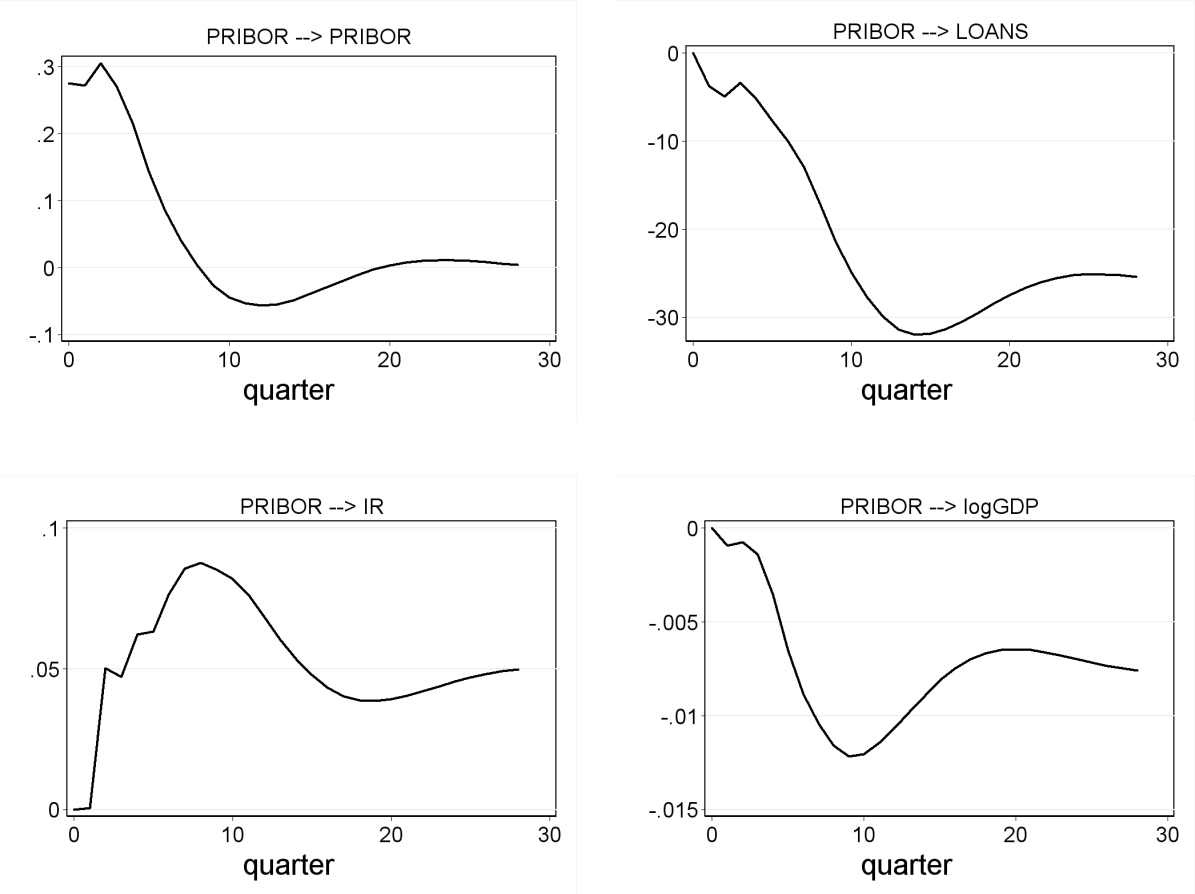
$$logGDP = 7.8 + 0.014 \cdot PRIBOR + 0.15 \cdot IR \tag{6.3}$$

$$LOANS = 5078.9 + 82.1 \cdot PRIBOR + 495.4 \cdot IR \tag{6.4}$$

The cointegrating equations represent a long term relationship between the variables. The "unit coefficients" in these equations are due to the normalization performed by Stata; any variable present in equations (6.3) and (6.4) can be easily normalized if we divide the respective equation by the variable's (non-zero) coefficient. We chose LOANS and logGDP to be normalized to one - if there was only a single equation, equation (6.3) could be interpreted as a long-term semi-elasticity and describe e.g. by how many percent GDP changes with a one percentage point change in PRIBOR. If (6.4) was the only cointegrating equation, it would have the standard level-level interpretation.

Unfortunately, interpreting the overal behaviour of the model with the use of cointegration matrix for $r > 1$ is difficult, because the equations might describe "several sectoral equilibria" (Kennedy 2008). We will thus rely instead on the impulse-response functions pictured in Figure 6.1.

Figure 6.1: **Impulse-response functions**



Source: ARAD, author's own calculations.

Unlike in traditional VAR models, the VEC model represents a change that is not only transitory, but is permanent. Indeed the graphs in Figure 6.1 show that the impulse response functions to not revert back to zero in the observed period. In the minimum point 2.5 years after the shock, the GDP is 1.2 % below the level before the shock. The timing is very similar to model estimated by Hülsewig *et al.* (2004). Private credit reaches the minimum roughly 3.5 years after the monetary shock. LOANS decline by more then CZK 30 billion CZK: given that the mean value of LOANS is CZK 1,105 billions, it is almost

3 percent decline: the estimated 3 percent decline lies between the numbers estimated by Hülsewig *et al.* (2004) and Buigut (2010). The direction of the response of lending interest rate IR is also as predicted, but the magnitude of the response is in our opinion surprisingly low.

The crucial information however comes from combining information from responses of logGDP, IR and LOANS to shocks from PRIBOR. The three assumptions stated by Buigut (2010) are fulfiled. IR and LOANS can be understood as the equilibrium price and quantity, respectively, in the credit market. Then the simultaneous increase in the lending rates and decrease in LOANS suggests that the changes originates from the leftward shift of supply of credit, or, more precisely, that the decrease of supply was more notable then the decrease of demand. The leftward shift of the credit supply is the way in which banks are predicted to behave under the theory of the bank lending channel. Taking into account the aforementioned theoretical predictions and the IRFs described in Figure 6.1, we conclude that our model provides an evidence for the existence of the bank lending channel in the Czech Republic.

Chapter 7

Conclusion

In this thesis we attempted to analyse the ways in which the financial system may influence the real economy. Though some notable economists realized during the Great Depression that a banking crises could have contributed to the economic crises, the most influential schools of economic thought placed only little attention to the workings of the financial system. Subsequent research however confirmed the role of the financial system in economic development and in the transmission of monetary policy.

The conventional interest rate channel of monetary transmission, according to which banks played only a passive role, however could not explain some observed responses to a monetary policy change. A complementing mechanism called the credit channel incorporates the credit market imperfections and provides a more complete description of the monetary transmission mechanism. The credit channel has two sub-channels – the balance sheet channel and the bank lending channel – which influence the real economy through changing the supply of credit in addition to a change of demand for credit generated by the interest rate channel. Balance sheet channel affects the lending policies of banks by modifying the value of borrowers' assets. Bank lending channel does the same by altering the balance sheets of banks.

Particular attention is paid to the bank lending channel, which is the more controversial of the two sub-mechanisms. For this channel to operate, monetary policy of the central bank must be able to influence the supply of bank loans, and at the same time it must not be able for firms and households to perfectly substitute bank loans for other sources of finance. Though the va-

lidity of both assumptions has been questioned, recent empirical evidence and theoretical literature from the United States and from Europe show that it is the second assumption that is more likely to be violated, and therefore that the existence of the bank lending channel depends predominantly on the role of banks within the financial system.

We analyzed the Czech financial system and find that banks play a very important role in the Czech financial system, as bonds and stock market are not common sources of finance. We therefore make a hypothesis that the bank lending channel operates in the Czech Republic, even though the widespread practices of relationship banking and intra-group financing could mitigate the channel. We also point to the recent legislative change that could promote the use of bonds for future financing.

Finally we estimated a Vector error correction model and analyse the results through impulse response functions. The model contains four relevant variables – GDP growth, the amount of loans to non-financial firms and households, 3M PRIBOR rate as a policy rate and the lending rate on bank loans. The impulse response functions subsequently revealed that following a monetary shock, the total amounts of loans decreased and the lending rate increased, which we interpret as an evidence of a bank lending channel.

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Appendix A

Diagnostic tests

Table A.1: **ADF test**

Augmented Dickey-Fuller test Null hypothesis: unit root is present Lags selected by SIC, MAIC or Ng-Perron method						
	SIC		Ng Perron		MAIC	
Time series	lag	p	lag	p	lag	p
logGDP	1	0.9233	1	0.9233	1	0.9233
PRIBOR*	1	0.1947	1	0.1947	1	0.1947
LOANS	4	0.7645	4	0.7645	1	0.0034
IR*	1	0.7049	6	0.5957	6	0.5957
*= no trend						

Table A.2: **VAR lag order selection**

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-205.219				1.31234	11.6233	11.6847	11.7992
1	22.0668	454.57	16	0	0.000011	-0.11482	0.192226	.764909*
2	34.3572	24.581	16	0.078	0.000013	0.091267	0.643958	1.67479
3	55.641	42.568	16	0	0.000011	-0.20228	0.59605	2.08502
4	71.2173	31.152	16	0.013	0.000014	-0.17874	0.865235	2.81236
5	91.8843	41.334	16	0	0.000015	-0.43802	0.851595	3.25686
6	114.402	45.036	16	0	0.000019	-0.80012	0.735133	3.59855
7	162.301	95.798*	16	0	0.000011	-2.57229*	-.791399*	2.53016
8	-	-	16	-	-6.6e-22*	-	-	-

Table A.3: **Cointegration rank**

max. rank	parms	LL	eigenvalue	trace statistic	5% crit. value
0	36	6.639857	-	78.3958	47.21
1	43	28.33913	0.65302	34.9973	29.68
2	48	39.99137	0.43357	11.6928*	15.41
3	51	44.5055	0.19764	2.6645	3.76
4	52	45.83775	0.06292		

Table A.4: **VECM**

	Coef.	Std. Err.	z	p-value	[95% Conf.	Interval]
D_logGDP						
_ce1						
L1.	-0.2174	0.120363	-1.81	0.071	-0.45331	0.018507
_ce2						
L1.	-6.14E-07	0.000024	-0.03	0.98	-4.8E-05	4.64E-05
logGDP						
LD.	0.418829	0.157713	2.66	0.008	0.109718	0.727941
L2D.	0.05986	0.160942	0.37	0.71	-0.25558	0.3753
LOANS						
LD.	-1.2E-05	5.97E-05	-0.19	0.847	-0.00013	0.000106
L2D.	-0.00017	5.66E-05	-2.96	0.003	-0.00028	-5.7E-05
PRIBOR						
LD.	-0.00019	0.004091	-0.05	0.964	-0.0082	0.007833
L2D.	0.004328	0.003914	1.11	0.269	-0.00334	0.012
IR						
LD.	0.0235	0.008045	2.92	0.003	0.007732	0.039268
L2D.	-0.00142	0.004463	-0.32	0.751	-0.01016	0.007331
_cons	0.012024	0.002828	4.25	0	0.006482	0.017566
D_LOANS						
_ce1						
L1.	1231.335	259.9487	4.74	0	721.8445	1740.825
_ce2						
L1.	-0.32416	0.051772	-6.26	0	-0.42563	-0.22269

logGDP						
LD.	-230.597	340.6142	-0.68	0.498	-898.189	436.9944
L2D.	-773.017	347.5877	-2.22	0.026	-1454.28	-91.7574
LOANS						
LD.	-0.108	0.128903	-0.84	0.402	-0.36065	0.144641
L2D.	-0.34138	0.122236	-2.79	0.005	-0.58096	-0.1018
PRIBOR						
LD.	-4.79785	8.834892	-0.54	0.587	-22.1139	12.51822
L2D.	2.070531	8.453094	0.24	0.807	-14.4972	18.63829
IR						
LD.	16.99197	17.37472	0.98	0.328	-17.0619	51.0458
L2D.	-0.8408	9.639062	-0.09	0.93	-19.733	18.05141
_cons	6.31E-05	6.106895	0	1	-11.9692	11.96936
D_PRIBOR						
_ce1						
L1.	-2.47462	5.830328	-0.42	0.671	-13.9019	8.952617
_ce2						
L1.	-0.00071	0.001161	-0.61	0.542	-0.00298	0.001569
logGDP						
LD.	3.245998	7.639556	0.42	0.671	-11.7273	18.21925
L2D.	-4.64379	7.795963	-0.6	0.551	-19.9236	10.63601
LOANS						
LD.	-8.73E-06	0.002891	0	0.998	-0.00568	0.005658
L2D.	-0.00185	0.002742	-0.68	0.5	-0.00722	0.003523
PRIBOR						
LD.	0.097469	0.198156	0.49	0.623	-0.29091	0.485847
L2D.	0.233315	0.189593	1.23	0.218	-0.13828	0.60491
IR						
LD.	0.331593	0.389694	0.85	0.395	-0.43219	1.095378
L2D.	0.002429	0.216192	0.01	0.991	-0.4213	0.426158
_cons	-0.00883	0.13697	-0.06	0.949	-0.27729	0.259626
D_IR						
_ce1						
L1.	1.914181	2.108562	0.91	0.364	-2.21852	6.046887

_ce2						
L1.	-0.00027	0.00042	-0.64	0.522	-0.00109	0.000554
logGDP						
LD.	-3.78685	2.762877	-1.37	0.17	-9.20198	1.628294
L2D.	-7.64069	2.819442	-2.71	0.007	-13.1667	-2.11468
LOANS						
LD.	0.001977	0.001046	1.89	0.059	-7.2E-05	0.004027
L2D.	-0.00133	0.000992	-1.34	0.18	-0.00327	0.000614
PRIBOR						
LD.	-0.00297	0.071664	-0.04	0.967	-0.14343	0.137491
L2D.	0.193208	0.068567	2.82	0.005	0.058819	0.327596
IR						
LD.	-0.4249	0.140934	-3.01	0.003	-0.70113	-0.14868
L2D.	-0.1346	0.078187	-1.72	0.085	-0.28785	0.018639
_cons	-0.04809	0.049536	-0.97	0.332	-0.14518	0.049001

COINTEGRATING EQUATIONS:

Equation	Parms	chi2	P-value
_ce1	2	91.4387	0
_ce2	2	7.1224	0

Beta	Coef.	Std. Err.	z	P values	[95% Conf.	Interval]
_ce1						
logGDP	1	-	-	-	-	-
LOANS	0	-	-	-	-	-
PRIBOR	0.014389	0.005444	2.64	0.008	0.003718	0.02506
IR	0.146384	0.010369	14.12	0	0.126062	0.166706
_cons	-7.80329	-	-	-	-	-
_ce2						
logGDP	0	-	-	-	-	-
LOANS	1	-	-	-	-	-
PRIBOR	82.0917	23.39764	3.51	0	36.23316	127.9502
IR	495.4486	44.55938	11.12	0	408.1138	582.7834
_cons	-5078.88	-	-	-	-	-

Table A.5: **Residual autocorrelation test**

Lagrange multipliers test of autocorrelation Null hypothesis: no autocorrelation at a lag			
lag	chi2	df	P-value
1	19.1639	16	0.26026
2	17.3692	16	0.3621
3	10.7026	16	0.82746
4	25.1846	16	0.06664
5	12.3814	16	0.71733
6	10.5596	16	0.83582
7	17.4664	16	0.35605
8	11.0602	16	0.80575

Table A.6: **Residual normality tests**

Null hypothesis: normal distribution of residuals			
JARQUE-BERA TEST			
Equation	chi2	df	P-values
D_logGDP	3.062	2	0.21629
D_LOANS	0.262	2	0.87709
D_PRIBOR	3.858	2	0.14531
D_IR	1.459	2	0.4821
Joint	8.642	8	0.37343

SKEWNESS TEST				
Equation	Skewness	chi2	df	P-value
D_logGDP	-0.66551	3.027	1	0.08191
D_LOANS	-0.18705	0.239	1	0.62486
D_PRIBOR	-0.74762	3.819	1	0.05066
D_IR	0.44838	1.374	1	0.24116
Joint	-	8.459	4	0.07615

KURTOSIS TEST				
Equation	Kurtosis	chi2	df	P-value
D_logGDP	3.1448	0.036	1	0.84992
D_LOANS	3.1166	0.023	1	0.87892
D_PRIBOR	2.85	0.038	1	0.84457
D_IR	2.7764	0.085	1	0.77013
Joint	-	0.183	4	0.99607

Table A.7: **Stability conditions**

EIGENVALUE		MODULUS
Real part	Complex part	
1		1
1		1
0.837056	+.2438838i	0.871861
0.837056	-.2438838i	0.871861
0.015555	+.7388806i	0.739044
0.015555	-.7388806i	0.739044
0.602466	+.3330671i	0.688403
0.602466	-.3330671i	0.688403
-0.511		0.511002
-0.26838	+.2518253i	0.368024
-0.26838	-.2518253i	0.368024
-0.36724		0.367244

Figure A.1: Companion matrix