Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies

MASTER THESIS

Households Indebtedness and Financial Stability: Empirical Analysis from the Czech Republic

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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.

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Prague, July 30, 2014

Jan Kroupa

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Abstract

This thesis studies interconnections between macroeconomic environment and non-performing loans ratio (NPL) of banking loans provided to households in the Czech Republic in years 2005–2014. This analysis serves as tool for macroprudential policy to detect potential risks before negative consequences occur. The thesis examines mutual relations between households' non-performing loans ratio and variables capturing macroeconomic environment such as GDP growth, unemployment rate, CPI, interest rate and exchange rate. For purposes of this analysis, vector autoregressive approach and vector error correction model are applied. Based on impulse response analysis, most of expected relations are confirmed. Generally, favorable macroeconomic conditions increase payback capacity of households and reduce share of non-performing loans. According to forecast variance decomposition, increase in unemployment rate is the most serious threat for financial stability of the country from the perspective of non-performing rate increase.

JEL Classification	C32, C52, E21, G21
Keywords	Households, indebtedness, financial stability, non-performing loans, Czech Republic, VAR, VECM

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Abstrakt

Tato práce se zabývá studiem vzájemných vazeb mezi makroekonomickým prostředím a podílem úvěrů v selhání na celkovém množství poskytnutých úvěrů domácnostem v České republice mezi roky 2005 a 2014. Tato analýza slouží jako nástroj makroobezřetnostní politiky pro včasnou identifikaci potenciálních rizik před propuknutím negativních následků. S využitím metody vektorové autoregrese a VEC modelu práce zanalyzuje vzájemný vztah mezi podílem úvěrů v selhání poskytnutých domácnostem a makroekonomických proměných typu růst HDP, míra nezaměstnanosti, indexu spotřebitelských cen, úrokové míry a směnného kurzu. Většina očekávaných vztahů je potvrzena metodou odezvy na impuls. Obecně lze říci, že příznivá ekonomická situace zvyšuje schopnost domácností splácet své závazky a vede k nižšímu podílu úvěrů v selhání. Na základě rozkladu rozptylu je nejvážnější hrozbou pro finanční stabilitu z pohledu růstu podílu úvěrů v selhání nárůst míry nezaměstnanosti.

Klasifikace	C32, C52, E21, G21
Klíčová slova	Domácnosti, zadlužení, finanční stabilita, úvěry v selhání, Česká Republika, VAR, VECM

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Acronyms

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroscedasticity
BIC	Bayesian Information Criterion
CNB	Czech National Bank
CPI	Consumer Price Index
CZK	Czech Koruna
GDP	Gross Domestic Product
HQIC	Hannan-Quinn Information Criterion
IPI	Industrial Production Index
IRA	Impulse Response Analysis
KoB	Konsolidační Banka
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange-Multiplier
LTV	Loan to Value
NPL	Non-performing Loans
PRIBOR	Prague Interbank Offered Rate
SIC	Schwarz Information Criterion
VAR	Vector Autoregressive
VECM	Vector Error Correction Model

Master Thesis Proposal

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Proposed Topic:

Households' indebtedness and financial stability: Empirical analysis from the Czech Republic

Topic Characteristics:

The level of households' indebtedness has risen substantially in absolute terms as well as relative to household income over past two decades practically in whole Europe. This trend raised concerns about the sustainability of household debt and the consequences for the financial stability. Two main factors behind this increase are financial deregulation, which decreased the level of credit rationing, and lower nominal as well as real interest rates. Situation in the Czech Republic during 90s was unique. There was no substantial raise in the level of indebtedness. It could be attributed to huge economic and social changes, unsure future and unwillingness of banks to provide loans for small clients. Volume of loans started to rise substantially around the year 2000. The environment with stable and low interest rates, GDP growth or investments in the economy was behind this increase. Increasing level of households' indebtedness could be dangerous mainly because of two reasons – households will be more sensitive to the, especially unexpected, changes in interest rates and to changes in income resulting from unemployment.

The aim of this thesis is to evaluate main factors affecting the level of households' indebtedness and their influence on the amount of non-performing loans. Using macroeconomic data thesis will also provide comparison of the structure of households' debts between Czech Republic and other similar countries such as Slovakia, Poland etc.

In this thesis I am going to use macroeconomic data provided by Czech Statistical Office and Czech National Bank. If micro-data will be also available they could be used for the deeper analysis of the structure of indebtedness.

Hypotheses:

1. Lending rate and households' consumption have significant effect on the level of households' indebtedness.
2. The amount of non-performing loans is increasing with raise in the level of households' indebtedness and with rising interest rates and is decreasing with positive GDP growth and inflation.
3. Credit growth to households in the Czech Republic is not excessive.
4. Increased indebtedness made households more vulnerable to falls in house prices.

Methodology:

The connection between financial stability indicators such as GDP growth, inflation, unemployment rate, household consumption, interest rates or house prices and the households' debt will be examined through error correction model or OLS regression. HP filter method and pooled mean group estimation method will be used to test whether credit growth to households in Czech Republic is excessive or not.

In summary following methods will be employed in this thesis.

1) Error correction model of household debt based on Nakornthab (2010)
2) OLS regression
3) HP filter method
4) Pooled mean group estimation method based on Pesaran et al. (1999)

Outline:

- Introduction to the topic
- Literature review and theoretical framework
- Development of households‘ indebtedness and possible implications for financial stability
- Data analysis
- Results
- Discussion
- International comparison
- Conclusion

Core Bibliography:

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Author **Supervisor**

1 Introduction

Starting from the middle of 1980s, household borrowing in developed countries has significantly increased in absolute terms as well as relative to household income. According to Debelle (2004), much of this increase can be attributed to two factors: financial deregulation of the early 1980s accompanied with decrease in the level of credit rationing; and the reduction in interest rates, both nominal and real. This development led to easing of liquidity constraints on households. Therefore, households could better adjust their borrowing to reflect desirable path of consumption over their life cycle. On the other hand, households sector became more sensitive to changes in interest rates and income (Debelle, 2004).

Similar development, just with time delay, experienced also post-communist or less developed countries in Europe. Rapid expansion of credits to households has usually positive as well as negative impact on the welfare of households, performance of credit institutions and the overall economic environment (Roman and Sargu, 2011). On the one hand, increase in credits allows households to increase their consumption, to acquire houses easier, it raises credit institutions' profitability and it could lead to the improvement of the macroeconomic environment (e.g. increase in employment rate). In contrast, rapid and unsustainable credit growth exposes households more to unexpected changes in economic environment. Excessive credit growth could have negative consequences for macroeconomic stability. Increasing borrowing in private sector allows higher consumption beyond standard level. This growth pushes aggregate demand away from potential output and causes the economy to overheat resulting in higher inflation (Roffia and Zaghini, 2007). Due to the overall optimism in economy, lending institutions can further weaken their requirements about potential debtors' characteristics and provide loans to borrowers with high-risk profiles and therefore with higher probability of default. However, these borrowers are usually more sensitive to unexpected deterioration of economic activity when their debt-paying capacity decreases as a result of rise of unemployment or interest rates, which elevates debt payments. Therefore, the amount of non-performing loans is usually increasing during recession which negatively affects banks' balance sheets. This increase can lead to substantial losses for banks. Excessive amount of household debt can also have indirect negative effects on banks' profits. Decreasing consumption leads to lower demand in the real sector and reduces corporate sector income flows. Furthermore, over indebtedness of households have

undesirable effects from social point of view, leading to social exclusion and poverty. As amount of loans going to households represents significant item in banks' balance sheets, this development could have subsequent negative effects on financial stability of the country. It is therefore not surprising that the assessment of overall asset quality and credit risk is the crucial part of macro-prudential surveillance. Moreover, the level of non-performing loans ratio became one of the relevant measures of financial vulnerability.

In addition to characteristics, which are common to most countries, each state often exhibits its own specific features. This thesis analyzes households' indebtedness in the Czech Republic, where the situation was in some sense unique. The level of credits to households during 90s was relatively negligible. It could be attributed to significant economic and social changes, unsure future and unwillingness of banks to provide loans to minor clients. Regulation of banks was insufficient and fundamentals of banking sector have been just evolving. As a result of this risky environment, credit institutions have been providing mostly short term loans. Deep banking crisis in the end of 1990s changed banking sector dramatically. This crisis was followed by credit growth to households. Despite the fact that the credit growth was quite fast in pre-crisis period and almost reached 25% in the end of 2007, Czech banking sector was able to provide credit without major disturbances in the period of financial crisis in 2008. Frait, Geršl and Seidler (2011) proposed one of the possible explanations for this anomaly: growing portfolio of loans was financed mainly from local deposits and households have been taking loans in the local currency only, therefore exchange rate risk was not present. The amount of households' debt was rising after this crisis and exceeded the level of one trillion CZK in the middle of 2010. The first monthly decline in the level of households' debt since 2001 was spotted in February 2013, which was just an exception and then households indebtedness started to grow again.

The aim of this thesis is to evaluate effects of shocks in variables determining macroeconomic environment on quality of banks'portfolio of loans. Quality of banks' portfolio of loans is approximated by the share of non-performing loans on total amount of loans provided to households. High NPL ratio might be considered as a possible indicator of banking sector distress. Mutual sensitivity of households' non-performing loans dynamic and macroeconomic performance in the Czech Republic is examined using VAR and VECM approaches. We use unemployment rate, industrial production index, consumer price index, PRIBOR 1M and CZK/EUR as variables capturing macroeconomic environment. Differences in

results provided by these two approaches and their suitability for our analysis are evaluated.

This analysis is used for financial stability assessment of the particular country since the increasing amount of NPL deteriorates banks' balance sheets and is the warning indicator for macro-prudential policy to detect potential risks before negative consequences occur. We determine, which variables are the most significant drivers of development of share of non-performing loans over observed period and to which extend influence the level of NPL ratio.

Results indicate that there is relation between macroeconomic environment and credit market performance. Most of findings are in accordance with previous studies with the exception of response of NPL ratio to shock in PRIBOR 1M. Results for VAR approach and VECMs are consistent. The main difference is permanent response of NPL ratio to innovations in endogenous variables observed by VECM, which is in compliance with construction of this model.

Organization of the thesis is following. The first chapter summarizes the most important studies related to topics of households' indebtedness, financial stability, quality of banks' portfolio of loans and investigation of mutual relations between non-performing loans and various macroeconomic indicators.

The second chapter describes major events in the history of Czech banking sector from the time of transformation period until present. Main focus is aimed at description of changes made in the past in order to improve the quality of banking environment. Causes and effects of crises which Czech Republic experienced during this period are also discussed.

The last chapter is the key part of the whole thesis. Firstly, models used for analysis are described. Next, reasoning for selection of variables used, expected relations between NPL ratio and those variables and basic time series characteristics are provided. Then, three different VAR models and three VECMs are estimated in order to evaluate expected interconnections between endogenous variables. Impulse response analysis and forecast variance decomposition are used for these purposes. At the end of the chapter, discussion of results is provided.

2 Literature review

A considerable amount of literature has been published on the topic of households' indebtedness. Most of them are empirical in nature, but some studies just postulate theoretical reasoning for the existence of household debt and discuss variables that influence the level of this debt. Literature can be basically divided into two groups according to type of data used in the analysis. The first one, which uses macroeconomic data to examine relation between the level of debt and important macroeconomic variables (Jacobsen and Naug, 2004; Finocchiaro, Nilsson, Nyberg and Soultanaeva, 2011; Dynan and Kohn, 2007) or to discuss factors affecting the share of non-performing loans in banks' loans portfolio (Rinaldi and Sanchis-Arellano, 2006; Nkusu, 2011). On the contrary, the second one using micro data from surveys on the households' level examining the impact of personal characteristics (age, region, income, number of children, education…) on the level of indebtedness and discovering the most vulnerable categories of population (Albacete and Lindner, 2013; Anderloni, Bacchiocchi and Vandone, 2011). Key macroeconomic variables for determining the level of household debt are often derived from several variations of life cycle model (e.g. Lawrence, 1995). Mostly used variables are GDP growth, rate of unemployment and inflation, but also real interest rate, exchange rate, index of house prices or consumption are often included. This thesis examines the impact of households' indebtedness on the financial stability from macroeconomic perspective; therefore the majority of literature review is focused on these studies.

However, there has been relatively little literature published on the topic of household indebtedness in case of the Czech Republic. To the best of my knowledge, there are only very few studies dealing with econometric analysis of macroeconomic factors affecting the level of household debt. The lack of long enough suitable data could be behind this loophole in research. Šedová (2011) in her study describes potential risks of household indebtedness in the Czech Republic. She states that risks attached to Czech household indebtedness correlate with those in advanced economies. Basic description of evolution of household indebtedness is provided by Prčíková (2012). The relationship between credit growth and financial stability is discussed in study conducted by Frait, Geršl and Seidler (2011). They compare two different techniques which are often used to evaluate a period of the excessive credit growth. HP filter method could play its role as a first step

in analyzing available data. In order to obtain more accurate results, one should use more experienced approach, which reflects the development of economic fundamentals, and therefore enables to distinguish between the state of excessive credit growth and catching up with advanced countries in its economic development. Frait, Geršl and Seidler (2011) also find out that Czech Republic is below the equilibrium level of indebtedness, and thus credit growth is not excessive.

Taking into account researches concerning the evolution of NPL ratio as the most appropriate available indicator for financial fragility, there are basically two types of studies: the first group which uses vector error correction model to capture short term as well as long term relationships between changes in NPL and macroeconomic variables (Rinaldi and Sanchis-Arellano, 2006; Bofondi and Ropele, 2011); and the second group using VAR models to examine interrelations among variables of our interest (Doutnáčová, 2013; Babouček and Jančar, 2005). Most of studies using macroeconomic data does not differentiate between total NPL ratio (Bofondi and Ropele, 2011; Festić and Romih, 2008) and NPL ratio just from loans to households (Alves and Ribeiro, 2011; Rinaldi and Sanchis-Arellano, 2006). These results could be different as households reactions to macroeconomic conditions differ from reactions of corporations (e.g. with different lags). VAR approach is broadly used for the analysis of quality of banks' loans portfolio, but just few papers use VAR to investigate patterns of NPL concerning households.

The first systematic assessment of links between loans quality and macroeconomic shocks in case of the Czech Republic was provided by Babouček and Jančar (2005). They forecast that in the end of 2006 the share of non-performing loans will follow a declining trend below double-digit rates, which was true. Babouček and Jančar (2005) confirm most of the broadly agreed hypotheses on the causal relations in the investigated transmission that have been presented in the empirical literature so far. Only 7 out of 45 hypotheses cannot be confirmed. According to Babouček and Jančar (2005), failure to support these hypotheses can be reasonably explained by specific features of particular countries. These results were confirmed by Doutnáčová (2013) who studies linkages between macroeconomic performance in case of the Czech Republic and banks' loans portfolio quality in years 2003–2013 using VAR model and impulse responses analysis. She conducted analysis on the aggregate level as well as on the sectorial level. Doutnáčová (2013) finds out that increasing unemployment, interest rate, inflation and exchange rate cause significant deterioration in banks' loans quality. Negative correlation between GDP growth and aggregate NPL ratio was confirmed by this study. Regarding sectorial analysis, results are in accordance with aggregate level.

The only differences between non-financial corporations and household sector are in the extent to which NPL ratio reacts to various shocks and in time delay of this response. According to Doutnáčová (2013), the influence of GDP growth and interest rates is larger and more rapid by non-financial corporations sector. It can be said that households react less impulsively to changes in macroeconomic environment and with larger delay.

Comparison between Czech Republic, Slovakia and Slovenia in terms of factors affecting the level of aggregate NPL was done by Festić and Romih (2008). This study supports the relevance of country specific features suggested by Babouček and Jančar (2005). According to Festić and Romih (2008), most of the macroeconomic variables affect the level of NPL in the same manner, but still, some differences between countries exist. For example, the study failed to support hypothesis that GDP growth decelerates the level of NPL in case of the Czech Republic and rejects this hypothesis in case of Slovakia. On the contrary, this hypothesis is accepted in case of Slovenia. Festić and Romih (2008) also conclude that rising interest rates accelerate NPL growth in Slovenia, while the effect in case of the Czech Republic and Slovakia is opposite. This finding of negative correlation between interest rates and NPL is in contrary to Doutnáčová (2013) and Babouček and Jančar (2005).

Nkusu (2011) investigates response of aggregate NPL ratio to its macroeconomic determinants using dataset of 26 advanced countries. Based on the panel regression, he includes nine different variables into VAR analysis. Impulse responses functions show that out of all nine variables, NPL is the only one, which has a statistically significant response to and a predictive power on, every single variable over a 4-year forecast period. The directions of the IRFs are mostly as expected. His study also confirms that increasing level of non-performing loans ratio weakens performance of the economy, which subsequently leads to emergence of macro financial vulnerabilities. Main findings of this study can be used for forecasting and stress testing purposes by supervisory authorities or banks. Study conducted by Beck, Jakubik and Piloiu (2013) suggest to also add share prices as the explanatory variable for NPL.

Louzis, Vouldis and Metaxas (2010) study determinants of NPL in Greek banking sector. Their findings are consistent with globally accepted conclusions about factors affecting the level of NPL. Particularly, real GDP growth rate, unemployment rate, lending rates and public debt have strong effect on number of defaults. Analysis of different types of loans shows that consumer loans are the most

sensitive ones to changes in lending rates and business loans to the real GDP growth rates. On the contrary, mortgages are the least sensitive loans to changes in macroeconomic environment.

Japelli, Pagano and Marco (2008) model the drivers of households' propensity to default from a sample of 11 euro area countries. Research confirms financial fragility hypothesis which says that insolvencies are associated with greater households' indebtedness. Panel analysis of insolvencies shows that countries that experienced fast growth of indebtedness also featured larger increases in insolvency rates. They also provide evidence that debt is associated with institutional factors. Better enforcement of creditor rights and information sharing arrangements reduce the sensitivity of insolvencies to household debt.

Rinaldi and Sanchis-Arellano (2006) work with panel of seven EU countries to examine patterns of NPL from households' debt. They find out that variables included in their model explain quite well the variation of arrears and capture elements behind arrears' development. They also show that increases in real disposable income allow, ceteris paribus, relatively higher increase in debt to income ratio leaving the level of NPL from households' debt unchanged. In addition to these findings, model indicates that monetary variables affect total NPL in long run and positive shock will be fully transferred within two years and half. Finally, the study confirms that in the short-run financial wealth and housing wealth serve as a buffer in case of unexpected shocks to income. Alves and Ribeiro (2011) model evolution of households' defaults using data from Banco de Portugal. They divided loans into two groups – for housing and for consumption purposes – and compare differences betweem these models. Alves and Ribeiro (2011) suggest that in addition to variables used in other studies, one should use dummy variable capturing crisis period after the failure of Lehman Brothers to model defaults on loans for housing purposes. On the other hand, the flow of overdue credit for consumption purposes could be explained quite well using only its autoregressive term, unemployment rate and interest rate. On the contrary from Rinaldi and Sanchis-Arellano (2006), Bofondi and Ropele (2011) investigate patterns of aggregate NPL in the case of just one country, Italy. They find out that NPL ratio can be quite well explained using only few macroeconomic variables (growth rates of real GDP, house prices, unemployment rate and short-term nominal interest rate). In accordance with previous study, above mentioned macroeconomic determinants influence share of NPL with different lags. Model provided by Bofondi and Ropele (2011) also shows quite satisfactory out-of sample predictive accuracy.

Another study regarding Italy was conducted by Marcucci and Quagliariello (2008). They investigate the cyclical behavior of aggregate default rates in Italian banks. Marcucci and Quagliariello (2008) find that number of defaults decline in favorable macroeconomic times and increase during downturns, i.e. the anti-cyclical behavior. In addition to study of aggregate default rates, authors also examine the behavior of NPL ratio on the sectorial level but no major differences were spotted.

Study conducted by Klein (2013) confirms the anti-cyclical behavior of aggregate NPL. It basically holds that during the period of higher GDP growth, people have higher income and are able to better service their debt. On the other hand, when there is a slowdown, the level of NPL tends to increase as a result of higher unemployment. It has been also demonstrated that exchange rate, interest rate and inflation affect loans quality as well.

Less literature is devoted to analysis of the level of household debt and factors affecting this debt. The research undertaken by Debelle (2004) states that financial deregulation associated with decrease in credit rationing as well as reduction in interest rates were behind rapid growth of household borrowing at the turn of the 20th century. The research studies development of households' indebtedness in developed countries and provide international comparison of this development. It also highlights the importance of type of household mortgage interest rate as loans with variable interest rate increase sensitivity of borrowers to changes in interest rate. He concludes that enhancement of debt level raises the sensitivity of the household sector to changes in income, assets prices and interest rate.

The evolution of household debt and its implications for financial stability is the main topic for studies conducted by Finocchiaro, Nilsson, Nyberg and Soultanaeva (2011), Dynan and Kohn (2007) and Bloxhem and Kent (2009). Finocchiaro, Nilsson, Nyberg and Soultanaeva (2011) examine the rise in household debt in Sweden over the past 15 years and conclude that most of the rise could be attributed to low real interest rates and more generous LTV ratios. Authors suggest that investigation of micro-data to assess the impact of increasing house prices, credit supply or changes in disposable income on households' indebtedness will be interesting as well. Dynan and Kohn (2009) perform a similar research regarding the USA. They find out that rise in the debt of U.S. households reflects their effort to smooth consumption over time as a reflection of anticipated changes in future income, wealth and interest rates. According to them, increasing house prices combined with financial innovations have significant effect on the level of debt

as well. Greater indebtedness of U.S. households exposed them more to shocks in assets prices and interest rates through the greater leverage in their balance sheets. It makes them more vulnerable. Bloxhem and Kent (2009) conduct a research comparing the level and causes of households' debt among developed countries with focus on Australia. They state out that the rise in households' debt is higher for countries which experienced larger decline in inflation, macroeconomic volatility or unemployment. In compliance with previous studies, some of the rise in indebtedness could be attributed to decline in lending standards. This fact led to rising rates of mortgage defaults and to decline in house prices. As a result of this, financial institutions experienced large losses and significant stress. Bloxhem and Kent (2009) also discuss similarities between situations in Australia and USA regarding house prices bubble. However, the main limitation to mentioned studies is absence of any econometric analysis and reasoning.

Other studies have considered the relationship between the level of household debt and macroeconomic variables in an econometric way. Jacobsen and Naug (2004) use vector error correction model to estimate long term as well as short term relationships between household debt and explanatory variables in case of Norway. The model contains effects of house prices, housing stock, the number of house sales, banks' lending rates, unemployment rate, total wage income in the economy and the number of students aged 20-24 as a share of total population. By including the share of students in total population they capture the effect of higher education on the debt level. Authors conclude that the growth of debt in Norwegian households is highly related to developments in the housing market. Moreover, the study shows that increase in house prices will contribute to debt growth for a long time as a result of higher final wealth and better position during loan negotiations.

Similar study conducted by Nakornthab (2010) investigates patterns of household debt in South East Asian countries. Due to the unavailability of long-term data series for some countries, econometric analysis is done only for Philippines, Taiwan and Thailand. Error correction model is again used with explanatory variables depending on each country's characteristics. Commonly used variables are GDP growth, house prices, unemployment rate, interest rates and lag of household debt from previous periods. Study suggests positive relationship between the level of household debt and house prices, GDP growth and lagged household debt. On the contrary, negative correlation between unemployment or interest rates and the level of household debt has been detected.

Turinetti and Zhuang (2011) explore factors, which are behind the rapid growth of household debt in USA. Using quarterly data from 1980 to 2010 study finds that negative relations between unemployment rate, interest rate, household income and household debt are present. On the other hand, positive relation between share of working age population and the amount of household debt occurs.

Büyükkarabacak and Valev (2010) evaluate whether household and enterprise credit has different impact on the economy. They obtained data from 45 countries and with use of population averaged panel logit model find out that household credit growth is an important predictor of banking crisis with higher explanatory power than enterprise credit expansions. Authors also suggest that a differential policy of targeting household credit may reduce the probability of crises without limiting the growth of credit to enterprise sector.

There are also plenty of studies using micro-data to describe the nature of household indebtedness. Alfaro and Gallardo (2012) study determinants of debt default in Chile. They find that variables such as income, number of people in the household who contribute to the total income, education and dummy for having a bank account are most important in explaining the amount of household debt. This view is supported by Albacete and Lindner (2013) who examine household debt in Austria. They claim that risk to financial stability stemming from the debt of vulnerable households is relatively low, mainly because of the fact that they hold lower nonmortgage debt compared to richer households. According to CNB Financial Stability Report, CNB (2013a), similar fact holds for the Czech Republic as well. Low-income households are over-indebted most frequently and show the highest sensitivity to negative changes in economic environment. On the other hand, the losses of the financial sector arising from the materialization of depression scenario would be limited given the relatively low overall debt of these households (CNB, 2013a, p. 35).

Another research by Anderloni, Bacchiocchi and Vandone (2011) evaluate the level of financial vulnerability of Italian households. They find out that 13% of households are not capable to face unexpected expenses. Exciting finding is that the effect of debt on vulnerability is stronger when a household holds consumer credit.

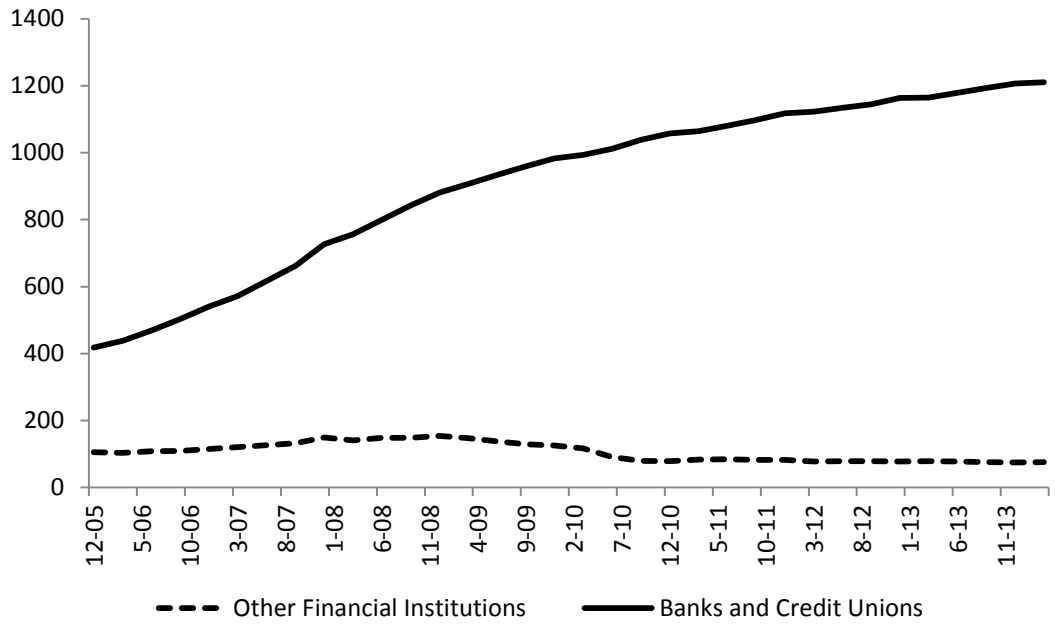
Generally, following factors are often used for studying the level of households' indebtedness: GDP growth, house prices, lending rates, unemployment rate, exchange rate and income. Basically, the same variables are used to model the evolution of NPL ratio. Some studies also use their own specific variables in particular models to capture country specific features. More research was done using

micro level data, which opens the space for further investigation of households' indebtedness on the macroeconomic level. We believe that there is a gap in the research regarding the impact of household sector borrowing on financial stability in case of the Czech Republic.

3 Evolution of Czech banking sector

Nowadays, Czech banks are from far away the prevalent provider of loans to private sector, including households. Figure 1 shows the increasing share of banks and credit unions in lending compared with loans provided by other financial institutions. While the amount of loans provided by banks and credit unions has been rising nearly linearly, the popularity of other financial institutions is decreasing since 2010. This trend could be attributed to higher confidence in banks.

Figure 1: Evolution of households' indebtedness by provider in billions of CZK



Source: ARAD data series system, the Czech National Bank

It is therefore reasonable to focus this part of the thesis on the banking sector. Because of significant changes in Czech economy during transformation after the Velvet Revolution, we briefly summarize the development of Czech banking sector and reveal its typical features.

3.1 The beginning of transformation process of Czech economic system

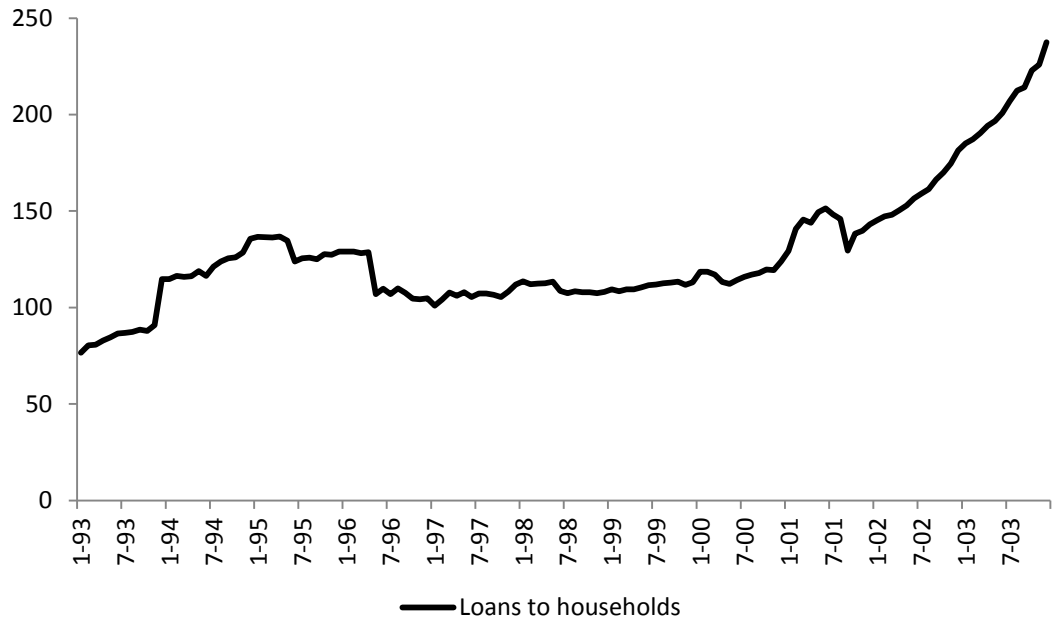
Just after the Velvet Revolution, Czech Republic had to deal with transformation of central-planned economy into market economy. There was just one former socialist "monobank", which had to be split into four large state-owned banks to create two-tier banking system. During this period, the banking sector was suffering from all imperfections inherited from the age of central planning system: undercapitalization, a burden of bad loans, a shortage of the long-term funds necessary to support banks' development plans, inexperienced staff, non-existent risk management, legal loopholes…Due to above mentioned problems, banking sector has been very weak and government assistance was unavoidable (Singer and Bárta, 2006). On the other hand, banking system started to follow the principle of universal banking; thus banks have not been concentrated only on deposits and loans, but also have been participating in capital markets or in insurance sector via subsidiaries. Thanks to the liberal licensing policy, 59 commercial banks had been already established by 1995 (Šmídková, 1996).

In order to provide healthy banking industry, cleaning up of banks' balance sheets has to be undertaken. In the first round large banks were freed from bad loans. Konsolidační banka was established as a main tool for dealing with this problem. The overall cost of Consolidations Programme 1 is estimated to have reached more than CZK 100 billion (about 7% of 1995 GDP) (Bárta and Singer, 2006). In 1994 more attention was paid to smaller banks as well. During this period, share of bad loans on the total amount of credit granted increased. It was on the level of 19% in 1992 but reached 26% in 1995 (Šmídková, 1996). Several small and medium-sized banks failed and lost their licenses. In fact, 18 banks out of a total of 54 banking institutions went bankrupt between 1990 and 1998 (Dubská, 2013). These banks were usually undercapitalized and faced risks which they did not know from the past. As banking supervision was still weak and inexperienced, small banks went on the path of unsound development strategies to increase their market share. Problems, mostly in banks with Czech capital, have occurred soon. In order to keep public confidence in the banking sector unthreatened, deposit insurance law was accepted in 1994. Dědek (2001) demonstrates that lost-making business of these banks presented no systemic risk itself, but costly prevention against negative impact on public has to be introduced. Maximum level of indemnity provided by deposit insurance fund was set to the level of CZK 300 000.

3.2 Recession at the end of 1990s

The end of the twentieth century showed that the Czech Republic was far from the completion of its economic transformation. Banking and subsequent financial crisis in 1997 disrupted the image of the Czech Republic as the most stable and developed post-communist country. The crisis culminated in currency crisis in May 1997 (for more details see Horvath 1999). Currency system was changed from pegged to floating. Bursting of the privatization asset price bubble led to Korunas depreciation and increased inflation expectations. Due to the uncertainties in economy, poor condition of supply side and monetary policy tightening, economy felt into recession. In 1997 GDP declined by 0.7% and by 1.2% in 1998. The growth of GDP was still sluggish in 1999 – 1.2% (Bárta and Singer, 2006). Indirect consequence of this crisis was fall of one of the biggest banks, IPB, in 2000. Figure 2 illustrates the impact of recession which was reflected in decreasing amount of loans provided by banks to households during this period.

Figure 2: Loans to households during the crisis in the end of 1990s (bil. CZK)



Source: ARAD data series system, The Czech National Bank

Decline in the amount of loans to households was supported by high real interest rates and more prudent behavior of commercial banks. Unwillingness of banks to provide loans slowed down the economic recovery and weakened efficiency of tools of Czech National Bank monetary policy. During the end of 1990s, the ratio of classified loans on the amount of total loans was at very high levels

(around 30%)[1]. This ratio reflected poor performance of the economy and low amount of newly granted loans. In order to improve their portfolios, banks started to invest in less risky assets (Hampl and Matoušek, 2000, p. 39). But not only loans were affected. Banks also suffered from decline of deposits. Czech state was still the largest shareholder of the biggest banks, and therefore had to try to improve their situation. In particular, state helped to clean up their balance sheets. This step was also necessary for later privatization of banks.

3.3 Privatization of the banking sector and its recovery

The Czech bank crisis accelerated necessary changes which should have been already done in the past. These changes were also indispensable for accession to the EU. The issue of privatization of large banks was very difficult. Voucher privatization was not ideal technique for banks. As a result, ownership was untransparent and too diluted (Bárta and Singer, 2006, p. 208). The main purpose of banks' privatization was to increase efficiency, profitability and competitiveness of Czech banks, in particular with respect to future EU membership (Dědek, 2001). Main Czech banks were sold to following investors:

- ČSOB was sold to the Belgian Kredietbank in 1999
- IPB was sold to Nomura in 1998
- Česká spořitelna was sold to Erste Bank in 2000
- Komerční banka was sold to Société Générale in 2001

The economic recovery accelerated in 2000. Key things behind this recovery were capital strengthening, takeover of bad loans done by KoB and privatization of Czech big banks. The ratio of non-performing loans started to decline dramatically after 2000 (Bárta and Singer, 2006). Moreover, banking regulation and supervision was improved as a result of entrance into the European Union. Czech Republic had to implement supra-national European law into the national legislative. Implementation should improve bank supervision, necessary condition for stable and effective banking system. It will also help to protect depositors and increase credibility of banking sector.

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[1] For this period, NPL ratio is not available. Contrary to NPL, classified loans contain also watched loans (overdue arrears between 30-90 days) other parts (substandard loans, doubtful loans and loss loans) being equal.

3.4 Financial crisis in 2008

Czech banking sector has been stable since 2000. The crisis, which originated in USA in summer 2007, changed situation in the Czech Republic as well. At the beginning of the crisis, primarily advanced economies were affected. Later in 2008, because of strong international connections, persistent unfavorable situation at markets and worldwide risk aversion, emerging economies were also heavily affected (Frank and Hesse, 2009). Thanks to the lesson taken from crisis, which Czech Republic experienced in the end of 1990s, and subsequent expensive restructuring of banking sector, Czech Republic belongs to countries, which were less severely affected by this global crisis. Czech banking sector was well-capitalized and "prepared" for the crisis. According to CNB (2009), banks' balance sheets were not burdened by toxic assets and the whole system was able to provide enough liquidity. Foreign currency loans were at limited levels, thus exchange risk was very low. But still, the impact of the global financial crisis on real economy led to increase in share of NPL as well as to lower credit growth. Table 1 indicates increase in amount of loans to households in 2007 but then, growth rates were lower. On the contrary, share of NPL increased during, and especially after, the crisis.

Table 1: Loans to households and NPL around crisis in 2008

	Year	2006	2007	2008	2009	2010	2011
Loans in total	Billions of CZK	536.390	720.915	873.374	974.750	1044.067	1098.171
	Change	29.3%	34.4%	21.1%	11.6%	7.1%	5.2%
NPL	Billions of CZK	17.575	21.144	25.592	38.701	53.378	54.368
	Share from total	3.3%	2.9%	2.9%	3.9%	5.1%	5%

Source: ARAD data series system, The Czech National Bank

In 2007, the amount of loans to households increased by nearly 35% while the share of NPL decreased to 2,9%. The impact of crisis on total loans provided is visible since 2008 (but mainly since 2009) when loans to households were still growing but at much lower pace. On the contrary, NPL ratio was affected with a lag. It started to rise in 2009 and increased by 38% in 2010. In terms of NPL, the crisis started to fade out in 2011, but credit growth was still at low levels.

In this section, main events regarding development of Czech banking sector were summarized. Transmission from central-planned economy into market economy lasted for decade. Some mistakes made during this process helped to the existence of recession in the end of 1990s and led to expensive restructuring of balance sheets of Czech banks. Major Czech banks were privatized and sold to foreign investors around 2000. It helped to increase their competitiveness, efficiency and prepared Czech banking sector for accession to the European Union. Implementation of supranational European law into Czech legislature improved bank supervision and regulation. Due to the crisis from the end of 1990s, the impact of global crisis from 2008 was not as severe as in other countries, but still visible from decreasing amount of loans and increasing share of non-performing loans.

4 Econometric analysis

The first chapters of this thesis were concentrated on existing literature dealing with the topic of households' indebtedness and briefly discussed the history of Czech banking sector. This part is focused on empirical analysis of available data. The aim is to find mutual relationships between the share of non-performing loans, financial indicators and variables capturing economic development of the Czech Republic. Based on the results of this analysis we would like to either confirm or decline generally accepted expectations regarding relationships between these variables.

4.1 Vector Autoregression approach and Vector Error Correction model

Models, which will be used for further analysis, are described in this section. Models' specifications, assumptions and their practicability are discussed.

4.1.1 VAR approach

The idea of VAR model was firstly presented in study conducted by Sims (1980). According to Sims (1980), VAR is dynamic multivariate model where each endogenous variable is regressed on its own lags and lags of all other variables. It serves for modeling and describing dynamic interrelations between individual variables. The main objective of this approach is to evaluate the dynamic response of the system to shocks in variables without being dependent on many identification restrictions as by structural models (Dickinson, Ford, Sun, 2010). VAR approach became popular mainly in macroeconomics. It is suitable for qualitative analysis of economic relationships as well as for forecasting.

VAR model can be understood as a natural generalization of univariate autoregressive models. It is kind of a hybrid between univariate time series models and simultaneous equations models. According to Brooks (2008, p. 291), this model has several advantages:

- All variables are treated as endogenous.
- The value of variable can depend on more features than just on its own lags. Therefore, VARs are much more flexible than univariate AR models and may be able to describe data better and provide better forecasts.
- Forecasts produced by VAR models are often better than forecasts produced by traditional structural models (see, for example, McNees, 1986).

On the other hand, VAR models also have some cons:

- It is challenging to interpret coefficients estimated by the model.
- The appropriate lag length selection is also not straightforward and several procedures are being used for it.

There is no general agreement, whether variables used should be stationary or not. If we want to examine statistical significance of coefficients, we need to have stationary variables. On the other hand, by first differencing we are losing valuable information on any long-run relationship and examining relationships between variables is the purpose of VAR estimation.

VAR model examines development of a set of *n* endogenous variables over time period *(t = 1, 2,…,T)*. Each variable is described as a linear function of its own lags and past realizations of remaining variables. A *p-th* order VAR, denoted VAR(p), can be defined as:

$$y_t = \alpha + A_1 y_{t-1} + A_2 y_{t-2} + A_3 y_{t-3} + \cdots + A_p y_{t-p} + \varepsilon_t \qquad (1)$$

where y_t is an *n x 1* random vector $(y_{1,t}, \dots, y_{p,t})'$, α is an *n x 1* vector of constants, A_i is a time invariant *n x n* matrix of coefficients and ε_t is an *n x 1* vector of error terms (for error terms requirements see Lütkepohl, 2005, p. 13).

Eq. 1 is so called reduced form of VAR. In each *i-th* equation, the only variable which is non-lagged is y_i and this variable is on the left hand side of the equation. This form of VAR can be easily estimated, even equation by equation via OLS. One can also include a set of *s* exogenous variables into the model (see Eq. 1.1).

$$y_t = \alpha + A_1 y_{t-1} + \cdots + A_p y_{t-p} + B_1 x_t + \cdots + B_s x_{t-s} + \varepsilon_t \qquad (1.1)$$

where x_t is the set of *s* exogenous variables.

As we mentioned earlier, all time series in VAR are assumed to be stationary. On the other hand, by differencing we are losing desirable information about comovement of variables. Therefore, the most crucial assumption is that the whole system is stable. Stability of the system is evaluated via eigenvalues of the matrix of coefficients. We can rewrite VAR(p) using lag operator (Eq. 1.2):

$$(I_n - A_1 L - A_2 L^2 - \cdots) y_t = A(L) y_t \tag{1.2}$$

with characteristic polynomial defined as (Eq. 1.3):

$$\pi(z) = (I_n - A_1 z^1 - A_2 z^2 \ldots) \tag{1.3}$$

If all roots of $|\pi(z)| = 0$ are within the unit circle, then VAR process is stable.

4.1.2 Vector Error Correction Model

Basically, VAR models have satisfactory characteristics when applied to covariance-stationary time series. But applying them to non-stationary or integrated processes could result in spurious results. If we have two time series both integrated of order one, I(1), we could model their relationships by taking first differences and including these differences into VAR or structural model. This procedure would be suboptimal if series are cointegrated. Under these circumstances, VAR approach expresses only short-run reactions to shocks in each series and does not capture long-run tendencies.

If set of series are I(1) and if there exists one or more cointegrating vectors, then VECM approach is optimal (Hamilton, 1994). This model accounts for both short run changes in variables as well as for deviations from equilibrium. The vector error correction model is a dynamic model where movements of variables are related to previous period's gap to long-run trend. The main difference from VAR models is the inclusion of lagged error correction term. This model might be applied if we expect that variables have common trends and they move together to some extent.

Error correction model is the combination of the first differenced and lagged levels of cointegrated variables. It is defined as (Brooks, 2008, p. 338):

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2 (y_{t-1} + \gamma x_{t-1}) + u_t, \text{where}$$

$y_{t-1} + \gamma x_{t-1}$ is known as an error correction term. In case of cointegration between y_t and x_t with cointegration coefficient γ, then $y_{t-1} + \gamma x_{t-1}$ are I(0) even though y_t and x_t are I(1).

Of course, the VECM can be estimated for more than just two variables. Any VAR(p) model can be rewritten as a VECM. For a set of *K* time series $y_t = (y_{1t}, \dots, y_{Kt})'$, the VECM is defined as:

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{p-1} \Delta y_{t-p+1} + \varepsilon_t, \tag{2}$$

where $\Pi = \left(I_K - A_1 - \cdots - A_p\right) and\ \Gamma_i = -\left(A_{i+1} + \cdots + A_p\right) for\ i = 1, \dots, p-1.$

VECM(p - 1) is derived from VAR(p) model by subtracting y_{t-1} from both sides of equation and rearranging terms. This model, as well as VAR model, can be extended by involving exogenous variables and deterministic terms. The key concept for this approach is the level of cointegration.

4.1.3 Cointegration

The decisive criterion for choosing appropriate model is whether series are cointegrated. It can happen that there exists some long-term systemic relationship between two variables and they are actually moving together, so that the residuals are stationary. Bivariate cointegrating relation simply requires the existence of linear combination of I(1) variables that is I(0). In other words, if x_t and y_t are I(1) and we can find two numbers such that $\alpha y_t + \beta x_t$ is I(0) ($\alpha \neq 0$, $\beta \neq 0$), then these two series are cointegrated. In case of multivariate analysis, the situation is little bit trickier. If y_t is a *K x* 1 vector of I(1) variables and we are able to find a vector β, such that βy_t is a vector of I(0) variables then y_t, is said to be cointegrated of order one with cointegrating vector β (Lütkepohl, 2005). The decisive parameter is the rank of matrix *Π* in Eq. 2:

- If $h(\Pi) = 0$, then all processes are I(1) and not cointegrated.
- If $h(\Pi) = K$, then all processes are I(0) and we use VAR approach.
- If $0 < h(\Pi) < K$, then vectors α and β exist, such that $\Pi = \alpha\beta'$ *and* $\beta' y_t$ represents cointegration relationship.

There are several tests to evaluate whether series are cointegrated. The first one was introduced by Engle and Granger (1987). They proved that cointegration implies error correction and vice versa and test presence of cointegration via error correction model. However, this approach is not suitable for our purposes. It is a

single equation model which does not allow for the existence of more than one cointegrating relationship. Therefore, more sophisticated lambda-max test introduced by Johansen (1988), which allows for existence of more than one cointegrating relationship, is used in this thesis. This test is based on VAR models and the test statistic involved is a maximum generalized eigenvalue. The null hypothesis of the test is the rank of cointegration equal to *r*. Alternative hypothesis is the rank of cointegration equal to *r+1*.

4.1.4 Lag length selection

It is challenging to determine appropriate lag length to be used in the model just from financial theory. We will use information criteria to determine this characteristic of the model. Basically, information criteria trade off a fall in residuals sum of squares as more lags are added to each equation with increasing penalty term. As it is usually desirable to have the same number of lags in each equation, we have to use multivariate version of these criteria. Following information criteria are most widely used:

$$AIC = Tlog|\mathrm{E}| + 2m$$

$$HQ = Tlog|\mathrm{E}| + 2(\log(logT))m$$

$$SIC = Tlog|\mathrm{E}| + (logT)m,$$

where *T* is the number of observations, $|\mathrm{E}|$ is the determinant of variance-covariance matrix of residuals and *m* is the number of parameters used in all equations.

We see that the only difference is in the extent to which they “penalize” for number of observations and parameters. Most of statistical softwares offer the possibility to determine optimal lag length in few steps. Generally, the lower the value of criterion is, the better. This procedure holds for VAR approach as well as for VECM. It is necessary to choose the maximum lag length to be tested. In this selection, number of observations, financial theory and periodicity should be taken into account.

4.1.5 Impulse Response Analysis

Due to many parameters, which are included in VAR or VECM, it is often not easy to interpret results in meaningful way. The question of interest is to evaluate the response of one variable to shock in another variable in a system, which includes some additional variables. IRA is designed to depict the effect of exogenous shock or

innovation in one of the variables on some or all other variables included in the model. As variables have sometimes different scales, we usually consider innovations of one standard deviation. If we have *m*-dimensional VAR model we can examine up to m^2 responses from the time of initial impulse (there are *m* responses in individual equations for all of the *m* endogenous variables). If the model is stationary, the influence of impulses disappears completely over time (Cipra, 2008). However, the persistence of effect of innovations is different for individual variables.

According to Lütkepohl (2005, p. 62), the main limitation of IRA is potential incompleteness of the system. As we are usually working with low-dimensional VAR/VECM models, the problem of omitted variables may occur. These effects are assumed to be in innovations. Therefore, if relevant variables are not included in the system, it may lead to significant distortions in the impulse responses and makes them worthless for further interpretations.

4.1.6 Variance decomposition

The second possibility how to interpret results of VAR/VECM, is by decomposing the final response to individual components. In other words, what portion of movements in endogenous variables is due to their own shocks and what portion of movements stemming from shocks to other variables. To be more precise, this method determines how much of the *h*-step ahead forecast error variance for particular variable is explained by innovations in individual equations ($h = 1, 2, \ldots$). For the dependent variable of particular equation usually holds, that the biggest portion of forecast error variance is explained by the innovation in the same equation (Cipra, 2008).

4.2 Selection of dataset

This section reveals the reasoning for selection of endogenous variables which will be used later in econometric analysis. Basic tests are provided as well as description of features of these time series. Variables are predominantly selected in compliance with academic literature, which was summarized in literature review.

Empirical part of this thesis and its econometric analysis is mostly inspired by studies of Rinaldi and Sanchis-Arellano (2006) and Nkusu (2011). Both works are examining relations between non-performing loans and financial indicators such as real lending rate, unemployment rate, inflation or GDP growth using VAR models or VECM. Rinaldi and Sanchis-Arellano (2006) chose variables on the basis of life-cycle consumption model. Considering availability of data and specific features

of the Czech Republic, following variables will be included in the model. GDP growth as indicator of financial condition is approximated by industrial production index as data for GDP are available only quarterly. CZK/EUR as the most important exchange rate reflects the competitiveness of the country. PRIBOR 1M is taken as approximation for interest rate as all market interest rates reflect PRIBOR after some period. Next variables included are unemployment rate as indication of financial vulnerability, inflation and the share of NPL from the total amount of loans provided to households.

In order to maximize the amount of observations, we decided to use monthly data. There were basically two main restrictions regarding the time period for our observations. Data capturing non-performing loans are available since January 2002 but, due to adjustments made to reflect bad loans from the past, data are applicable since the middle of 2003. Another inconvenience is that the Ministry of Labour and Social Affairs has changed methodic of monitoring unemployment rate two times during just the last 20 years. Therefore, the longest available time series concerning unemployment rate is available since January 2005. Based on these facts, the econometric analysis is done using monthly data in the Czech Republic over the period 1/2005 to 4/2014, resulting in 112 observations. For complete list of relevant variables, please see table 2.

Table 2: Overview of possible variables used in VAR/VECM model

Variable	Notation	Description	Units
Non-performing loans ratio	NPL	Ratio of households' NPL to gross households' loans	%
Unemployment rate	Unemp	Percentage of unemployed people in the population (aged 15-64)	%
Interest rate	PRIBOR 1M	PRIBOR 1 month	%
Inflation	CPI	Consumer price index, average of the 2005 = 100	%
Exchange rate	Exrate	CZK/EUR exchange rate	%
GDP growth	IPI	Industrial production index, average of the 2010 = 100	%

Source: ARAD, Czech Statisical Office, Ministry of Labour and Social Affairs

Most of the time series are available from the public database ARAD – part of the information service provided by the Czech National Bank. Some data are taken from database of Czech Statistical Office as well as from database of Ministry of Labour and Social Affairs. In order to have all data with monthly frequencies, we decided to approximate GDP by industrial production index.

4.2.1 Expected relations between macroeconomic factors and NPL

Based on existing literature and author's own consideration, expected mutual relationships between macroeconomic environment and the evolution of NPL are discussed in this subsection. Life-cycle consumption model and its various adjustments often serve as a source or reasoning for selection of determinants of NPL ratio. Lawrence (1995) introduces the probability of default into the model and highlights the role of income in being able to meet loan obligations. According to this study, people with low income face higher probability of default as a result of more severe consequences of potentially being unemployed. Rinaldi and Sanchis-Arellano (2006) as well as Jacobsen (2004) include lending rates as a cost of loan into the model. It would be also exciting to include a variable capturing age structure of the Czech Republic. Such variable is not available with monthly frequency and therefore it would require much longer period to carry this kind of study. Moreover, Dvořáková and Seidler (2012) confirm the existence of wealth effect in the Czech Republic. Again, the variable reflecting housing wealth is not available with monthly frequency and therefore not suitable for our study.

Our sample period covers prosperous years before the financial crisis in 2008, years of recession as well as recovering from this crisis. It is therefore reasonable to expect that the evolution of NPL ratio varies over time reflecting financial development and performance of economy. Below see expected mutual relationships between selected variables and the evolution of non-performing loans ratio:

- **Unemployment rate**

According to Debelle (2004), the most significant negative shock to household income is unemployment. The Effect of sudden increase in unemployment is even larger in countries with growing overall indebtedness. Growing indebtedness is associated with higher debt service levels. For households, whose members lost job, will be more difficult to finance loans and thus the probability of default will be higher. Based on this discussion, the increase in unemployment will result in higher share of NPL as households will find themselves in worse financial situation.

- **Interest rate**

The effect of changes in interest rate on NPL ratio depends on whether households hold loans with variable or fixed interest rate and whether the change in interest rate was anticipated by households at the time of loan arrangement. We can simplify the meaning of interest rate as a cost of borrowing. Higher the rate implicates higher cost of loan and it increases the probability that households will lose ability to meet payments. Most significant effect of changes in interest rates is expected by mortgages. Mortgages are usually designed for many years with the possibility of changes to the level of interest rate after some period. Unexpected shifts in yield curve could significantly change the patterns of payment. Therefore, the rise in interest rates should be associated with rise in NPL ratio. There are many types of interest rates that can be used in our analysis. We can expect that PRIBOR rates will be reflected in most rates after some period. Therefore, PRIBOR 3M or PRIBOR 1M, which are often used for determining mortgage interest rate, are possible candidates as the approximation of interest rate. However, 5Y IRS is also relevant, as mortgages interest rates are mostly fixed for the period of five years. We are going to perform analysis using different interest rates and evaluate, whether there are significant differences in results.

- **Inflation**

It is not so straightforward to determine whether inflation affects the share of NPL in positive or negative way. According to Khemraj and Pasha (2009), there is a positive relationship between share of NPL and inflation. Inflation pressures increase the level of impaired loans and reduce real income of households when wages are sticky. Thus make it more difficult to finance their loans. On the other hand, Nkusu (2011) suggests that inflation could make it easier for households to finance debt payments by reducing the real value of remaining loan. Another possible explanation for negative relationship is connected to Phillip's curve. According to Phillips (1958), higher inflation implicates lower unemployment and higher income. Based on this discussion and on previous studies, the effect of inflation on the share of NPL is ambiguous.

- **Exchange rate**

The influence of exchange rate on NPL ratio depends on whether households hold loans in foreign currency. Even though this type of loans is not typical for the Czech Republic, we include exchange rate in our analysis. The main reason for inclusion is interventions from Czech National Bank made in the end of 2013 against

CZK in order to avoid deflation. There is a wide discussion about suitability of interventions between academics, politicians, economists and public. There are some opinions that as a result of Koruna depreciation, households are actually poorer and their consumption power will further deteriorate. Therefore, we test whether there is increase in NPL ratio when currency depreciates. CNB admits that immediate consequences of weaker Koruna could be negative in some sense (CNB, 2013b). Imported inputs, goods and energies will be more expensive. On the other hand, this will be overcome in longer term. As a result of higher prices of imported goods, the demand for local goods will increase. Moreover, households will realize that waiting for lower prices is not efficient and most of them will increase their consumption instead of saving. Czech companies are expected to have higher revenues, higher ability to employ more workers and to reward current employees with larger salaries. This consideration supports hypothesis that currency depreciation could improve households' financial situation and reduce the share of NPL. Changes in exchange rate also influence inflation. The weaker the currency is, the higher the inflation. Previous discussion about relation between inflation and NPL ratio is therefore suitable here as well. Thus, the sign of effect of currency depreciation on NPL ratio is ambiguous. We use CZK/EUR as approximation for exchange rate as Eurozone area countries are most important partners for export/import.

- **GDP**

The last variable included is industrial production index. It serves as an approximation of GDP and represents the overall activity of economy. It is reasonable to expect that during prosperous years unemployment is lower and households' incomes are higher. It improves financial situation of households and reduces probability of having financial difficulties. Therefore, we expect negative relation between rise in GDP and share of NPL. The question whether GDP growth and unemployment rate are highly correlated is of importance here. If it is so, our model could suffer from multicollinearity. It does not affect the predictive power or reliability of the model, but estimated impact of variable X, ceteris paribus, on explained variable Y tends to be less precise than in the case of no correlation among independent variables. It is possible that changes in GDP and unemployment follow the same trend. If this is the case, multicollinearity could be present.

Table 3 summarizes expected relations between variables which are analyzed in our thesis.

Table 3: Expected mutual relations between NPL and other variables

Variable	Expected relationship with NPL ratio
Unemployment rate	Positive
Interest rate	Positive
Inflation	Ambiguous
Exchange rate	Ambiguous
Industrial production index	Negative

Source: Author's consideration

4.2.2 Descriptive statistics

In this subsection we examine time series plots of original data. Basic statistics like mean, median, maximum and minimum values are also provided (see Table 4).

Figures 3-8 indicate that series are most likely not stationary over time. There are clear trends during this decade and neither mean nor the variance is stable over time. Formal tests will be provided later. The whole concept of stationarity is described in chapter 4.2.3.

Another feature, which is visible from graphs, is the effect of financial crisis. Regarding non-performing loans ratio (Figure 3), the effect of crisis is visible with a short delay. At the end of 2008 and in the beginning of 2009, the share of NPL was at the lowest level. Since that time, it started to rise and culminated at the end of 2010 at the value around 5.2%. Up to now, it has been relatively stable. Similar story holds for unemployment rate where we see rapid increase at the beginning of 2009 (Figure 4). There is clear upward trend during the last 5 years. Current values of unemployment rate are about 4 % higher than the pre-crisis level.

Concerning interest rate and CPI, these variables are moving more or less in opposite direction (Figures 5, 6). Industrial production index seems to be the most volatile one with the most severe decline during the crisis and slow recovery just after it (Figure 7). Regarding exchange rate, currency has been appreciating against EUR until the crisis in 2008 (Figure 8). There is sharp depreciation during crisis and subsequent return to pre-crisis level of about 25 CZK/EUR. At the end of period of

our interest, the effect of interventions made by the Czech National Bank is present as currency depreciated to the target level about 27-28 CZK/EUR.

Table 4: Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Non-performing loans	4.22	0.88	2.8	5.33
Unemployment rate	6.3	1.17	3.8	8.6
PRIBOR 1M	2.07	1.07	0.44	4.36
CPI (2005 = 100)	112.5	7.73	99.1	123.2
IPI	101.67	9.39	80.54	121.86
CZK/EUR	26.51	1.75	23.53	30.31

Source: Author's calculations

Figure 3: Plot of NPL ratio

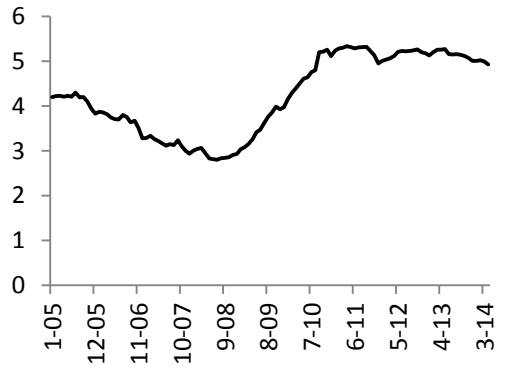


Figure 4: Plot of unemployment rate

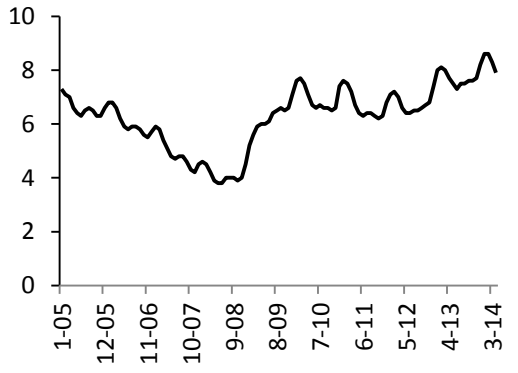


Figure 5: Plot of PRIBOR 1M

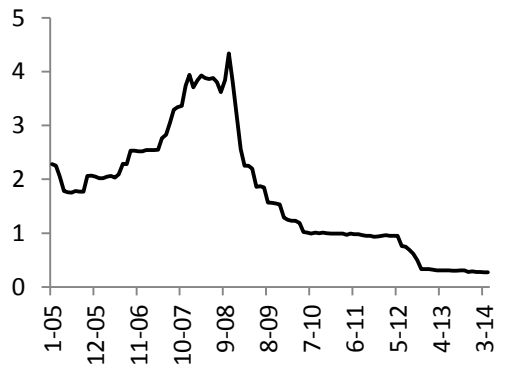


Figure 6: Plot of CPI (2005 = 100)

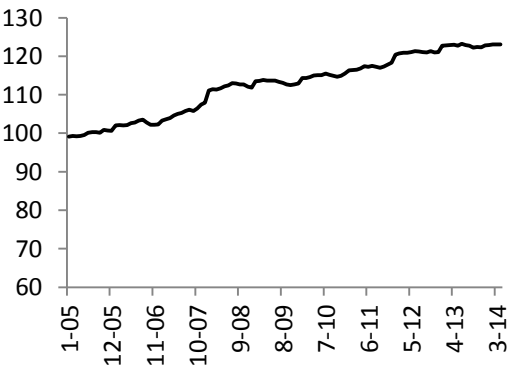


Figure 7: Plot of IPI

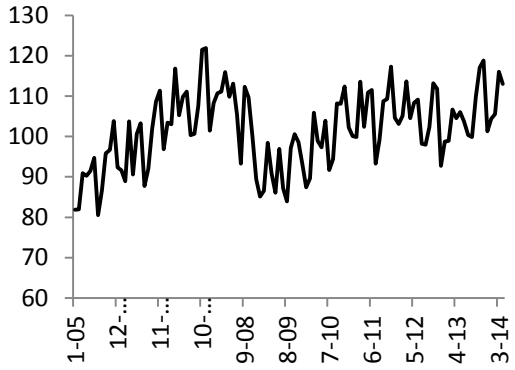


Figure 8: Plot of CZK/EUR

Source: ARAD, Czech Statistical Office

4.2.3 Time series stationarity

The important characteristic of time series is its stationarity. There are several methods which can be used for testing this feature. In this thesis, we use ADF test and KPSS test. All tests are run at 90% confidence level. Results of tests for original time series (levels) are available in Table 5.

ADF test is defined as follows:

$$\Delta y_t = \alpha + \delta t + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \cdots + \gamma_p \Delta y_{t-p}.$$

This version includes both trend and constant, but as we are interested in long run comovement, we will not include trend in our tests. The null hypothesis is non-stationarity of the system.

KPSS test reflects the possibility, that the impossibility to reject null hypothesis is just because of insufficient information (e.g. lack of observations). Therefore, this test has reverse hypotheses. We combine these tests in our thesis, in order to have as precise results as possible. It means that we can reliably reject non-stationarity when ADF test rejects H_0 and KPSS test does not.

Based on results of tests, original time series are not stationary. The only exception is industrial price index, where we reject the null hypothesis of non-stationarity using ADF test. According to KPSS test, none of the variables is stationary. The most common way how to make data stationary, is using their first differences. First differences can be understood as changes from one period to the next. Therefore, the interpretation of data is still useful.

Results of tests for stationarity after first differencing are much more satisfactory (see Table 6). The null hypothesis of unit root (non-stationarity) is

rejected using ADF test for all variables. This result is supported by KPSS test, as we are not able to reject null hypothesis that data are stationary. We can conclude that data are I(1) which is very encouraging finding for our future analysis[2].

Table 5: ADF test and KPSS test for stationarity (original time series)

Variable	ADF test statistics	KPSS test statistics
NPL	-0.521	**1.868***
Unemployment rate	-0.854	**1.228***
PRIBOR 3M	-0.43	**1.725***
IPI	**-2.967***	**0.652***
Exchange rate	-1.9	**1.666***
Inflation	-1.26	**2.8***
CZK/EUR	-2.072	**1.679***
PRIBOR 1M	-0.501	**1.847***
5Y CZK IRS	-0.502	**2.15***

Source: Author's calculations

Table 6: ADF test and KPSS test for stationarity (first differenced series)

Variable	ADF test statistics	KPSS test statistics
NPL	**-3.142***	0.448
Unemployment rate	**-4.972***	0.219
PRIBOR 3M	**-3.994***	0.198
IPI	**-11.306***	0.045
Exchange rate	**-4.717***	0.267
Inflation	**-5.334***	0.115
CZK/EUR	**-4.617***	0.313
PRIBOR 1M	**-3.987***	0.202
5Y CZK IRS	**-6.546***	0.156

Source: Author's calculations

[2] I(1) means that time series are integrated of order 1. It reports the minimum number of differences required to obtain a covariance stationary series.

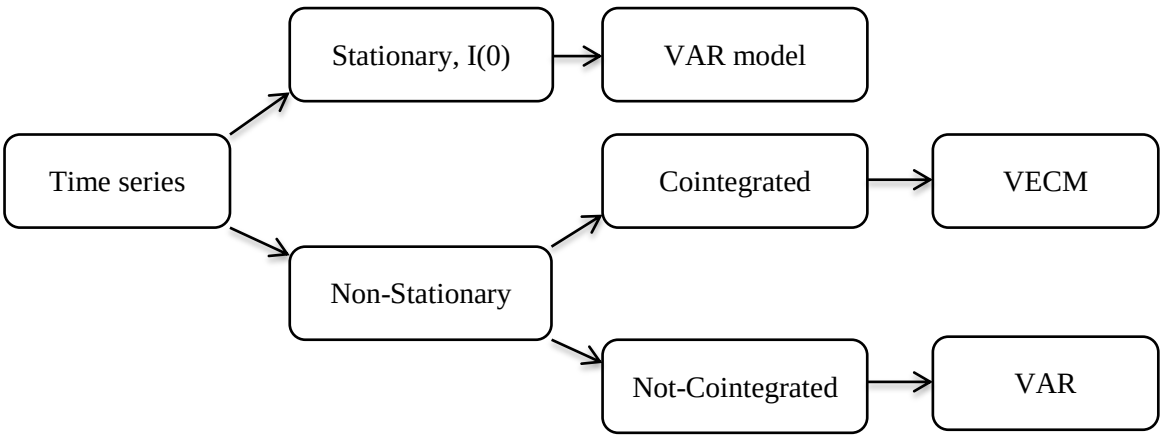
4.3 Model specification

Various types of models are estimated in this section. Firstly, VAR approach is used to evaluate short run reactions of variables to shocks in each series. Selection of variables is made according to existing literature, economic intuition, information criteria, robustness of results and characteristics of the model. Each model is followed by deep analysis of assumptions which are necessary for appropriate conclusions. Two methods, impulse response analysis and forecast variance decomposition, are used for interpretation of results.

Next, we test whether there is cointegration relation among series. If cointegration is present, we can use VECM to examine long term relationships between variables. Same methods as for VAR are used to check assumptions and evaluate results. At the end of this section, we discuss whether estimation provided by VAR differs significantly from estimation provided by VECM.

Figure 9 shows procedure for the selection of appropriate model:

Figure 9: Selection of appropriate model



Source: Based on Cipra (1998)

4.3.1 Modeling households' NPL ratio using VAR approach

In this section we model share of NPL on total amount of loans provided to households using various specifications of VAR model. Models differ in variables used or in lag length selection.

4.3.1.1 VAR(4) of NPL, Unemployment, IPI, CPI, PRIBOR and CZK/EUR

The first model examines mutual relations between households' indebtedness and variables capturing macroeconomic environment. Households' non-performing loans ratio, unemployment rate (U), consumer price index (average of 2005 = 100), industrial production index (average of 2010 = 100) as approximation of GDP growth, PRIBOR 1M (PR) and CZK/EUR are taken as endogenous variables. All series are not stationary, but stability of whole system is of importance.

First of all, the optimal lag length of the model is determined. Method based on cross-equation restrictions is not adequate as we have six variables and F-test would be used separately for the set of lags in each equation. This would be suboptimal and time consuming to perform (Cipra, 1998). Therefore, the optimal lag length is selected according to information criteria and the goodness of fit of the model. Each information criterion suggests different number of lags to be used. AIC selects the optimal length to be equal to twelve. However, this model does not satisfy stability condition. BIC suggests only one lag, HQIC suggests two lags and final predictor error suggests four lags. Based on this information and on properties of the estimated model, we choose VAR(4) model as the most suitable one. This model is formalized for NPL_t as following:

$$\begin{aligned} NPL_t = \mu &+ \alpha_1 NPL_{t-1} + \alpha_2 U_{t-1} + \alpha_3 IPI_{t-1} + \alpha_4 CPI_{t-1} + \alpha_5 PR_{t-1} \\ &+ \alpha_6 CZKEUR_{t-1} + \beta_1 NPL_{t-2} + \beta_2 U_{t-2} + \beta_3 IPI_{t-2} + \beta_4 CPI_{t-2} \\ &+ \beta_5 PR_{t-2} + \beta_6 CZKEUR_{t-2} + \gamma_1 NPL_{t-3} + \gamma_2 U_{t-3} + \gamma_3 IPI_{t-3} \\ &+ \gamma_4 CPI_{t-3} + \gamma_5 PR_{t-3} + \gamma_6 CZKEUR_{t-3} + \delta_1 NPL_{t-4} + \delta_2 U_{t-4} \\ &+ \delta_3 IPI_{t-4} + \delta_4 CPI_{t-4} + \delta_5 PR_{t-4} + \delta_6 CZKEUR_{t-4} + \varepsilon_t \end{aligned}$$

It means that current value of the share of NPL on total amount of loans is determined by its own lags and lags of all other variables which are included in the model. The outcome of the whole model consists of 144 coefficients that are needed to be estimated. Out of 144 coefficients, 41 are statistically significant at 90% confidence level (roughly 28.5%). Table 7 shows results for equation of our interest, where the share of non-performing loans is on the left hand side of the equation. However, these coefficients are of little importance. We are not able to interpret them as eleasticities between particular variables because of dynamic structure of the VAR model. By the construction, F-test results do not explain the sign of the relationship or duration of the effect of one variable on another (Lütkepohl, 2005). For this purposes impulse response analysis and forecast variance decomposition are used.

Table 7: VAR(4) – NPL, Unemployment, CPI, IPI, PRIBOR 1M, CZK/EUR

VAR(4), 108 observations, AIC = 4.47, HQIC = 5.98, SBIC = 8.19			
NPL	Coefficient	p-value	z-value
NPL (t-1)	**0.909****	0.000	9.52
NPL (t-2)	0.14	0.27	1.1
NPL (t-3)	-0.132	0.299	-1.04
NPL (t-4)	-0.218	0.807	-0.24
U (t-1)	**0.076***	0.077	1.77
U (t-2)	-0.044	0.562	-0.58
U (t-3)	-0.124	0.122	-1.55
U (t-4)	**0.136****	0.002	3.11
IPI (t-1)	**-0.002****	0.041	-2.04
IPI (t-2)	-0.002	0.142	-1.47
IPI (t-3)	-0.001	0.234	-1.19
IPI (t-4)	0.001	0.431	0.79
CPI (t-1)	0.009	0.534	0.62
CPI (t-2)	0.021	0.269	1.1
CPI (t-3)	-0.013	0.466	-0.73
CPI (t-4)	-0.016	0.217	-1.23
PR (t-1)	0,004	0.945	0.07
PR (t-2)	-0.075	0.337	-0.96
PR (t-3)	0.074	0.356	0.92
PR (t-4)	-0.034	0.542	-0.61
CZEU (t-1)	**-0.041****	0.018	-2.37
CZEU (t-2)	-0.004	0.877	-0.15
CZEU (t-3)	0.042	0.104	1.63
CZEU (t-4)	**-0.029***	0.096	-1.67

Significance at 10% level (*), significance at 5% level (**)

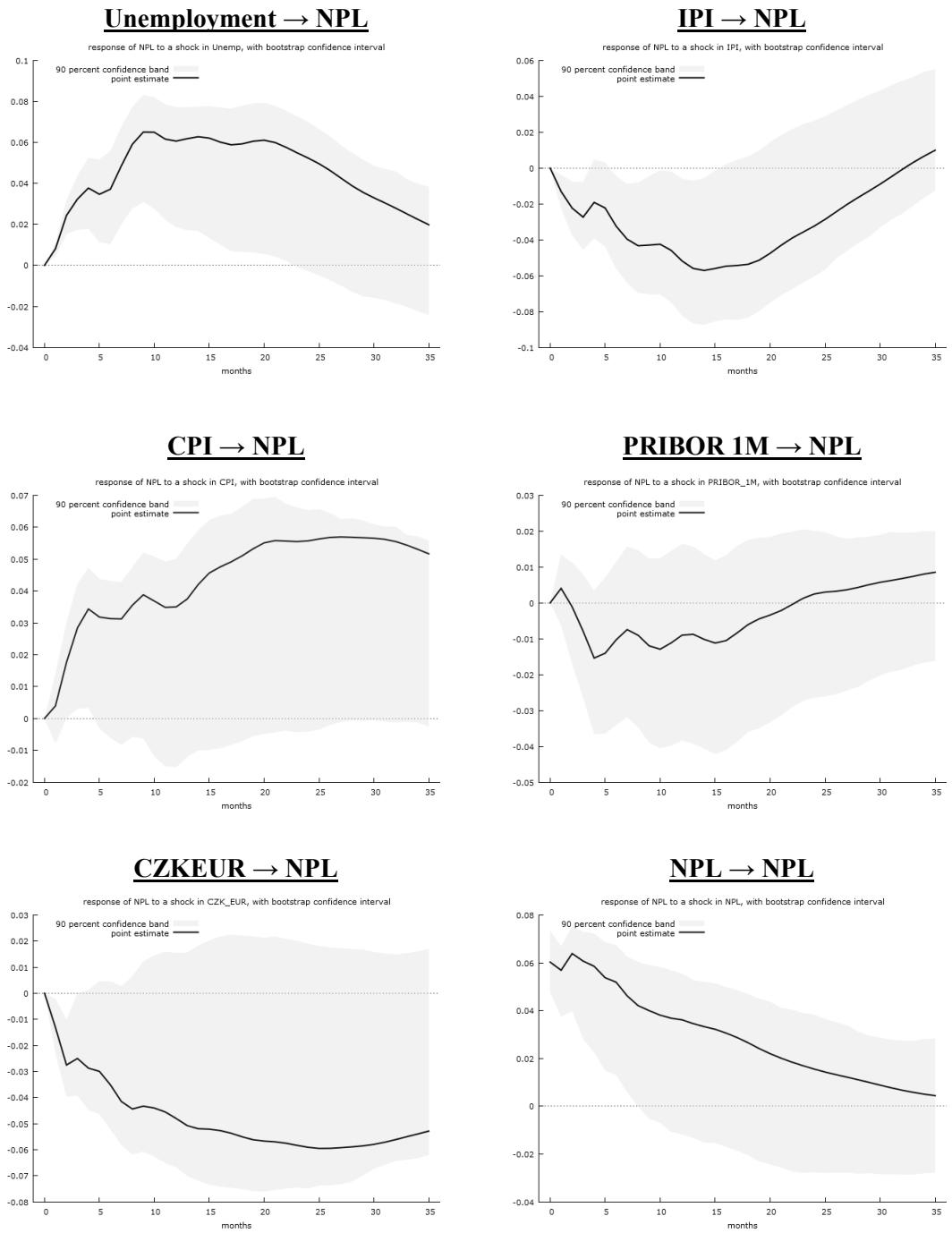
Before analyzing results we check the validity of model. Stability condition is satisfied as all eigenvalues lie inside the unit circle (see Appendix 1). Lagrange-multiplier test was not able to reject the null hypothesis of no residuals autocorrelation for individual equations as well as for different lag orders. Test for ARCH effect was not able to reject the null that there is no ARCH effect present. The only assumption, which is violated, is the normality of residuals. The normality

of residuals is rejected by Jarque - Bera test. According to Juselius (2003), the normality assumption is often violated in empirical VAR models as a result of inability to capture large shocks and to appropriately distinguish between ordinary and extraordinary shocks. However, Juselius (2006) argues that residuals in VARs/VECMs need not to be normally distributed, if it is caused mostly by excess kurtosis, which is the case of our model.

We also check stability of our analysis using CUSUM test. CUSUM statistic is based on a normalized version of the cumulative sums of residuals. Under the null hypothesis, the CUSUM statistic is zero and parameters are perfectly stable. This test gives us usefull visual impression of the stability of parameters. A set of ±2 standard error bands is usually plotted around zero. Any statistic lying outside the bands is considered as evidence of parameter instability (Brooks, 2008). According to this test, all equations are stable with one exception of CZK/EUR exchange rate (see Appendix 2). This equation shows instability at the end of 2013 and it is probably because of interventions made by Central Bank against CZK. We estimated another model including dummy variable to capture the start of interventions. It makes this equation stable. However, results are nearly the same. Therefore, it is not necessary to revise specification of our model as the instability of CZK/EUR equation is not dramatic and does not have significant effect on other variables.

Now, we proceed to the analysis of mutual interactions between individual variables. We examine the effect of innovation in one of the variables on some or all other variables included in the model. This is done through impulse response analysis. We need to cover sufficiently long period; therefore response of variable is traced during 36 months following the time of initial shock. Figure 10 shows IRA of VAR(4) model.

Figure 10: IRA of complete VAR(4) model



Source: Author's calculations

The effect of shock in unemployment rate has expected effect on the share of non-performing loans. Increase in unemployment indicates higher level of NPL ratio. This effect is strongest during the first 10 months. Afterwards, it is stable for couple of months and starts to return back to zero after 2 years. According to this analysis, the effect is statistically significant during the first 22 months from the time of initial

shock. Our results are consistent with Bofondi and Ropele (2011), Babouček and Jančar (2005), Jouini and Messai (2013) and Debelle (2004).

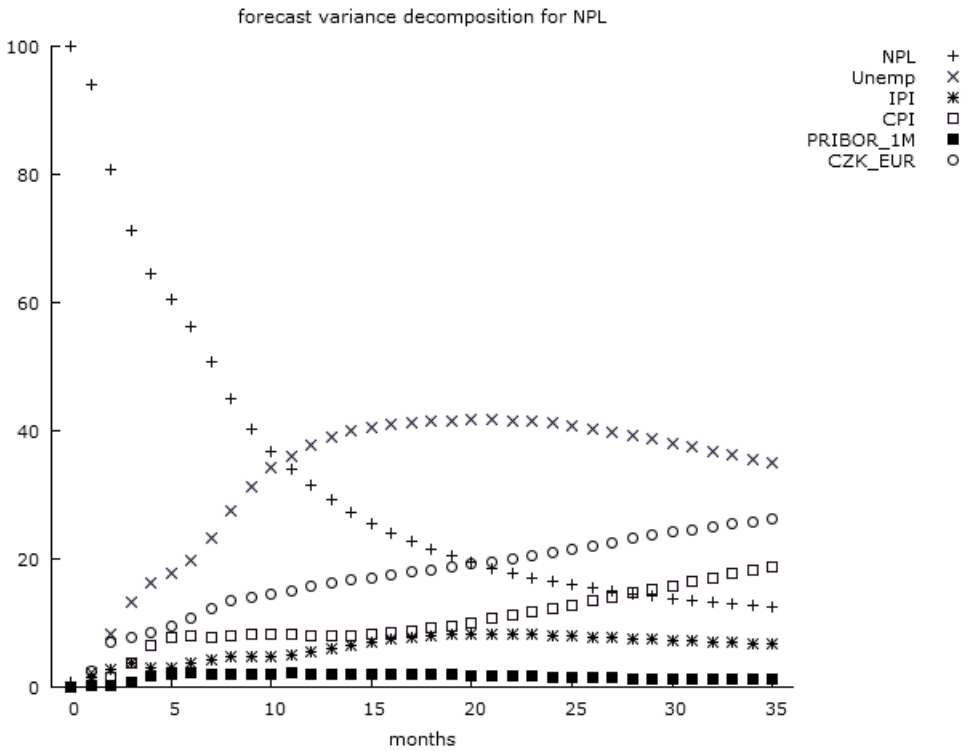
Negative relation between GDP growth and NPL ratio is confirmed by our analysis. GDP growth, which is approximated by industrial production index, lowers the level of NPL ratio. Delay of the effect is similar as for unemployment rate. It reaches its peak around one year from the time of initial shock. After that, share of NPL returns back to zero and it is not statistically significant anymore. This result corresponds to studies conducted by Rinaldo and Sanchis-Arellano (2006), Bofondi and Ropele (2011). Babouček and Jančar (2005) also tested link between NPL and GDP growth in case of the Czech Republic, but they were not able to confirm the presence of negative relation, which is in contradiction with our findings.

Positive interconnection is found between consumer price index and non-performing loans ratio. However, this effect is negligible and significant with a short delay just during first few months. Similar relationship was found by Babouček and Jančar (2005) in case of the Czech Republic, Khemraj and Pasha (2009) in case of Guyana. It indicates that inflation reduces real income of households and this is not reflected in higher wages. Thus households have problems with repaying existing loans. On the other hand, Bofondi and Ropele (2011) found opposite effect of inflation on the share of NPL using data from Italy.

The effect of PRIBOR 1M is in contradiction with our expectations. However, the effect is negligible, negative and statistically insignificant. It can result from the fact that Czech households prefer loans with fixed interest rate, and thus changes in interest rate do not affect the level of regular payments.

According to our analysis, depreciation of CZK against EUR increases payback capacity of households. The effect is relatively minor, but significant during the first 3 months after the shock. Since that time, the effect is not significant anymore. This result corresponds to Doutnáčová (2013) and is supported by the fact that Czech Republic is export oriented country. Thus depreciation helps exporters, which are sensitive to changes in exchange rate, to produce and export more goods. Better financial situation of export oriented firms might be reflected in more job vacancies and higher salaries after some period. This effect will be reflected in lower households' NPL ratio with a delay. However, results of our analysis are in contradiction with this theory, as effect of depreciation is immediately reflected in lower NPL ratio. IRA shows long-term negative relation, but not statistically significant.

Figure 11: Forecast variance decomposition of complete VAR(4)



Source: Author's calculations

By decomposing the response of NPL ratio to innovations in all series individually we see, that own shock has the most significant influence during the first 10 months but explaining only about 17% at the end of observed period (see Figure 11). The influence of unemployment rate is increasing over time and reaches its peak after one year explaining nearly 40% of the response. Since this time, shock to unemployment mostly explains development of NPL ratio. The influence of CZK/EUR shock is increasing linearly and exceeds 20% after 3 years. Around 15% of response of share of NPL is explained by shock in CPI. Just minor part of response is explained by innovations in IPI. The influence of PRIBOR 1M is distinctly less important.

Next several chapters present results of additional models with different specifications. Findings are mostly consistent with this first model and are also in line with studies conducted by Bofondi and Ropele (2011), Babouček and Jančar (2005), Jouini and Messai (2013), Rinaldo and Sanchis-Arellano (2006), Khemraj and Pasha (2009), Debelle (2004) and Doutnáčová (2013). If results differ from the first model or previous studies, this difference is mentioned.

4.3.1.2 VAR(3) of NPL, Unemployment, CPI, PRIBOR and CZK/EUR

The second specification of model and subsequent selection of variables is based on the idea presented in chapter 4.2.1 that unemployment rate and industrial production index are moving together over time. Therefore, the inclusion of both variables in the model could be not necessary and could result in multicollinearity. The second model includes following variables: households' non-performing loans ratio, unemployment rate, consumer price index (average of 2005 = 100), industrial production index (average of 2010 = 100) as approximation of GDP growth, PRIBOR 1M and CZK/EUR.

First of all, we have to determine the right number of lags to be used in the model. Again, information criteria provide inconsistent results for lags selection. Two of them select 2 lags as the best choice; however resulted model does not fulfill the assumption of no autocorrelation. Therefore, we decided to use 3 lags for modeling. This model is formalized for NPL as following:

$$\begin{aligned} NPL_t = \mu &+ \alpha_1 NPL_{t-1} + \alpha_2 U_{t-1} + \alpha_3 CPI_{t-1} + \alpha_4 PR_{t-1} + \alpha_5 CZKEUR_{t-1} \\ &+ \beta_1 NPL_{t-2} + \beta_2 U_{t-2} + \beta_3 CPI_{t-2} + \beta_4 PR_{t-2} + \beta_5 CZKEUR_{t-2} \\ &+ \gamma_1 NPL_{t-3} + \gamma_2 U_{t-3} + \gamma_3 CPI_{t-3} + \gamma_4 PR_{t-3} + \gamma_5 CZKEUR_{t-3} + \varepsilon_t \end{aligned}$$

The outcome of the whole model consists of 75 coefficients, which are needed to be estimated. Out of these 75 coefficients, 29 are statistically significant at 90% confidence level (approximately 39%). It means that higher percentage of coefficients are statistically significant than by the first model. However, coefficients are of little importance for us.

We check stability conditions using the same methods as by the first model. All eigenvalues lie inside the unit circle which means that our model is stable again (see Appendix 3). There is also no evidence of residuals autocorrelation for individual equations as well as for different lag orders. ARCH effects are also not present in this model. The only assumption which is again violated is the assumption of normally distributed residuals. As in the case of the first model, non-normality is mainly result of excess kurtosis, and therefore violation of this assumption is not crucial for further analysis. CUSUM test is used to check stability of our results (see Appendix 4). At this time, all equations are stable over time with only slight disruption of the boarder by CZK/EUR equation after interventions against CZK at the end of 2013. As the violation is not crucial, no additional steps are needed to fix this problem.

As our model satisfies all necessary assumptions/see above, we present results in Table 8. As mentioned earlier, we are not able to make any conclusions from these coefficients. Therefore, we continue with impulse response analysis and forecast variance decomposition to examine mutual relations.

Table 8: VAR(3) – NPL, Unemployment, CPI, PRIBOR 1M, CZK/EUR

VAR(3), 109 observations, AIC = -1.51, HQIC = -0.71, SBIC = 0.46			
NPL	Coefficient	p-value	z-value
NPL (t-1)	**1.053****	0.000	11.2
NPL (t-2)	0.242	0.86	0.18
NPL (t-3)	**-0.168***	0.062	-1.86
U (t-1)	**0.128****	0.002	3.07
U (t-2)	**-0.156****	0.019	-2.34
U (t-3)	0.053	0.196	1.29
CPI (t-1)	0.004	0.741	0.33
CPI (t-2)	0.019	0.309	1.02
CPI (t-3)	**-0.026***	0.052	-1.94
PR (t-1)	-0.047	0.391	-0.86
PR (t-2)	-0.067	0.393	-0.85
PR (t-3)	0.065	0.229	1.2
CZEU (t-1)	**-0.052****	0.005	-2.82
CZEU (t-2)	0.013	0.632	0.48
CZEU (t-3)	0.145	0.448	0.76

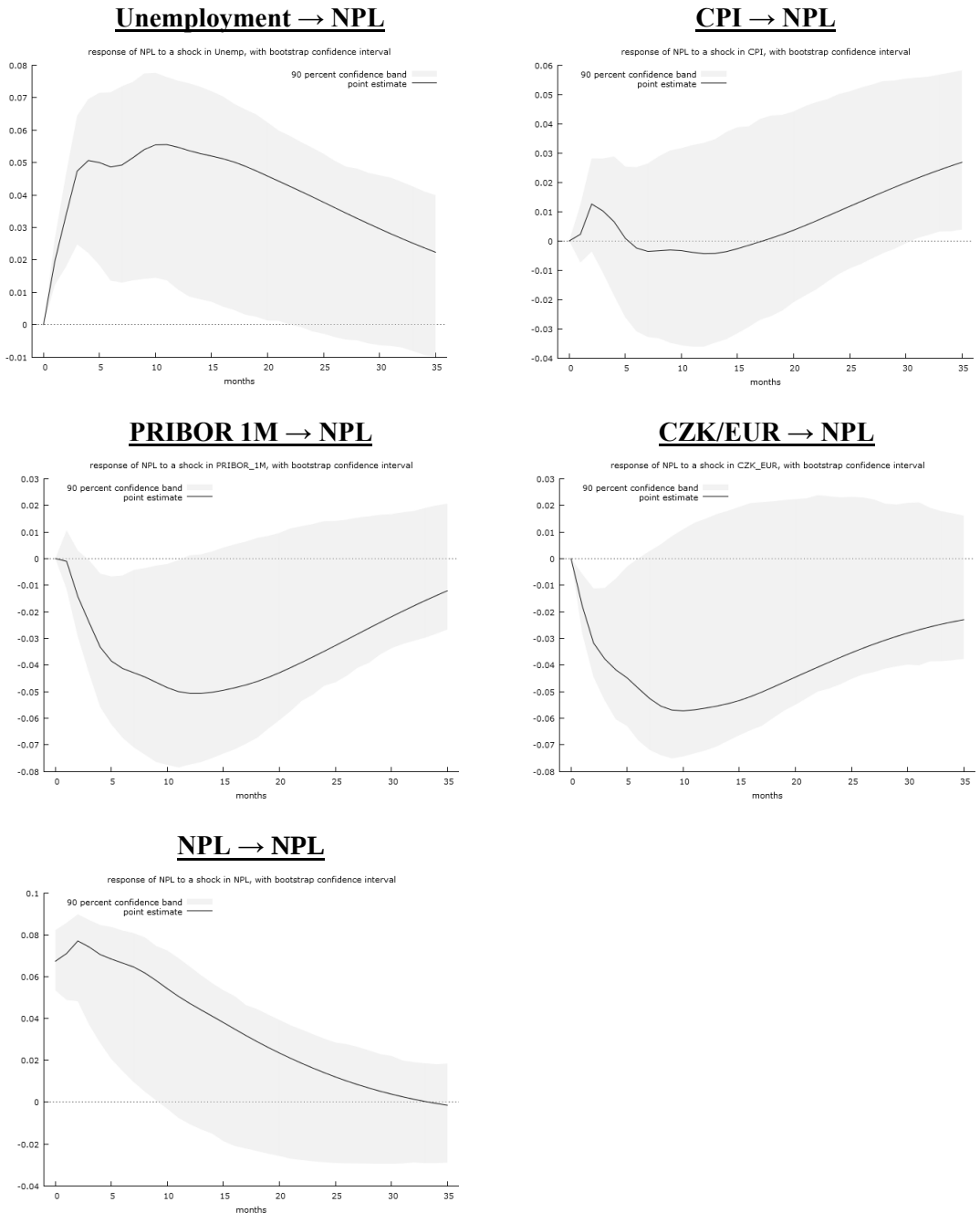
Significance at 10% level (*), significance at 5% level (**)

As well as for the first model, we choose the period of 36 months for our analysis during which responses of variables to innovations in other variables are traced. This period has to be long enough to capture the whole effect of the change. We consider innovations of one standard deviation. Figure 12 shows IRA for this model.

The effect of shock in unemployment rate on the share of NPL is as expected. It causes significant increase during the first three months and NPL ratio remains stable after that for around a year. Since that time, it starts to decrease slowly to zero. If we compare this chart with chart from the first model we see, that the effect of shock is stronger from the very beginning. However, the magnitude of response to the innovations in unemployment rate is weaker after 10 months. Regarding significance,

both results are consistent. This shock is also smoother than the one presented in the first model.

Figure 12: IRA of VAR(3) model without IPI



Source: Author's calculations

The interconnection between consumer price index and non-performing loans ratio becomes statistically significant after 30 months. The effect is weak and since it is long time after the initial shock, we consider it as not so reliable. Moreover, response of NPL ratio seems to be explosive. We looked at longer time period in order to examine this effect. After 42 months, response function is again not significant and constant. Compared to the first model, the influence of CPI is quite different. The response is minor at the beginning and statistically insignificant. It can be caused by the use of lower number of lags or by exclusion of IPI from the model.

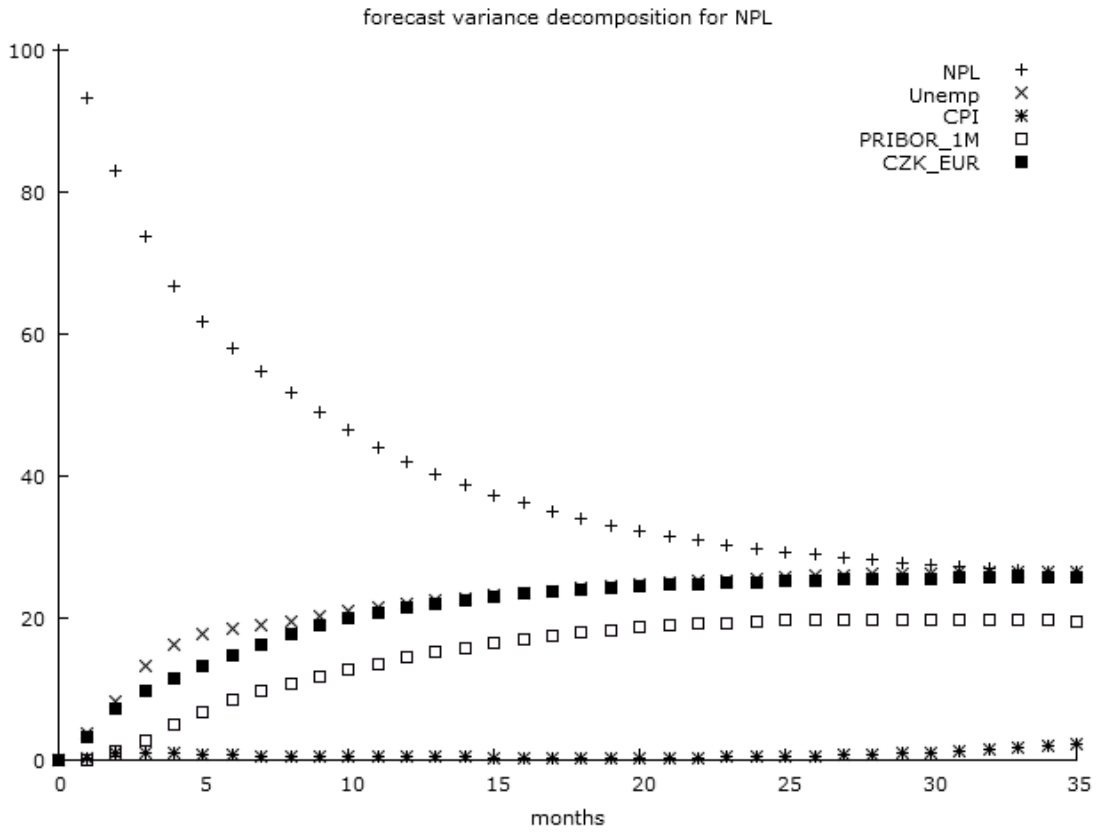
PRIBOR 1M influences NPL ratio similarly as by the first model. The effect is negative, but statistically significant for the second half of the first year. It is not consistent with our expectations of positive relation. It can result from the fact, that loans with variable rates are not so widespread among debtors, which confirms also CNB (2014a). Second possible reasoning could be lower demand for loans in environment with higher interest rates. Compared to the first model, response to shock is bigger, smoother and NPL ratio returns slower to zero. However, this result is in contradiction with empirical evidence of positive correlation between interest rate and NPL (Nkusu, 2011; Adebola, Yusoff and Dahalan, 2011; Louzis, Vouldis and Metaxas, 2010).

According to our analysis, shock in CZK/EUR (depreciation of CZK against EUR) lowers the share of non-performing loans. The magnitude of effect is similar as by unemployment rate and is significant during 7 months following the initial shock. This result is consistent with the first model. However, the influence is significant for longer time and value of NPL ratio returns to zero faster. This result is also consistent with study conducted by Farhan, Sattar, Chaudhry and Khalil (2012).

Based on forecast variance decomposition (see Figure 13), the main influence on the evolution of share of NPL has the own shock. The effect of shock is exponentially decreasing and converging to value somewhere below 30%. The effect of own shock is more important than by the first model. The similar part of movements in non-performing loans ratio could be explained by either innovations in unemployment rate or by innovations in CZK/EUR. However, the influence of unemployment rate is significantly lower than by the first model. On the other hand, CZK/EUR drives NPL ratio in the same way as before. PRIBOR 1M is much more important than in the previous case. It explains nearly 20% of forecast error variance. The effect of CPI is nearly negligible. To summarize our results, by neglecting IPI, the effect of own shock and PRIBOR 1M became more important. Response of NPL ratio to shock in PRIBOR 1M was hindered by the presence of IPI. The influence of

CZK/EUR remains nearly the same. It means that CZK/EUR and IPI are probably not so much interconnected. The effects of unemployment rate and mainly CPI are much less significant. Little importance of CPI led us to the idea to omit CPI from the next model.

Figure 13: Forecast variance decomposition of VAR(3) without IPI



Source: Author's calculations

4.3.1.3 VAR(4) of NPL, Unemployment, PRIBOR 1M and CZK/EUR

The last specification of VAR model includes share of non-performing loans, unemployment rate, PRIBOR 1M and CZK/EUR exchange rate as endogenous variables. Because of insignificant results of CPI by the last model, we decided not to use this variable for further estimations.

The appropriate value of lag length is determined in the same way as before. Each information criterion suggests different number of lags to be used starting from 2 and ending with 12. We do not have enough observations to estimate model with 12 lags and VAR(2) estimation does not satisfy stability condition. The best results are obtained for VAR(4) specification, which minimizes information criteria, has

economic meaning and satisfies all necessary conditions. This model is defined for NPL as following:

$$NPL_t = \mu + \alpha_1 NPL_{t-1} + \alpha_2 U_{t-1} + \alpha_3 PR_{t-1} + \alpha_4 CZKEUR_{t-1} + \beta_1 NPL_{t-2} + \beta_2 U_{t-2} + \beta_3 PR_{t-2} + \beta_4 CZKEUR_{t-2} + \gamma_1 NPL_{t-3} + \gamma_2 U_{t-3} + \gamma_3 PR_{t-3} + \gamma_4 CZKEUR_{t-3} + \delta_1 NPL_{t-4} + \delta_2 U_{t-4} + \delta_3 PR_{t-4} + \delta_4 CZKEUR_{t-4} + \varepsilon_t$$

The outcome of the whole model consists of 64 coefficients which have to be estimated. Out of these 64 coefficients, 26 are statistically significant at 90% confidence level (approximately 41%). This share is similar to the previous model with the same conclusion, that sign or significance of coefficients are of little importance for us. Table 9 shows estimated results for the equation of our interest with non-performing loans on the left hand side of the equation.

Table 9: VAR(4) - NPL, Unemployment, PRIBOR 1M, CZK/EUR

VAR(3), 109 observations, AIC = -1.51, HQIC = -0.71, SBIC = 0.46

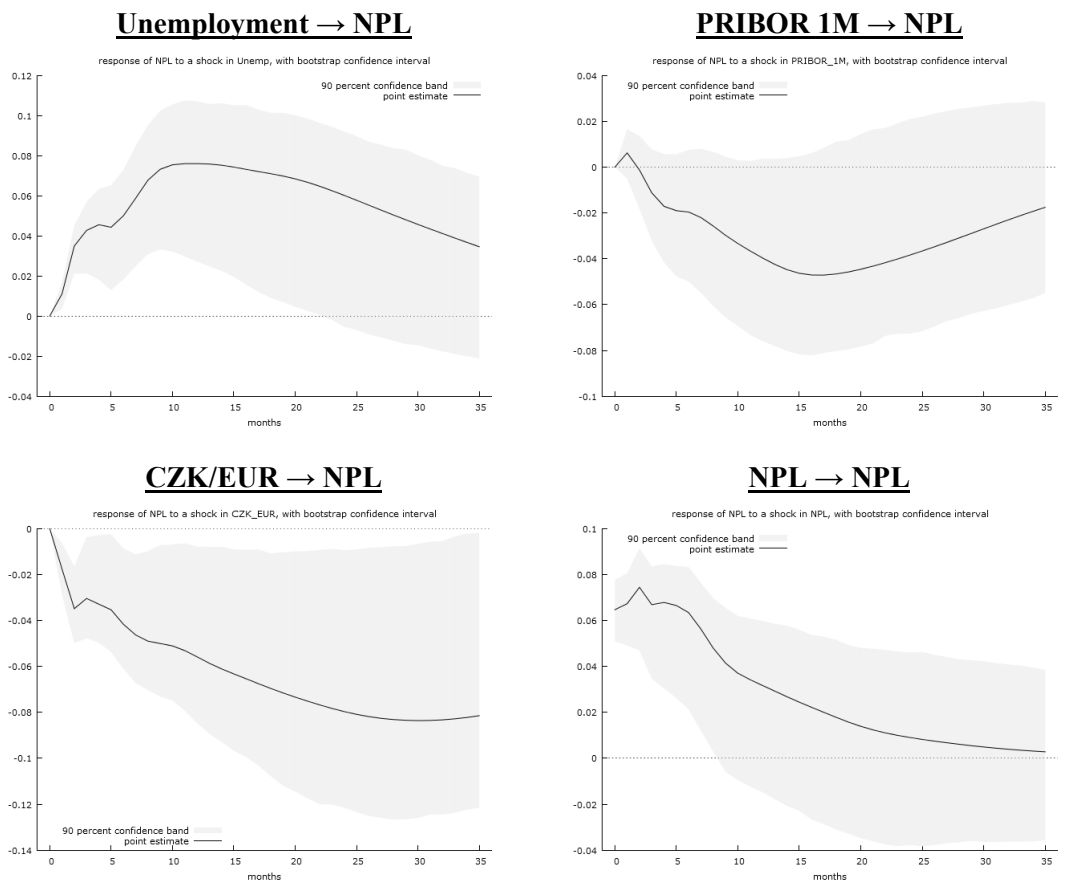
NPL	Coefficient	p-value	z-value
NPL (t-1)	**1.055****	0.000	11.41
NPL (t-2)	0.097	0.464	0.73
NPL (t-3)	**-0.26****	0.047	-1.99
NPL (t-4)	0.025	0.774	0.29
U (t-1)	**0.923****	0.027	2.21
U (t-2)	0.003	0.969	0.04
U (t-3)	**-0.175****	0.021	-2.31
U (t-4)	**0.143****	0.000	3.63
PR (t-1)	0.011	0.835	0.21
PR (t-2)	-0.125	0.113	-1.59
PR (t-3)	0.106	0.188	1.32
PR (t-4)	0.011	0.839	0.20
CZEU (t-1)	**-0.051****	0.004	-2.85
CZEU (t-2)	0.004	0.870	0.16
CZEU (t-3)	**0.052***	0.055	1.92
CZEU (t-4)	-0.03	0.105	-1.62

Source: Author's calculations

After estimation we proceed to checking assumptions of the model. All of the eigenvalues lie safely inside the unit circle and our model is stable again (see Appendix 5). Residuals are not autocorrelated in individual equations as well as at different lag orders. There is also no evidence of ARCH effects contaminating our residuals. As usual, our model is not able to distinguish between ordinary and extraordinary shocks since residuals are not normally distributed. As in previous cases, this violation is mainly caused by excess kurtosis, which makes this problem less severe. Finally, CUSUM test is applied to check stability of estimated results (see Appendix 6). Compared to previous models, all equations are stable over time and development of particular variables lies safely inside the bands implied by a set of ±2 standard errors.

As we know that our model satisfies all necessary assumptions, we proceed to further analysis. Figure 14 shows impulse response analysis for share of non-performing loans over the period of 36 month. The shock of one standard deviation is considered.

Figure 14: IRA of VAR(4) model without IPI and CPI



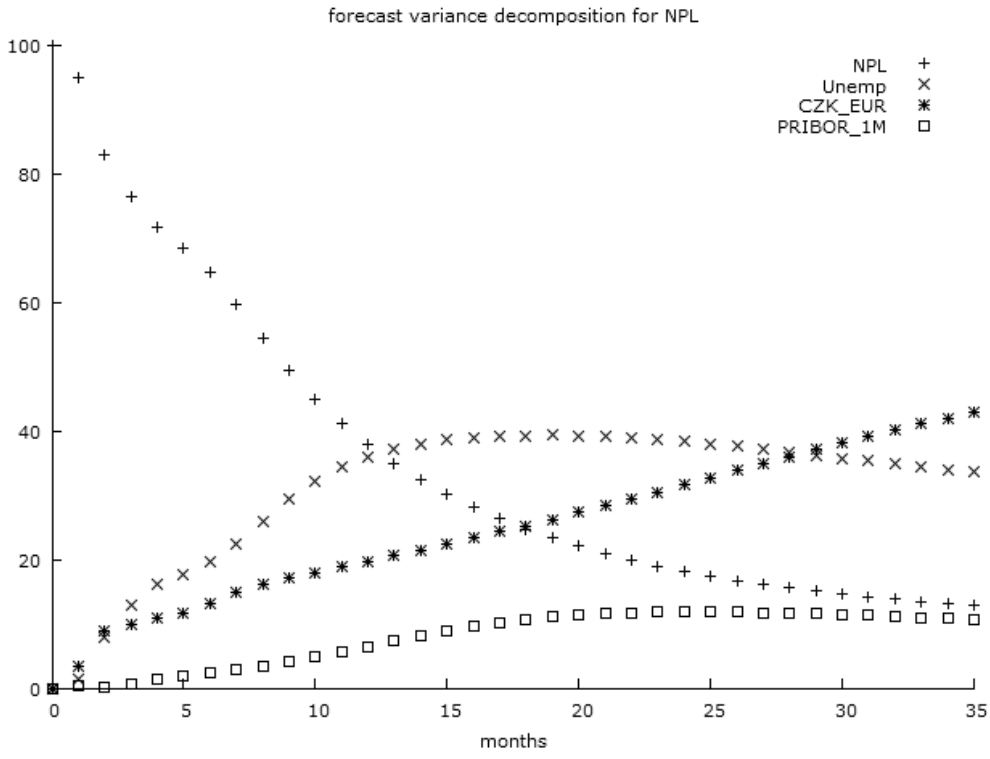
Source: Author's calculations

Our expectations regarding effect of shock in unemployment rate are again confirmed. The magnitude of the response is quite large comparing to previous models. The highest increase is visible around the end of the first year after the time of initial shock. After that, value of share of non-performing loans starts to decrease and converges to zero. The influence of shock is significant during the first two years. By omitting CPI, unemployment rate has larger influence on the value of NPL ratio. It could be because of relation between unemployment rate and CPI when the influence of shock in unemployment on NPL was hampered by the presence of CPI.

Regarding the effect of PRIBOR 1M on share of non-performing loans we make similar conclusions as before. The response is slightly negative, but not significant and not consistent with our expectations.

Negative interconnection is detected for the case of shock in CZK/EUR. Compared to previous models, the response is stronger and significant for longer period. It starts to return to zero after two years but very slowly. We conclude that this effect is probably permanent. This long-term effect of CZK depreciation against EUR is consistent with the idea that better situation of export oriented companies is reflected in lower households' NPL with delay of several months.

Figure 15: Forecast variance decomposition of VAR(4) without IPI, CPI



Source: Author's calculations

Figure 15 shows forecast variance decomposition of VAR(4) model without IPI and CPI. We see that own shock is the most essential driver of development of NPL ratio during the first year and is similarly important as by the first model. From twelfth to twenty-seventh months, shock in unemployment rate explains the biggest part of movements in NPL. The importance is again comparable to the second model. As opposed to previous models, significance of CZK/EUR in explaining movement of NPL is rising linearly over time and becomes the predominant driver of NPL ratio after thirty months. The less important variable for whole period is PRIBOR 1M explaining from zero to only about twelve percent of movements in NPL ratio, which is somewhere in the middle of responses obtained by previous models.

4.3.2 Modeling households' NPL using VECM approach

This section covers another approach which can be used for modeling share of non-performing loans on total amount of loans. This approach is called vector error correction model and is suitable for analysis of I(1) time series, where we expect the existence of cointegrating vectors. In other words, the model might be applied if some variables have common trend and move together to some extent. Not only short run changes in variables are captured, this model accounts also for deviations from long-term equilibrium. As in the case of VAR approach, we introduce three different models with different variables, appropriate number of cointegrating vectors and lag length. General VECM which will be further adjusted according to particular specifications is defined in following way:

$$\Delta y_t = v + \alpha\beta^T y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{4}$$

4.3.2.1 VECM(4, 2) of NPL, Unemployment, IPI, CPI, PRIBOR and CZK/EUR

The first model captures the same variables, which were used in chapter 4.3.1.1. All series are I(1) and we evaluate whether there are significant differences between estimations provided by VAR versus estimation provided by VECM.

The optimal lag length selection is selected in the same way as before. Therefore, we select four lags to be appropriate amount. Important thing, which has to be chosen, is cointegration rank. Because of nature of our model, we use Johansen approach to determine right number of cointegrating relationships. This test compares log likelihood of the unconstrained model that includes cointegrating equations with

log likelihood of the constrained model that does not include cointegrating equations. Based on the results of this test corrected for sample size, we decided to use two cointegrating relationships.

We then proceed to estimate VEC model. Key results, regarding equation containing share of NPL, are provided in Appendix 7. However, key parameters of the model may be expressed in following manner using notation from Eq. 4:

$$\Delta y_t = \begin{pmatrix} \Delta NPL_t \\ \Delta Unemployment_t \\ \Delta IPI_t \\ \Delta CPI_t \\ \Delta PRIBOR\ 1M_t \\ \Delta CZK/EUR_t \end{pmatrix}, \alpha = \begin{pmatrix} -0.005 & 0.074 \\ 0.331 & -0.153 \\ 0.889 & -4.92 \\ -0.86 & 0.133 \\ -0.007 & 0.092 \\ 0.034 & 0.107 \end{pmatrix}$$

$$\beta = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ -0.605 & -0.09 \\ 0.606 & 0.09 \\ 3.255 & 1.366 \\ 0.014 & -0.182 \end{pmatrix}$$

with 2 cointegrating equations:

*NPL = -19.5 - 0.605*IPI + 0.606*CPI + 3.255*PRIBOR + 0.014*CZK/EUR*

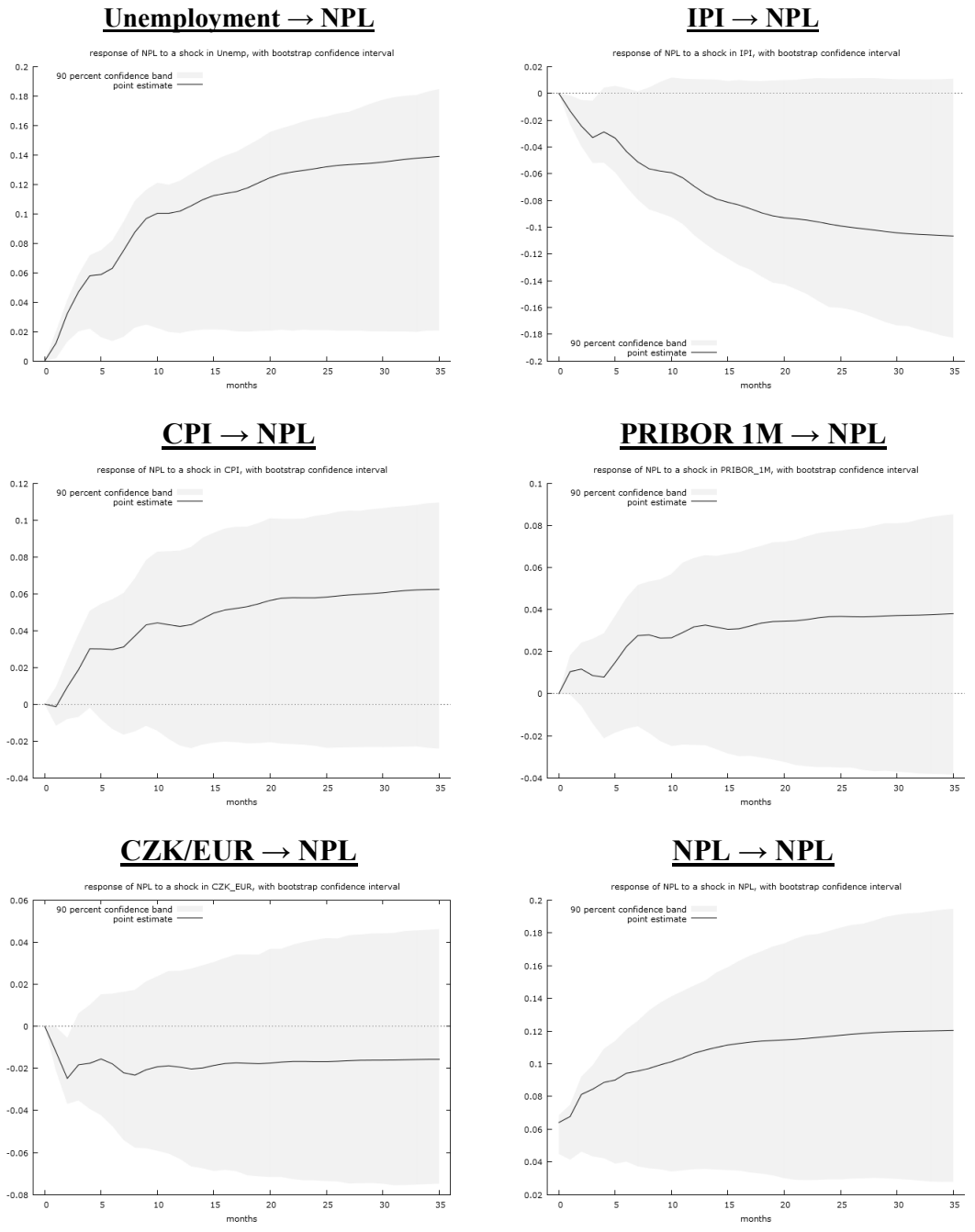
*Unemployment = -5.69 – 0.09*IPI + 0.09*CPI + 1.366*PRIBOR – 0.182*CZK/EUR*

Long-term equilibrium relationship is represented by cointegrating equations. The presence of unit coefficients is due to process of normalization performed by STATA. If there was only one cointegrating equation, it would be possible to interpret it in level-level way. But in case of two or more cointegrating vectors, interpretation of the overall behavior of the model is much more complicated. According to Kennedy (2008), equations might describe “several sectorial equilibria”, which makes it nearly impossible to interpret coefficients. Therefore, same methods for interpretation of results of VAR models are used – impulse response analysis and forecast variance decomposition.

Before we proceed to interpretation of results, we check assumptions of the model. Stability condition is satisfied as all relevant eigenvalues lie inside the unit circle (see Appendix 8). Test for autocorrelation of residuals was not able to reject the null hypothesis of no autocorrelation. There is also no evidence of ARCH effects contaminating residuals. Regarding normality of residuals, this assumption is again violated. Excess kurtosis is behind this violation, so we can consider it as a less

severe problem but still not optimal result. After checking the assumptions, we continue further to IRA (see Figure 16).

Figure 16: IRA of VECM(4, 2) – NPL, U., IPI, CPI, PRIBOR 1M, CZK/EUR



Source: Author's calculations

VECM represents, as opposed to VAR, changes, that are not only transitory, but permanent. Figure 16 confirms this assumption and indicates that impulse response functions do not revert back to zero during the observed period of 36 months.

There is clear positive relation between NPL ratio and shock in unemployment rate. The increase in unemployment rate results in significant permanent rise in the share of NPL. This increase is quite large and significant for the whole period. In comparison with the first VAR model, the response is more than two times bigger, significant for whole observed period and not only transitory.

Negative interconnection between share of NPL and IPI is also confirmed. However, the effect of shock is significant for a very short period of 4 months. Sign and magnitude of response is the same as for the first VAR model, but it is significant for shorter period. Moreover, the effect is not transitory.

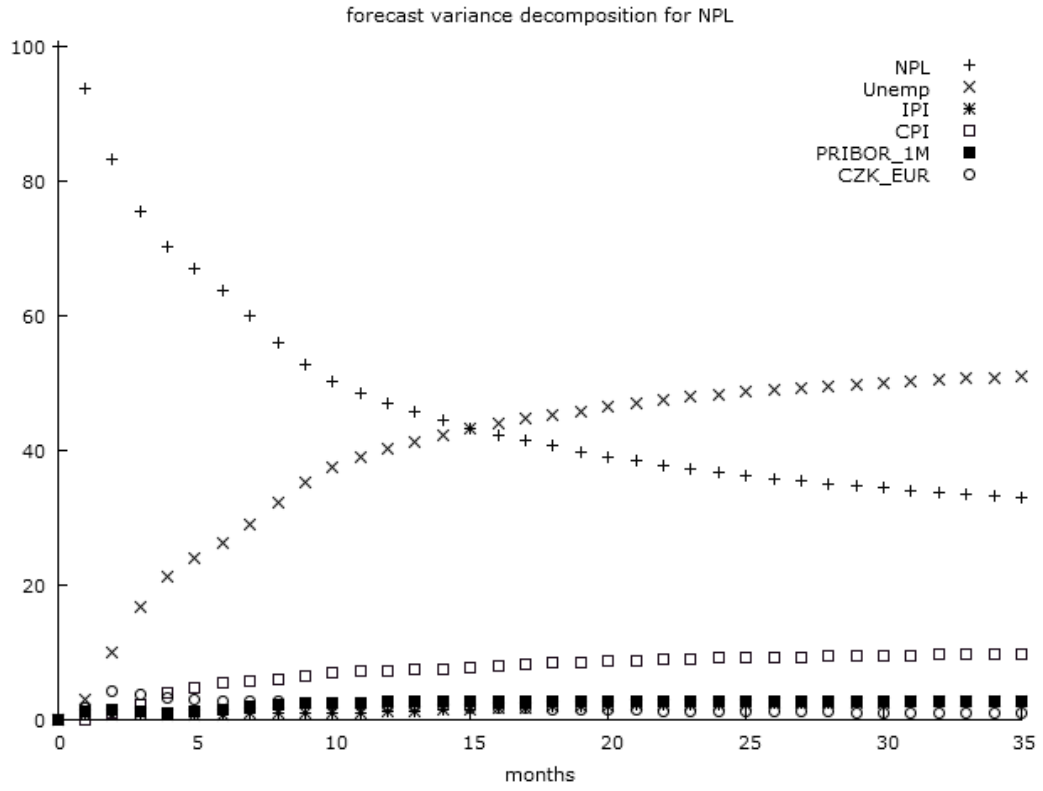
Influence of shock in CPI on the share of NPL is positive and permanent. However, the response is not significant and thus it is impossible to make any conclusions regarding this effect. In fact, the response of NPL ratio is very similar to the first VAR model.

Response of NPL ratio to shock in PRIBOR 1M has opposite sign than by the first VAR model. This result is consistent with our expectations and with studies conducted by Nkusu (2011), Adebola, Yusoff and Dahalan (2011) and Louzis, Vouldis and Metaxas (2010). It indicates that higher interest rates increase regular payments, thus make it more difficult to serve the loan. However, this effect is not significant and therefore not reliable.

Figure 16 indicates only slight reaction of NPL ratio to one standard deviation shock in CZK/EUR. The reaction is negative and indicates that depreciation of CZK increases households' payback capacity. In comparison with the first VAR model, the effect is negligible, but permanent and significant for similar number of months.

After decomposing movements in the share of non-performing loans we see, that the effect of own shock is most significant one during the first 15 months (see Figure 17). The influence of own shock deteriorates over observed period and remains stable at the value slightly below 40%. The second most important variable in explaining reaction of NPL ratio is unemployment rate. The influence of this variable is rising over time and converges to the value around 50%. The last variable, which has significant impact, is CPI. However, this contribution does not exceed 10%. Remaining variables (IPI, PRIBOR 1M and CZK/EUR) do not help in explaining forecast variance nearly at all. If we compare these results to the first VAR model we see, that less variables significantly influence development of NPL. Moreover, the effect of own shock and unemployment rate is higher. On the other hand, CZK/EUR becomes insignificant.

Figure 17: Forecast variance decomposition of complete VECM(4, 2)



Source: Author's calculations

4.3.2.2 VECM(4, 1) of NPL, Unemployment, CPI, PRIBOR 1M and CZK/EUR

The second VECM neglects IPI from estimation because of the same reason as in case of VAR models. We expect that unemployment rate and GDP are moving more or less together and it is not necessary to include both variables into analysis. We change number of lags from three to four, as there was no cointegration relation among variables for three lags and it does not change estimation results dramatically. In the case of four lags, Johansen test suggests to use one cointegration rank.

Now we proceed to the estimation of the model. The summary of key results is available at Appendix 9. Out of 80 coefficients, which have been estimated, 23 are statistically significant at 90% confidence level (approximately 29%). Key parameters, using notation from Eq. 4, are estimated as following:

$$\Delta y_t = \begin{pmatrix} \Delta NPL_t \\ \Delta Unemployment_t \\ \Delta CPI_t \\ \Delta PRIBOR\ 1M_t \\ \Delta CZK/EUR_t \end{pmatrix}, \alpha = \begin{pmatrix} 0.019 \\ -0.057 \\ 0.061 \\ -0.078 \\ 0.058 \end{pmatrix}, \beta = \begin{pmatrix} 1 \\ 2.2353 \\ 0.034 \\ 3.215 \\ -0.209 \end{pmatrix}$$

with one cointegrating equation:

$$NPL = -21.19 + 2.235 * U + 0.034 * CPI + 3.215 * PRIBOR - 0.209CZK/EUR$$

This equation shows long-term equilibrium relationship between variables. Unemployment rate, PRIBOR and CZK/EUR are significant at 90% confidence level. This equation can be interpreted in standard level-level way. It means that one unit increase in unemployment rate increases share of NPL by 2.235. Or one unit increase in PRIBOR 1M increases share of NPL by 3.215. These results are consistent with our expectations.

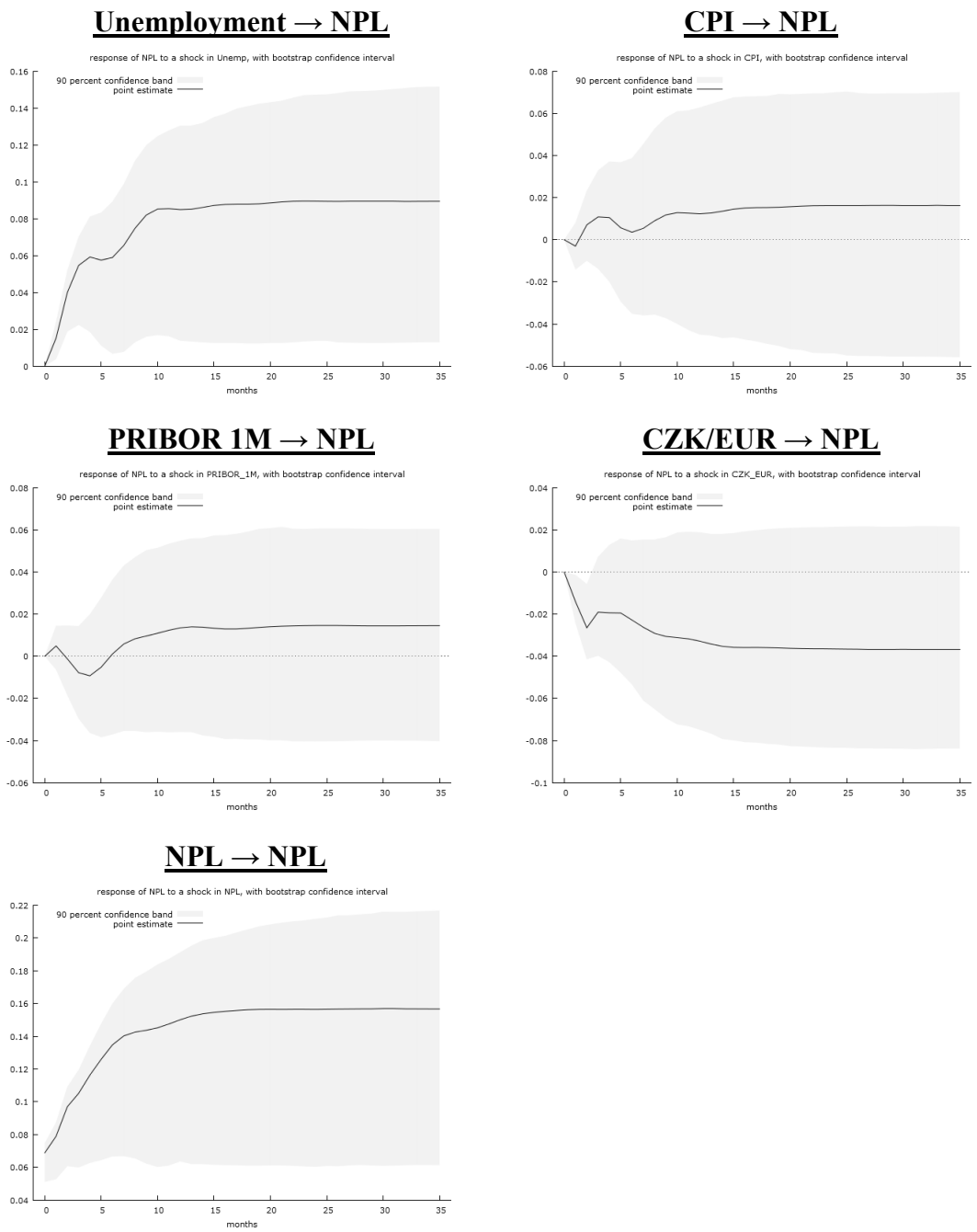
Before we continue to IRA and forecast variance decomposition, we check assumptions of the model. Model satisfies stability condition (see Appendix 10). The null hypothesis of no residuals autocorrelation is not rejected at any relevant confidence level, and therefore model satisfies this assumption. ARCH effects are not present as well. On the other hand, the normality of residuals is violated. As the violation is mainly caused by excess kurtosis we again conclude, that the violation is not so crucial. After checking all necessary assumptions, we continue to analysis of interconnections between variables using of IRA (see Figure 18) and forecast variance decomposition (see Figure 19).

As opposed to VAR analysis, responses of variables are permanent. However, responses of share of non-performing loans on total loans to innovations in CPI and PRIBOR 1M are not significant during the observed period of 36 months.

Looking at response of share of NPL to shock in unemployment rate we see expected permanent positive relation. The response is increasing during the first 10 months following the time of initial shock and remains stable and significant for the rest of the observed period. In comparison with the first VECM, the magnitude of response is smaller, smoother and converges faster to terminal value. However, the effect is still larger than by the second VAR model described in chapter 4.3.1.2.

The impact of shock to CPI on share of NPL is positive but negligible. As well as in the previous VECM, the effect of shock is not significant during the whole observed period. Impulse response of NPL ratio is similar to the first VECM, but not it is less significant and more stable.

Figure 18: IRA of VECM(4, 1) – NPL, Unemp., CPI, PRIBOR 1M, CZK/EUR



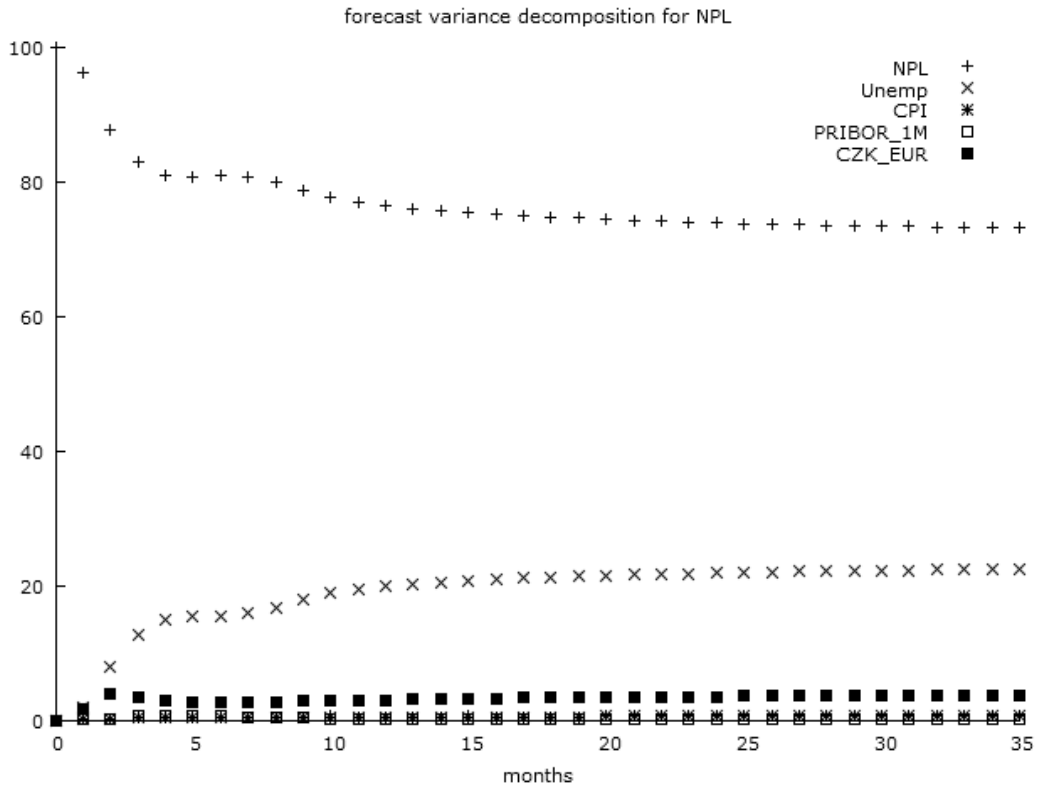
Source: Author's calculations

Nearly the same holds for response of NPL to innovations in PRIBOR 1M. Response is trifling, positive after few months and insignificant for whole observed period. Magnitude of response is even less significant than by the first VECM. Compared to the second VAR model, impulse response function exhibits opposite sign of reaction.

The response of NPL ratio to innovations in CZK/EUR is negative and significant for 3 months since the time of initial shock. The effect has the same sign and is larger than by the first VECM. It becomes stable approximately after one year. In comparison with the second VAR model, response is not so significant, more stable and not only transitory.

Generally speaking, by omitting IPI from our model, responses have slighter magnitude and are less significant. However, responses are also more stable over time and converge to terminal value faster.

Figure 19: Forecast variance decomposition VECM(4, 1) without IPI



Source: Author's calculations

Looking at the decomposition of movements in the share of non-performing loans on total amount of loans we see that the own shock has by far the strongest influence. Own shock explains about 75% of the whole response over time. The second most important driver of NPL ratio is unemployment rate which explains about 20%. These two variables are the only ones with significant impact on share of NPL. CZK/EUR explains only about 4% and the other two variables have just very little impact. In comparison with previous model, the influence of own shock is much more significant. On the other hand, the impact of unemployment rate fell significantly from nearly 50% to the value somewhere about 20%. CPI has lost

the influence as well. The only variable, which is more important, is CZK/EUR exchange rate. Comparing these results to VAR models it is obvious, that fewer variables significantly influence development of non-performing loans ratio during observed period following the shock.

4.3.2.3 VECM(4, 1) of NPL, Unemployment, PRIBOR 1M and CZK/EUR

Consumer price index is not included in the last model as response of NPL to innovations in CPI was not significant in previous model. Moreover, according to forecast variance decomposition, CPI has been explaining the lowest portion of movements in NPL ratio as a result of individual shocks. We use information criteria to set the optimal lag length to be equal to four. Johansen cointegration test suggests again one as an appropriate cointegration rank. Once we know these information, we proceed further to the estimation of model.

The summary of key results is available at Appendix 11. Out of 52 coefficients, which have been estimated, 16 are statistically significant at 90% confidence level (approximately 31%). Key parameters, using notation from Eq. 4, are estimated as following:

$$\Delta y_t = \begin{pmatrix} \Delta NPL_t \\ \Delta Unemployment_t \\ \Delta PRIBOR_t \\ \Delta CZK/EUR_t \end{pmatrix}, \alpha = \begin{pmatrix} 0.007 \\ -0.017 \\ -0.012 \\ 0.005 \end{pmatrix}, \beta = \begin{pmatrix} 1 \\ 9.644 \\ 10.654 \\ -1.632 \end{pmatrix}$$

with one cointegrating equation:

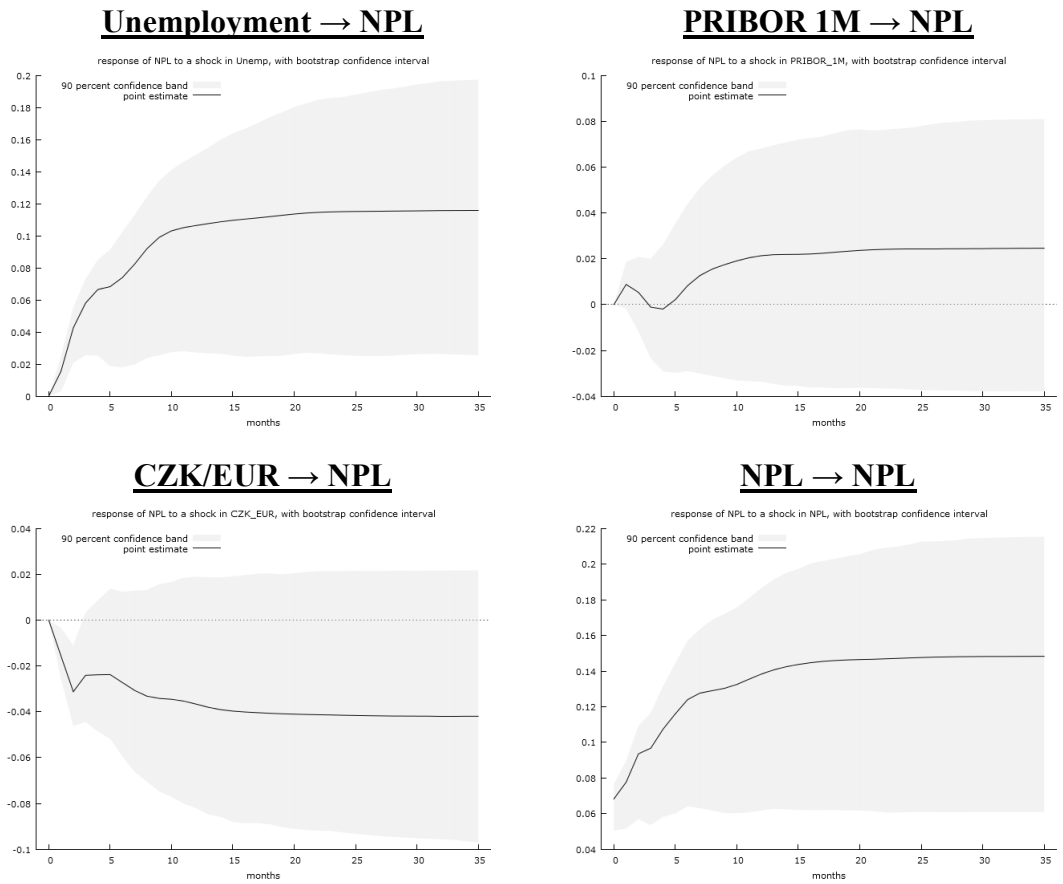
$$NPL = -40.03 + 9.64 * Unemployment + 10.65 * PRIBOR - 1.63 * CZK/EUR$$

This equation has level-level interpretation. One unit increase in PRIBOR means increase in share of NPL by 10.65. Constant is lower than in the previous model and, therefore, coefficients are higher in absolute value. Moreover, all variables are significant at 95% confidence level.

Next, we test all necessary assumptions. LM test for detecting residuals autocorrelation is not able to reject the null of no autocorrelation. Test for ARCH effects bring desirable results as well, as there is no evidence of any dependencies in squared residuals. Stability condition is satisfied as well (see Appendix 12). As in previous cases, normality test suggests that residuals are not normally distributed. Closer look at this problem advocates that this violation is again caused mainly by excess kurtosis. Therefore, the problem of not normally distributed residuals is not so crucial.

After checking all necessary assumptions we proceed to analysis of results of the model. Figure 20 shows IRA and Figure 21 offers forecast variance decomposition.

Figure 20: IRA of VECM(4, 1) – NPL, Unemployment, PRIBOR 1M, CZK/EUR



Source: Author's calculations

Consistent with previous models, responses of NPL ratio to all individual shocks are permanent and converge quite fast to terminal value.

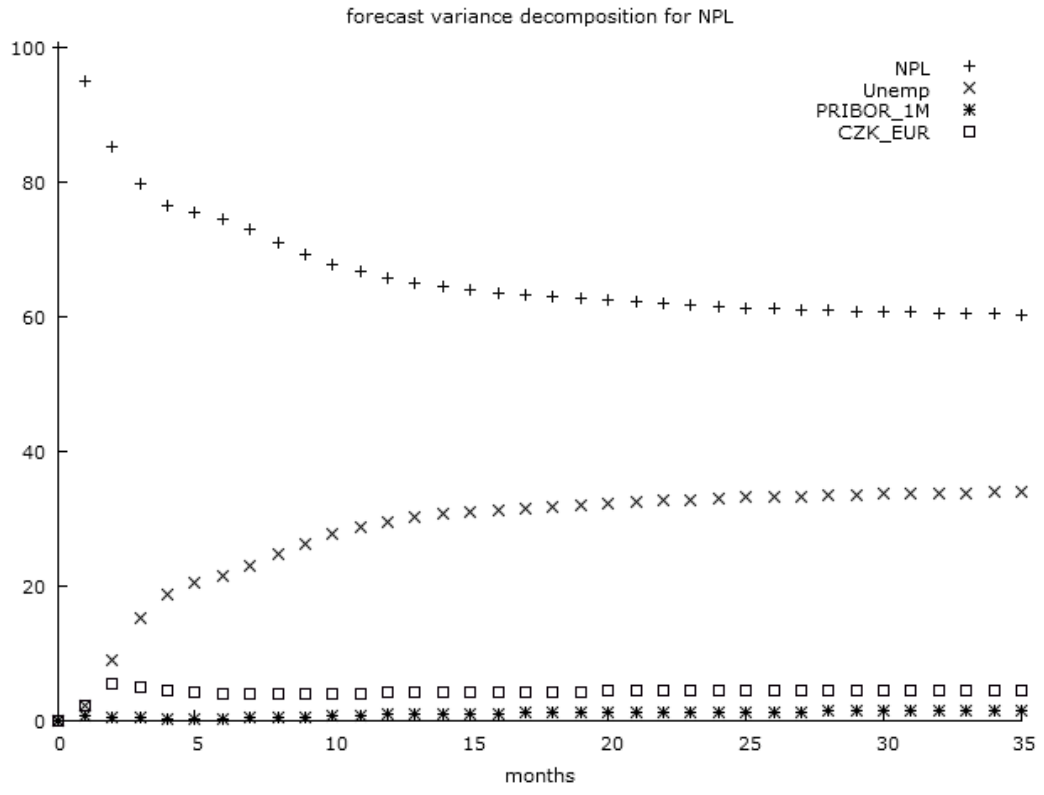
Magnitude of response of NPL ratio to innovations in unemployment rate is somewhere between the magnitudes suggested by the first and the second model. Relationship is again positive and significant for the whole observed period. It takes about 10 months from the time of initial shock until the response of NPL ratio is more or less constant. In comparison with the last VAR model, influence of unemployment rate is stronger, permanent, smoother and significant for longer time.

The second chart indicates positive relation between PRIBOR 1M and share of non-performing loans. However, response is negligible and NPL do not react to

shock in PRIBOR 1M at all (at least statistically). This result is very similar to previous VECMs and therefore, comparison to VAR models is the same as before.

Response of share of NPL to innovations in CZK/EUR looks very similar as by previous models. It is a little bit larger, but significant for only three months following the time of initial shock. Similar as in the case of unemployment rate, response of NPL ratio converges to terminal value after 12 months. In comparison with VAR models, response is smaller, smoother and less significant. However, as well as in the case of model described in chapter 4.3.1.3, response is permanent.

Figure 21: Forecast variance decomposition VECM(4, 1) without IPI, CPI



Source: Author's calculations

As well as in the previous case, own shock explains the biggest part of movements in the share of non-performing loans. This share converges to value little bit above 60%. Unemployment rate is the second most important variable explaining up to 30% of forecast error variance. This is greater portion than by the previous model, but smaller than by the first model. These two variables explain together nearly 90% of development of NPL following the time of initial shock. The remaining part is explained mainly by CZK/EUR. In compliance with previous models, PRIBOR 1M does not help to explain movement of NPL ratio nearly at all.

Fewer variables significantly influence movement of share of NPL over time than by the last VAR model.

4.4 Discussion of results

This thesis analyzes interconnections between share of non-performing loans on total amount of loans provided to households and variables capturing macroeconomic environment. This analysis serves as one of the possible indicators of potential financial instability and difficulties. Main findings, obtained from estimation of VAR models and VECMs, are discussed in this chapter as well as the comparison of those approaches. Furthermore, we discuss shortcomings of our analysis and opportunities for further research.

Table 10: Summary of results

Macro. variable	VAR			VECM		
	Sign	Significanc	Permanen	Sign	Significanc	Permanent
Unemploymen	+,+,	yes/yes/yes	no/no/no	+,+,	yes/yes/yes	yes/yes/ye
IPI	-	yes	no	-	yes	yes
CPI	+,+	yes/no	yes/no	+,+	no/no	yes/yes
PRIBOR 1M	-,-,-	no/yes/no	no/no/no	+,+,	no/no/no	yes/yes/ye
CZK/EUR	-,-,-	yes/yes/yes	yes/no/ye	-,-,-	yes/yes/yes	yes/yes/ye

Source: Author's results; sorted by the ordering of models in thesis

Table 10 shows results, which are mostly consistent with our expectations described in section 4.2.1. The only difference is response of NPL ratio to innovations in PRIBOR 1M by VAR approach. This result is also the only one which has different sign for VAR/VECM estimations. It is not straightforward to make any conclusion regarding this issue, as the only significant model is the second VAR. Different signs could be because of different nature of models when VECM accounts also for long-term effects. Therefore, we can expect that interest rate influences share of NPL with a delay.

According to all the models used, level of unemployment rate is the main determinant of NPL ratio, which is consistent with Debelle (2004). It is significant for all the models, positively related and has the largest impact. Increase in

unemployment rate could be therefore understood as warning signal of possible future banking sector distress. Increase in the amount of unemployed borrowers limits current and future purchasing power of affected households and can lead into troubles with meeting their loans commitments, which subsequently increases the level of non-performing loans. This finding, together with negative relation between GDP growth and NPL supported by the first VAR/VECM estimations, indirectly confirms Okun's law in case of the Czech Republic (Okun, 1962).

Reactions of NPL ratio to depreciation of CZK against EUR support the idea of Central Bank's interventions made in the end of 2013. However, the effect is immediate, while Central Bank expected that households will be better off after several months following interventions as it takes time before better financial conditions of export oriented companies are reflected in more job vacancies and higher wages. This inconsistency could be because of relatively short observed period and inadequate ability of these models to capture extraordinary shocks.

Our expectations regarding effect of CPI on share of NPL were ambiguous. Both models suggest positive interconnection but the only one is significant. It supports the idea that wages are sticky and higher prices make households poorer and deteriorate their financial condition, and thus worsens the ability to repay their debts.

The main difference between models is whether shock has permanent effect or is only temporary. Most of VAR models with only three exceptions suggest temporary effects of innovations while all VECMs suggest permanent effects. Therefore, results support idea that VECM, as opposed to VAR approach, captures not only short-run changes, but permanent effects as well.

It is desirable to mention limitations we have been facing during our analysis. The main limitation is length of available time series data. Meaningful data regarding share of non-performing loans are available since the middle of 2003 when a lot of bad loans were written off from banks' balance sheets. In 2005, Ministry of Labour and Social Affairs has changed methodology for computing unemployment rate. Since figures, consistent with older method, are not anymore published, resulting observed period is from the 1st of January, 2005 to 1st of April, 2014. Therefore, 112 observations were available for our analysis, which is on the lower bound of satisfactory amount. It mainly limits possible lag length used during our analysis and weakens long-term effect of shocks.

Not all data are available with monthly frequencies and proxies for all of them are not available, which can lead to omitted variables problem. According to Lütkepohl (2005), if relevant variables are not included in the system, it may lead to significant distortions in the impulse responses and makes them worthless for further interpretations.

We see opportunities for further research mainly in use of longer time series. It will be challenging to investigate effects of further variables on share of non-performing loans. We think that age structure of population has significant influence on amount of non-performing loans. Younger people usually have lower amount of savings and are more sensitive to adverse development of economy which is consistent with life cycle theory. We will be also interested in investigating wealth effects of households, where wealth of households is often approximated by house price index. Similar study was conducted in case of the Czech Republic by Dvořáková and Seidler (2012), but not together with macroeconomic variables which were used in our analysis. Variables capturing age structure of population and house prices are usually available with quarterly frequencies, and therefore longer time period is needed for this analysis. It is also possible to investigate micro data about characteristics of Czech households regarding indebtedness.

Empirical analysis mostly confirms our expectations regarding effects of innovations in various macroeconomic variables on share of non-performing loans on total amount of loans provided to households. With the exception of effect of increase in interest rate on the share of NPL suggested by VAR model, results are consistent with studies conducted by other researchers. However, all results should be interpreted with caution due to several limitations mentioned above.

5 Conclusion

The overall level of households' borrowing has been increasing during last couple of decades in majority of countries. This increase is visible in absolute terms as well as relative to household incomes. Same development holds also for the Czech Republic, where the level of households' indebtedness has been sharply increasing since 2000. Last global financial crisis from 2008 showed that large amount of debts, adverse economic development, severe mistakes and price bubbles can have fatal consequences not only for the economy of one country but also for the whole world. This crisis should serve as a reminder of how important is to study interconnections between quality of banks' portfolio of loans (represented by non-performing loans ratio) and various variables capturing macroeconomic development. As loans to households represent about 50% of total loans provided by banks, this sector is one of the most important debtors. This thesis investigates mutual relations between share of non-performing loans on total amount of loans provided to households and selected macroeconomic indicators such as unemployment rate, CPI etc. This study brings additional information to limited number of existing studies, which examine topic of households' indebtedness and financial stability in case of the Czech Republic.

Main part of this thesis is concentrated on the econometrical analysis. However, key events in the evolution of Czech banking sector after the Velvet Revolution are discussed as well. Czech Republic came through the period of transformation from a centrally planned economy to market economy and major, mainly institutional, changes were necessary to be done in banking sector. This process was connected with some problems, which negatively influenced the whole banking sector and overall loans quality. After some time, regulation and supervision of banking sector were strengthened, which together with privatization of state owned banks and accession to the European Union led to stabilization and helped to maintain effective banking system.

Empirical analysis is done using monthly data from the period starting on January 2005 and ending on April 2014. Two methods, VAR approach and VECM, are applied. We use impulse response analysis and forecast variance decomposition for interpretation of results. These methods are convenient for capturing mutual interconnections between individual variables and reactions to shocks in some of

them. Share of households' non-performing loans is taken as a proxy for the quality of banks' loans portfolio and as an indicator of potential financial difficulties. Reason, why we use both VAR approach and VECM, is in the construction of models. VAR captures only short-term effects as opposed to VECM which captures long-term deviations from equilibrium as well.

Following linkages were found during our analysis. There is a significant positive relation between unemployment rate and share of non-performing loans. Based on impulse response analysis, response of NPL ratio to shock in unemployment rate is temporary according to VAR and permanent according to VECM. Moreover, shock to unemployment is the main driver of evolution of NPL ratio. Increasing inflation influences banks' loans quality in the same way as unemployment rate, but to a lesser extent. On the contrary, negative relation is found between NPL ratio and GDP growth (represented by industrial production index), CZK/EUR exchange rate and PRIBOR 1M in case of VECM. This analysis contributes to the thorny topic of interventions made by Central Bank at the end of 2013 against Czech Koruna. Interventions are supported as depreciation of CZK against EUR improves the ability of households to serve their loans and decrease NPL ratio. Generally speaking, VAR suggests mostly temporary effects of shocks as opposed to VECM which suggests permanent effects of shocks.

Forecast variance decomposition method was applied to determine importance of variables, which drives evolution of non-performing loans over time after shock. Based on this analysis, own shock has the main influence right after the time of initial shock. Apart from own shock, unemployment rate seems to be the most important variable affecting evolution of quality of loans portfolio. This is not surprising as loosing job means lower income and more difficulties with servicing debt. Another relevant variable is CZK/EUR exchange rate. Results of this analysis postulate that unemployment rate should be used as a main warning signal of potential financial instability. According to VECM, the effect of unemployment rate is even more significant than in the case of VAR. This is another difference between these two models. Significance of other variables, than unemployment rate and own shock, is much more negligible by VECM than VAR over time in explaining development of non-performing loans ratio.

Our results are mostly consistent with previous studies and with our hypotheses. The only exception is negative relation between interest rate and NPL ratio, which is found using VAR approach. Reasoning for this anomaly can lie in the fact that loans with variable rates are not so popular among Czech households and

therefore changes in interest rates do not affect payments so significantly. Another possible reasoning is too short observed period.

This thesis extends existing literature regarding topic of households' indebtedness and financial stability. It also helps to understand better mutual linkages between the level of non-performing loans ratio and variables capturing macroeconomic development. Generally speaking, favorable economic conditions represented by GDP growth or lower unemployment rate contribute to improvements in banks' portfolio of loans. Our analysis has also its limitations and drawbacks, which can negatively influence final results like too short observed period or omitted variables with quarterly frequencies. Therefore, results should be interpreted with caution by taken these limitations into account.

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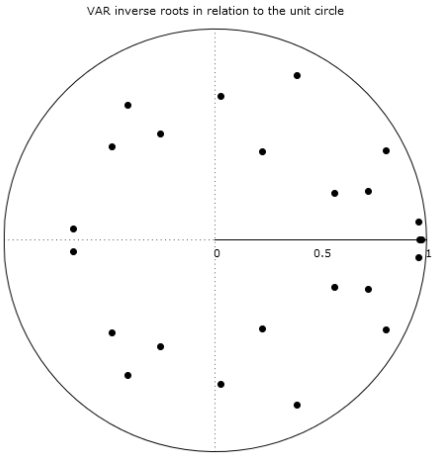
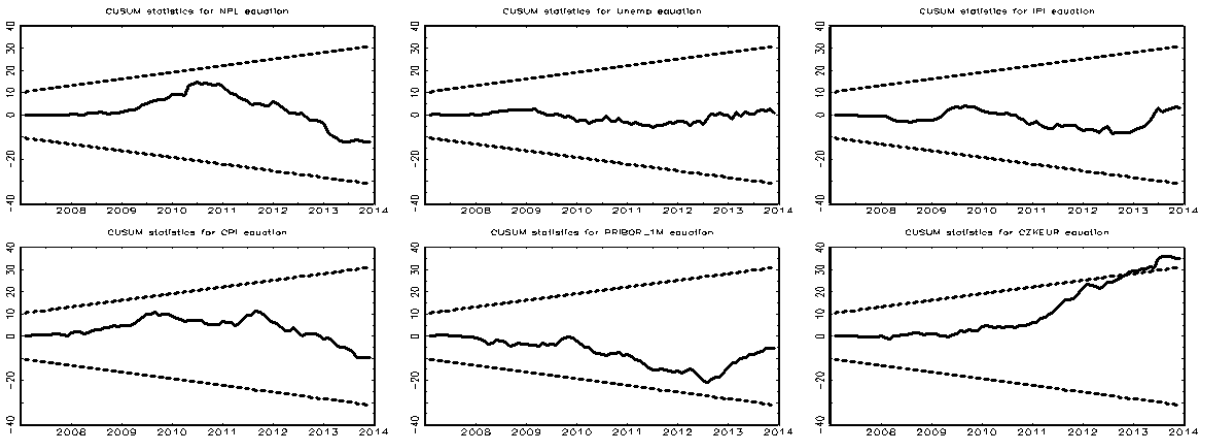
APPENDIX

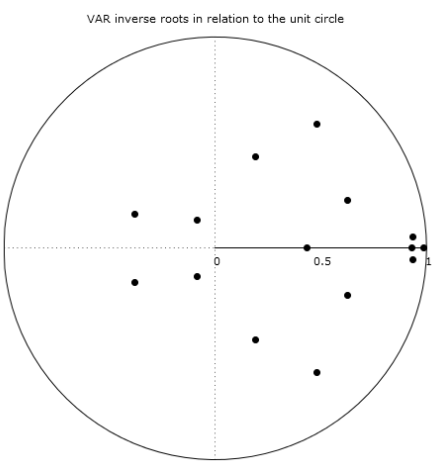
Appendix 1: VAR(4) complete model, inverse roots



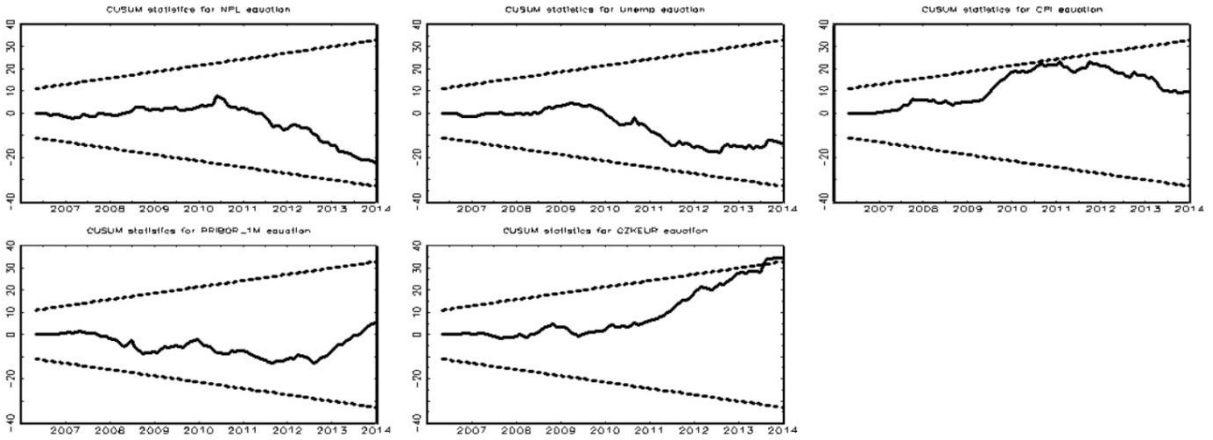
Appendix 2: CUSUM test VAR(4) complete model



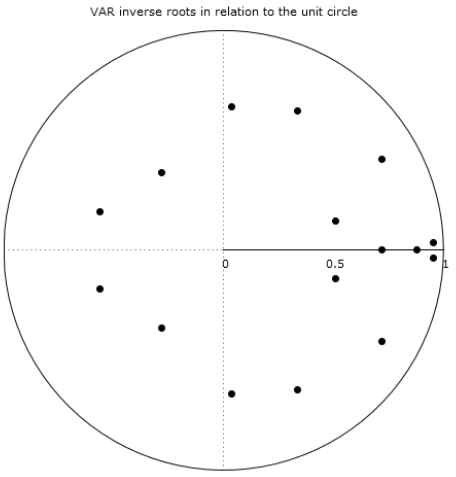
Appendix 3: VAR(3) without IPI, inverse roots



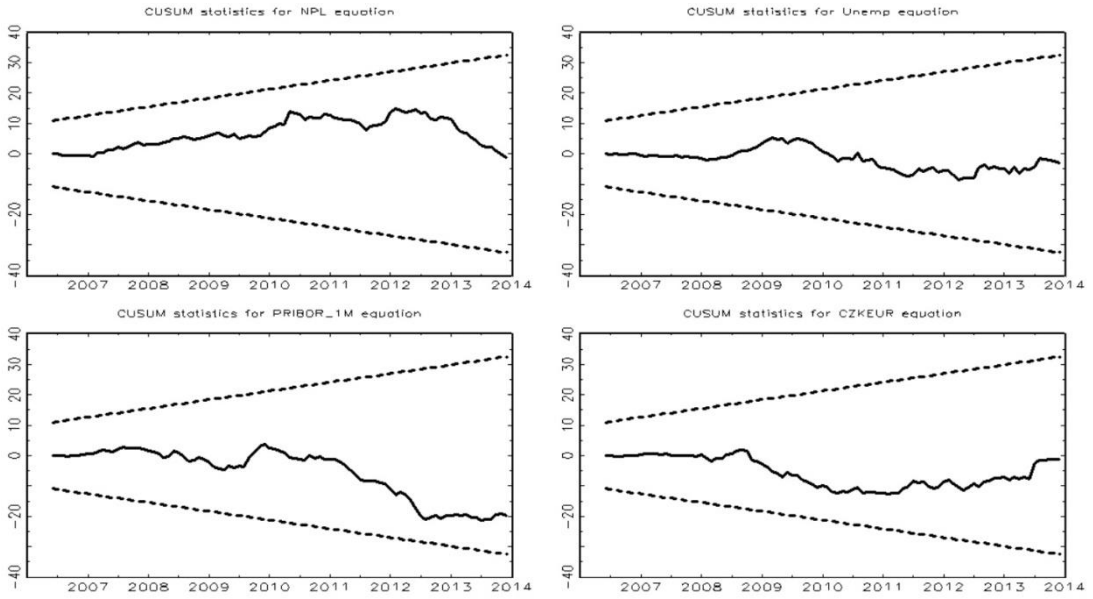
Appendix 4: CUSUM test VAR(3) without IPI



Appendix 5: VAR(4) without IPI, CPI, inverse roots



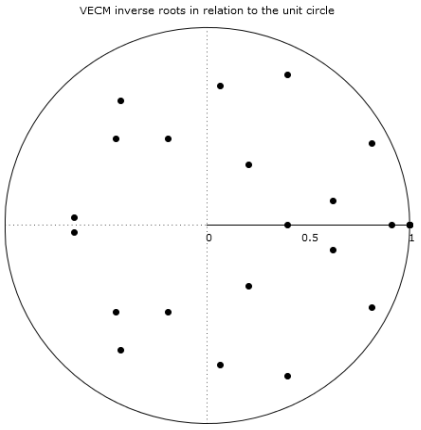
Appendix 6: CUSUM test VAR(4) without IPI, CPI



Appendix 7: VECM (4, 2) – NPL, Unemployment, IPI, CPI, PRIBOR 1M, CZK/EUR

D_NPL	Coefficient	z	p-value
_ce1	-0.005	-0.92	0.357
_ce2	0.074	2.99	0.003
NPL			
LD	0.044	0.41	0.679
L2D	0.197	1.91	0.056
L3D	0.041	0.4	0.693
Unemp.			
LD	0.045	0.99	0.322
L2D	-0.02	-0.34	0.733
L3D	-0.136	-2.64	0.008
IPI			
LD	0.002	0.75	0.455
L2D	0.001	0.06	0.95
L3D	-0.001	-0.56	0.573
CPI			
LD	-0.002	-0.14	0.891
L2D	0.19	1.23	0.22
L3D	0.003	0.23	0.82
PRIBOR			
LD	-0.022	-0.36	0.716
L2D	-0.099	-1.59	0.112
L3D	-0.019	-0.3	0.761
CZK/EUR			
LD	-0.023	-1.15	0.252
L2D	-0.023	-1.11	0.265
L3D	0.025	1.26	0.209
_cons	0.05	2.83	0.005

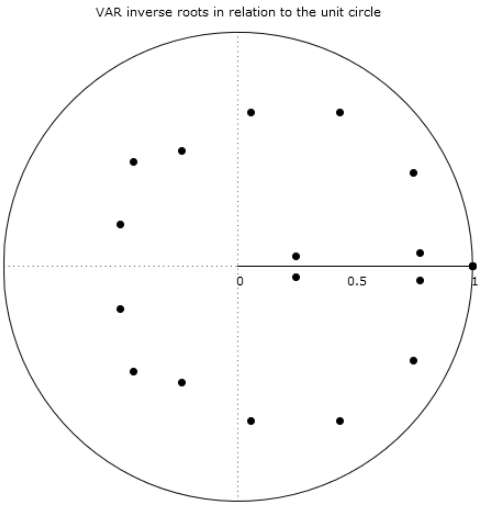
APPENDIX 8: VECM(4,2) stability test



APPENDIX 9: VECM(4, 1) – NPL, Unemployment rate, CPI, PRIBOR 1M, CZK/EUR

D_NPL	Coefficient	z	p-value
ce1	0.019	1.64	0.101
NPL			
LD	0.159	1.55	0.121
L2D	0.268	2.66	0.008
L3D	0.051	0.5	0.619
Unemp.			
LD	0.076	1.72	0.085
L2D	0.034	0.61	0.54
L3D	-0.119	-2.55	0.011
CPI			
LD	-0.008	-0.52	0.6
L2D	0.021	1.39	0.165
L3D	0.003	0.2	0.842
PRIBOR			
LD	-0.044	-0.74	0.461
L2D	-0.134	-2.16	0.031
L3D	-0.033	-0.55	0.58
CZK/EUR			
LD	-0.035	-1.69	0.092
L2D	-0.031	-1.49	0.136
L3D	0.025	1.19	0.235
_cons	-0.021	0.088	0.088

APPENDIX 10: VECM(4, 1) without IPI stability check



APPENDIX 11: VECM(4, 1) – NPL, Unemployment, PRIBOR 1M, CZK/EUR

D_NPL	Coefficient	z	p-value
ce1	0.007	2.81	0.005
NPL			
LD	0.15	1.51	0.131
L2D	0.27	2.81	0.005
L3D	0.01	0.1	0.919
Unemp.			
LD	0.059	1.37	0.171
L2D	0.023	0.42	0.673
L3D	-0.125	-2.86	0.004
PRIBOR			
LD	-0.039	-0.68	0.494
L2D	-0.145	-2.46	0.014
L3D	-0.04	-0.68	0.494
CZK/EUR			
LD	-0.033	-1.64	0.101
L2D	-0.027	-1.32	0.187
L3D	0.029	1.43	0.153
_cons	0.001	0.09	0.928

APPENDIX 12: VECM(4,2) without IPI and CPI stability test