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**Macroeconomic determinants for non-performing  
loans dynamic – the case of the Czech Republic**

MASTER THESIS

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## **Declaration**

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**Prague, May 14, 2013**

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**Jana Dounáčová**

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## **Abstract**

The thesis investigates the linkages between macroeconomic performance and banks loans portfolio quality represented by the non-performing loans ratio in the Czech banking system in years 2003–2013. The empirical analysis evaluates how banks non-performing loans are influenced by several macroeconomic indicators such as GDP, inflation, interest rate, unemployment rate and exchange rate. First we investigate loans quality on the aggregate level, next we analyze the quality of loans of households and non-financial corporations sector separately as the macroeconomic variables may affect these two sectors of borrowers differently. Finally the analysis of mutual links is done for different loan categories according to the level of failure also. The empirical results from vector autoregression model and impulse response analysis generally suggest that favorable macroeconomic conditions improve banks loans quality by lowering the non-performing loans ratio and vice versa. The thesis also identifies the feedback effect of increasing non-performing loans ratio on economic performance.

**Keywords:** banks loans quality, macrofinancial linkages, non-performing loans, Czech banking system

## Abstrakt

Diplomová práce se zabývá vývojem kvality bankovních úvěrů v závislosti na ekonomické výkonnosti v České republice v letech 2003–2013. Kvalita bankovních úvěrů je v tomto případě vyjádřena podílem úvěrů v selhání na celkově poskytnutých úvěrech. Empirická analýza ověřuje, jak je vývoj úvěrů v selhání ovlivněn makroekonomickými indikátory, jako jsou HDP, inflace, úroková míra, míra nezaměstnanosti a měnový kurz. Nejprve je provedena analýza pro agregátní úvěrové portfolio, dále je zkoumán vývoj kvality bankovních úvěrů pro sektor domácností a podnikový sektor samostatně vzhledem k možnosti, že změny v ekonomickém vývoji mohou ovlivňovat tyto dva sektory odlišně. Na závěr je provedena analýza vývoje kvality bankovních úvěrů pro jednotlivé úvěrové kategorie rozdělené na základě stupně selhání úvěru. Empirické výsledky vektorové autoregrese a analýzy odezvy na impuls obecně potvrzují pozitivní vliv příznivých ekonomických podmínek na kvalitu bankovních úvěrů. Příznivá ekonomická situace vede ke snižování podílu úvěrů v selhání na celkově poskytnutých úvěrech ve všech zmiňovaných kategoriích. Diplomová práce dále ukázala, že zhoršující se kvalita bankovních úvěrů negativně ovlivňuje celkovou ekonomickou výkonnost České republiky.

**Klíčová slova:** kvalita bankovních úvěrů, makroekonomické a finanční vazby, úvěry v selhání, český bankovní systém

## Master Thesis Proposal

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### Proposed Topic:

Macroeconomic determinants for non-performing loans dynamic – the case of the Czech Republic

### Topic Characteristics:

Quantity of non-performing loans is very important financial indicator in every banking system. Its percentage on a total quantity of loans is obviously associated to the banking stability and its high share is a significant predictor of possible banking failure. From this point of view it is evident why non-performing loan's examination is so important when examining banking and financial vulnerabilities. The aim of this study is thus to analyze the mutual sensitivity of non-performing loans dynamic and macroeconomic variables in case of the Czech Republic.

### Hypotheses:

The thesis will focus on several questions. First step is to determine which macroeconomic variables (such as GDP, unemployment, interest rates, public debt) influence amount and dynamic of non-performing loans the most significantly and with which lag, i.e. how long does it takes to recognize the change in non-performing loans caused by macroeconomic variables.

First hypothesis will examine whether these significant macroeconomic determinants and their effects will differ for different loan categories; non-performing consumer loans and non-performing business loans.

Next hypothesis will try to examine whether it is possible to use these macroeconomic variables to estimate the future development of a loan, i.e. into which class of non-performing loans (substandard, doubtful and loss categories) it will belongs to.

Third hypothesis is that non-performing loans display autoregressive behavior and also can have a feedback effect on macroeconomic variables examined as non-performing loans determinants.

## **Methodology:**

The mutual links and influences of macroeconomic determinants and non-performing loans will be analyzed using an econometric Markov switching VAR model as the variables and loans are suspected from reciprocal interconnections which can be reflected with a lags also. For more this type of non-linear model allows using multiple equations that can explain behavior of examined variable in different time periods. By using different variables (amount of non-performing loans, GDP, unemployment, interest rates, public debt) their mutual influences will be estimated.

For this purpose data of variables examined for past 10 years will be used as the non-performing loans are in the Czech Republic effectively monitored and published since year 2002. Earlier data are available but they are inaccurate because of the data consolidation in economic transformation period.

## **Outline:**

1. Introduction
2. Literature review
3. Non-performing loans in the Czech Republic
  - 3.1. Institutional factors of the Czech banking system
  - 3.2. Evolution of non-performing loans
4. Macroeconomic determinants of non-performing loans
5. Econometric analysis
  - 5.1. Econometric methodology, dataset
  - 5.2. Data analysis
  - 5.3. Discussion of results
6. Conclusion

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Supervisor

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## List of Abbreviations

<b>AIC</b>	Akaike Information Criterion
<b>CNB</b>	Czech National Bank
<b>CZSO</b>	Czech Statistical Office
<b>ČS</b>	Česká spořitelna
<b>ČSOB</b>	Československá obchodní banka
<b>FPE</b>	Final Prediction Error
<b>GDP</b>	Gross Domestic Product
<b>HQ</b>	Hannan-Quinn Criterion
<b>KB</b>	Komerční banka
<b>NPL</b>	Non-performing Loans
<b>PRIBOR</b>	Prague Interbank Offered Rate
<b>SBCS</b>	Státní banka československá
<b>SC</b>	Schwarz Criterion
<b>UK</b>	United Kingdom
<b>US</b>	United States
<b>VAR</b>	Vector Autoregression

# 1. Introduction

The deterioration in banks loans portfolio quality is one of the major causes of financial vulnerabilities which can consequently lead to costly banking system distress and economic crisis. Recent global financial crisis, which originated in the US, had devastating effects on the world economy and reminded the importance of linkages between financial and macroeconomic shocks. As a result, the financial crisis renewed interest in mutual interconnections of financial instability and credit market frictions.

Quantity of non-performing loans is considered to be important financial indicator in every banking system. Its percentage on a total quantity of loans is associated to banks portfolio quality and its high share might be a predictor of possible future banking sector distress. From this point of view non-performing loans examination is important when examining soundness of the banking sector and its possible vulnerabilities.

The main aim of this thesis is to analyze the mutual sensitivity of non-performing loans dynamic and macroeconomic performance in case of the Czech Republic. The vector autoregression methodology is applied on the Czech banking sector in order to examine banks loans quality sensitivity towards macroeconomic performance of the Czech economy. Following widely used econometric methodology, significant macroeconomic factors affecting the Czech banking sector stability are determined.

The findings indicate that non-performing loans ratio (NPLs ratio) has an important role in the linkages between credit market performance and macroeconomic vulnerabilities. The main results of our analysis are in accordance with previous studies. First, the quality of bank loans provided is inversely related with the economic performance represented by the industrial production index. Next, banks loans quality deteriorates with increasing costs of borrowing (represented by interest rate) and with increasing unemployment. Mutual connections between NPLs ratio and consumer price index and exchange rate

(expressed as CZK/EUR) are also mainly positive, which means that currency depreciation as well as increasing inflation also worsen the bank loans portfolio quality. For more, deteriorating bank loans quality has a negative feedback effect on the macroeconomic performance of the Czech Republic.

The thesis organization is following. First chapter reviews existing literature and recent studies examining mutual relationships of the banks loans quality represented by different banking measures, mainly NPLs ratio, and key macroeconomic indicators.

Second chapter describes the development of the Czech banking sector from the transformation period until present. Main focus is given to the non-performing loans development as a measure of the banks loans portfolio quality. Since 1990s the Czech economic system experienced many important changes influencing the quality of loans. This chapter describes initial institutional problems which led to the significant increase in NPLs and subsequent loans contraction as well as the period of improvement of functioning of the Czech banking system. The aim of this part is to briefly determine the most important institutional factors influencing the NPLs development in the Czech Republic.

Last chapter represents the main analysis of the interconnections of the NPLs and selected macroeconomic indicators. The analysis is performed using the method of vector autoregression with the main emphasis on the impulse response analysis. Firstly, significant macroeconomic variables and their expected connections to banks loans quality are described. Next part focuses on empirical application of the VAR model on selected variables. Three types of models according to NPLs categorization are analyzed. First, the aggregate NPLs ratio and its interconnections with macroeconomic factors are determined. Next, similar analysis is done for non-financial corporations and households sector separately in order to detect intersectoral differences. Last model determines whether macroeconomic indicators influence different NPLs loans categorized by the level of failure differently in the Czech Republic.

## 2. Literature review

Over the last thirty years the expansion of literature examining mutual relationships of the bank loans quality, represented by quantity of non-performing loans (NPLs), and different macroeconomic variables occurs. The share of non-performing loans on the total amount of banks loans is understood as an important indicator of credit risk in banks portfolio, which may result in bank failure. The main aim of these studies is therefore to examine the specific connections between non-performing loans and several key macroeconomic variables. As the key macroeconomic variables are mostly used indicators of macroeconomic growth such as GDP, rate of unemployment and inflation, but also real interest rate and real effective exchange rate are included often. For more, some studies examine also influence of different institutional indicators such as financial regulation or supervision. However this thesis works only with macroeconomic variables so the literature review is focused mainly on macroeconomic determinants also.

The first study dealing with the connection between banking efficiency represented by loan losses and economic performance was published by Keeton and Morris (1987). They examined data sample of almost 2 500 American commercial banks in time period 1979–1985. They found out that loan losses variation among American banks is caused by differences in local economic conditions and unusually poor performance of certain industries.

Number of studies dealing with the relationship between important macroeconomic variables and rate of non-performing loans represented by different banking measures such as loans quality, bad loans ratio or write-off ratio has been growing rapidly since 2000. Generally, these studies can be divided into two groups; the first group of studies focuses on loans quality examination in a single country model, the second group of studies deals with a group of countries. In the second case, cross-country differences can slightly influence results obtained.

From the group of global studies can be mentioned Nkusu (2011). His study confirms that increase in non-performing loans rate weakens macroeconomic

performance which leads to emergence of macro financial vulnerabilities. Also deterioration in macroeconomic environment such as slower growth, higher unemployment or falling asset prices causes debt service problems and rising rate of non-performing loans. Dataset of 26 advanced countries for years 1998–2009 is used in this study. Based on VAR model estimation and impulse response analysis, NPLs have a central role in the macro financial linkages as it is the only variable which has effects or responses to every single variable statistically significant. For example adverse shock to GDP growth (2.7 percentage point) causes increase in NPLs by 0.4 percentage point in the first year and 1.7 percentage point increase in the fourth year. Conversely NPLs shock (increase by 2.4 percentage point) leads to decline of GDP growth by 0.6 percentage point in the first year and 1.4 percentage point in the third year. For more, NPLs also exhibit autoregressive behavior when the same shock in NPLs causes itself increase by 3.8 percentage point after four years.

General expectations about mutual relationships of NPLs and macroeconomic variables also confirm studies by Espinoza and Prasad (2010) and Fofack (2005) who use NPLs ratio as a bank portfolio quality indicator. Using causality analysis Fofack confirms negative correlation of NPLs with real GDP per capita and inflation and conversely positive relation with real exchange rate appreciation for sub-Saharan countries in 1993–2002. Similarly Espinoza and Prasad examine dataset of 80 banks in Gulf Cooperation Council region over years 1995–2008 using dynamic panel model. Their results correspond with Fofack findings. Non-performing loans ratio of selected countries worsens with higher GDP growth. On the contrary, NPLs ratio is higher after the interest rate and risk aversion increase. For more, these results show that cumulative effects of examined macroeconomic shocks are large and significant in next 3 years. Besides macroeconomic shocks, Espinoza and Prasad examine feedback effect of NPLs increase on economic growth also. Using VAR approach, they confirm strong but short-term feedback effects of NPLs ratio on economic activity of examined countries.

Using ratio of banks loan losses as an indicator, Pesola (2005) obtains similar results. He analyzes the relation of ratio of banks loan losses to lending using the seemingly unrelated regression model on pooled panel data. In his analysis he used dataset of Nordic countries, Belgium, Germany, Greece, Spain and the UK for years 1980–2002. His findings show that distress in banking sector is mostly caused by customer indebtedness connected with adverse macroeconomic unexpected shock. For more he also confirms that loan losses have strong autoregressive behavior.

Rinaldi and Sanchis-Arellano (2006) focus in their study on the households financial fragility analysis. Using dataset of 7 Euro area countries (Belgium, France, Finland, Ireland, Italy, Portugal and Spain) for years 1989–2004 they examine vulnerability of financial conditions of households in dependence on the adverse shocks in their income and wealth. According to the results, households financial conditions significantly worsen with increasing inflation and lending rates. Next, improvement of real disposable income allows higher debt to income ratio of households while the level of NPLs ratio remains the same.

From the group of single country studies can be mentioned Bofondi and Ropele (2011) who also examine the banks portfolio quality for the households. In their study they focus on macroeconomic determinants of the quality of loans for Italy in years 1990–2010 using single equation time series regression model for households and companies sector separately. As a bank portfolio indicator is used new bad loans ratio which is defined as the ratio of new bad loans to the stock of performing loans at the end of previous period. For more, bad loans are in Italy defined as outstanding exposures to borrowers who are not expected to meet their obligations. The results show that for households the ratio of new bad loans has negative relation with the growth rate of the real GDP and house prices and positive relation with the unemployment rate and the short-term nominal interest rate. Based on impulse response analysis, increase in unemployment by 100 basis points leads to the increase of new bad loans by 4 basis points in 1 year. This influence is even bigger in case of GDP, where increase of GDP by 100 basis points causes decrease in new bad loans ratio by 6 basis points in 1 year horizon. For firms, new bad loans ratio changes in the same direction as the unemployment rate and the

ratio of net interest expenses to gross operating profits and changes in the opposite way to consumption of durables. In numbers, increase of unemployment by 100 basis points causes increase of new bad loans by 27 basis points in 6 months and same increase in gross operation profits leads to increase of new bad loans by 12 basis points.

Khemraj and Pasha (2009) follow the same results in case of Guyana using dataset of 6 commercial banks in years 1994–2004. Using fixed effect model for panel data they generally confirm positive relation of non-performing loans and real interest rate and negative relationship of NPLs with real GDP. For more, their results show that non-performing loans are also positively correlated with real effective exchange rate which means that international competitiveness of domestic economy is also an important economy indicator. The relationship of NPLs and inflation is quite uncertain as the relationship seems to be negative at time  $t$  and positive at time  $t-1$ .

Kalirai and Scheicher (2002) as well as Glogowski (2008) are using loan losses as the loans quality indicator. Glogowski examines the mutual relation of business cycle variables and loan losses of 108 Polish commercial banks over 1996–2006 time period. Using panel data approach, he confirms significant connections between loan losses and real GDP growth, real interest rate and unemployment rate. Kalirai and Scheicher confirm similar results for Austrian banking system using 1990–2001 dataset. According to findings they confirm positive effect of short-term nominal interest rate on loan loss provisions. On the contrary, loan loss provisions are negatively affected by shock in industrial production.

Similar results obtained also in case of single country study Ranjan and Dhal (2003), Shu (2002) and Hoggarth, Sorensen and Zicchino (2005). Ranjan and Dhal focus on the Indian banking system examination, specifically on the banks NPLs and macroeconomics shocks interconnections analysis. Based on the panel regression model, favorable macroeconomic conditions such as growing GDP and lowering unemployment lead to the decrease of NPLs. Similarly Shu examined the mutual influences of macroeconomic development and loans quality measured as the ratio

of bad loans to the total amount of performing loans in Hong Kong for years 1995–2002. Based on his results, loans quality improves with higher real gross domestic product growth, higher consumer price inflation rate and higher property prices growth. On the other hand, loans quality deteriorates with higher nominal interest rate. Same results obtained Hoggart, Sorensen and Zicchino. They examine banks write-off to loans ratio (which is directly linked to the non-performing loans) in UK for the period 1988–2004 using the VAR model and impulse response analysis. As a result, significant negative relationship is proved for write-off ratio and output gap. Weaker, but also negative relationship is found with inflation rate too. Conversely positive relationship exists between write-off ratio and nominal interest rate. Based on impulse response analysis, adverse shock to output gap affects the write-off ratio within 6 quarters with the maximum impact after 4 quarters. Increase in nominal interest rate influences write-off ratio significantly only after 1–3 years.

Vector autoregression approach is broadly used model for banks loans quality analysis lately. Since the Sims (1980) study, the VAR approach to empirical investigation of monetary policy shocks has gained its relevance. Blaschke et al. (2001) also proposed VAR methodology application for investigation of transmission mechanism between financial soundness indicators, such as ratio of non-performing loans to total loans, and economic performance indicators (output, inflation, interest rate, terms of trade and other macroeconomic indicators). From the vector autoregression approach group of studies we can mention Amediku (2006). Amediku uses similar model as Hoggart et al. (2005) in case of British banking system. He used VAR methodology for stress testing of Ghanaian banking system in years 1995–2005. The results confirm negative relation of NPLs ratio and output shock and the positive relationship of this ratio with inflation. Similarly Filosa (2007) uses VAR approach for stress-testing of Italian banking system. In his analysis he uses ratio of flow of new bad loans as the indicator of banking soundness in years 1990–2005. His findings also confirm negative relation of this ratio and output shock. On the contrary the estimated relation with inflation is negative. However this relation seems to be insignificant and short-term.

In the Czech Republic Babouček and Jančar (2005) examine the linkage between different macroeconomic shocks and loan quality represented by the NPLs ratio. For this analysis, unrestricted VAR model estimating monthly data of years 1994–2004 is used. Their results confirm theoretical assumptions and broadly agreed with the empirical findings mentioned above. This fact means that Czech banking system features some cross-country similarities with other foreign banking systems.

Generally, favorable macroeconomic environment such as increasing GDP, lower unemployment rate, lower interest rates and lower real exchange rate support improvement in banks loan quality which is reflected in lower amount of non-performing loans. Conversely deterioration in macroeconomic environment causes increase in NPL ratio which can lead to banking distress or even to serious financial crisis. The influence of inflation on the amount of non-performing loans seems to be uncertain. For more these relationships seem to be valid for different countries all around the world.

## **3. Development of the Czech banking sector**

### **3.1. Transformation of the Czech economic system**

The Czech economic system experienced many changes caused mostly by the transformation process since the beginning of 1990s. The aim of this transformation was the conversion of centrally planned economic system to market economy. One of the most important conditions of this successful transformation was functional financial system which would provide and allow effective resources allocation. Capital and money market weren't developed enough to provide finances that were needed, so the banking system became the only and dominant financial intermediary in the Czech economy (Buchtíková, 1997). The disadvantage was that the banking system in the Czech Republic was also in the development phase during and after the system transformation and serious failures were possible.

Before the transformation the only bank was the National Bank of Czechoslovakia. But one of the important conditions of functional market system is competition which means that this only bank was absolutely insufficient for the Czech financial market. The emergence of new financial institutions was needed. This fact caused the emergence of dual banking system in the Czech Republic. Two different types of banks started to exist; the central bank and commercial banks. The aim of the central bank was the stability of domestic currency, leading of the banking transformation and creating of the short term financial markets (Šmídková, 1996). Banking regulation and supervision was in the beginning of the transformation period in the competence of the Ministry of Finance (Hanousek and Podpiera, 2001). On the other hand the aim of commercial banks was to collect deposits and their effective allocation and to ensure the payment mechanism in the economy (Jonáš, 1998; Buchtíková, 1996). The problem was that these newly emerged banks missed trained employees, knowledge of bank principles and rules.

The most important loan borrower became non-financial corporate sector in that time. The main problem of this sector was that these newly founded

companies missed their own capital which caused that they became directly dependent on bank loans (Buchtíková, 1997; Čapek 1995). For more there was no information history about these companies as they were mostly newly founded or privatized. The facts about privatized companies became irrelevant after the transformation process so all of these companies were understood in the same way in the case of riskiness (Jonáš, 1998).

These facts together with the imperfect banking know-how and insufficient banking regulation caused that commercial banks had to face to extensive problems caused by providing of bad loans to unknown companies. Commercial banks tried to avoid this problem by providing mostly short-term loans<sup>1</sup> (Čapek, 1995) because they believed that the financial situation of the company can't change rapidly during the short time period so they perceived this kind of loans as less riskiness.

**Table 1: Levels and ratio of different types of loans**

		1993	1996	1997	2000	2010	2011
<b>Loans in total</b>	mld. CZK	670	890	1122	1050	2175	2304
<b>Short-term loans</b>	mld. CZK	279	386	470	384	374	378
	%	41.63%	43.4%	41.85%	36.52%	17.2%	16.41%
<b>Medium-term loans</b>	mld. CZK	190	229	266	205	292	308
	%	28.41%	25.74%	23.75%	19.55%	13.43%	13.37%
<b>Long-term loans</b>	mld. CZK	201	275	386	461	1508	1619
	%	29.96%	30.86%	34.4%	43.93%	69.33%	70.27%

Source: ARAD data series system, the Czech National Bank

Based on data in Table 1, short-term loans were the most provided kind of loans during the whole time period of 1990s. Its share created about 40 % of total loans which means that almost half of the total loans had a form of short-term loans. The biggest share of short-term loans occurred in 1996 when the loans boom in the Czech Republic achieved its peak. After this year the share of short-term

<sup>1</sup> Short-term loans are loans with the maturity in one year or less. For more we have medium-term loans (maturity 1-5 years) and long-term loans (maturity longer than 5 years)(CNB definition).

loans started to decrease slowly which was probably consequence of the loans contraction caused by increasing amount of non-performing loans. Short-term loans created an important part of provided loans after the system transformation. The rest of bank loans was created more or less by medium-term and long-term loans in the same share representing around 30 % of total loans in the beginning of 1990s. Change in this situation occurred in 1996 when the long-term loans got its dominance over the medium-term loans and its share started to increase over 30 %. Actually in 2000, long-term loans were the most provided category of loans with almost 44% share on total loans. Even short-term loans share was lower in this year (36.5 %).

Since 1997, when the amount of loans provided achieved its peak, the amount of loans doubled until year 2011 (Table 1). For more, the most important part of loans is created by long-term loans (its share is around 70 %, which means absolute dominance in comparison with short-term and medium-term loans). This trend is already visible in year 2000 when the share of long-term loans gained its dominance for the first time since the transformation started. On the other hand, short-term loans importance decreased from initial 43% share in 1996 to 16% share in 2011. This fact confirms the theory, that commercial banks preferred short-term loans against long-term loans believing that this type of loan is less risky.

The total amount of commercial banks loans grew up rapidly in the 1<sup>st</sup> half of 1990s even if these loans were often risky. Banking system and private sector were significantly linked together because of non-existing or insignificant own capital resources of private companies (Babouček and Musilová, 1999). For more, no other way to get initial financial resources did exist due to non-existing capital and money market in the Czech Republic (Buchtíková, 1997).

This significant increase in total loans is evident in Table 1. Between years 1993 and 1997 the amount of loans provided to private sector almost doubled. Sharp increase occurred immediately in 1994 when this measure was 15 %, but then this rate slowed down to annual increase around 7 %. Loans growth rate was the biggest between years 1996 and 1997 when it increased from 8 % to 26 %. It

means that this rate was more than tripled. But after this year the amount of total loans provided started to decrease due to bank crisis caused by increasing share of non-performing loans in commercial banks portfolios.

It is possible to find out some trends in bank loans in 1990s to try to avoid adverse selection problem and information asymmetry. As was already mentioned, commercial banks preferred mostly short-term loans in comparison with other loans categories. Next, banks tried to prefer well-known companies to avoid market risk and companies which were able to provide some kind of collateral as a guarantee (Tošovský, 1999).

Despite of these trends commercial banks were still borrowing also to unknown companies. During time, well performing companies repaid their loans back to commercial banks and lowered so their share on total amount of loans provided. Conversely badly performing companies didn't repay their bank loans and asked for new loans to refinance old loans (Buchčíková, 1999). This fact caused that the amount of non-performing loans increased as well as their share on total amount of loans. For more, this insolvency problem expanded in time also to well performing companies. Badly performing companies didn't repay their liabilities to these functional companies and transformed insolvency problem on them also. Finally this problem was transformed also on banks and started the Czech bank crisis in the 2<sup>nd</sup> half of 1990s (Buchčíková, 1996).

### **3.2 Loans contraction**

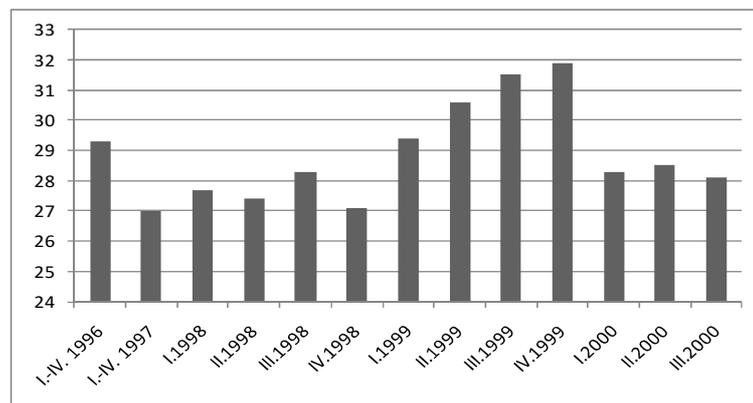
Bank crisis in late 1990s resulted into significant loan contraction noticeable since 1997. This crisis couldn't be prevented by using banking regulation which would lead banks to more prudent behavior. Banking regulation system was also in emerging phase; no credit rationing existed so there was no way how to avoid the problem of adverse selection and information asymmetry (Hanousek, Podpiera, 2001).

The change in bank loans dynamics thus was not caused by lower banks liquidity. Loan contraction was the result of more prudent commercial banks

behavior. Banks redirected their assets to less risky forms such as buying securities, depositing in another banks like the Czech National Bank or some foreign banks (Hampl, Matoušek, 2000). In this way they tried to improve their bank portfolios which were depreciated by increasing share of non-performing loans.

As these NPLs rates are publicly published since year 1996, no earlier examination is possible. But the increase of the share of non-performing loans is evident also on these reduced data in Figure 1. The first visible increase occurred in 1998 when this rate increased about almost 3 % and this share stayed higher during the whole year (the only almost comparable share with year 1997 occurred in the 4<sup>th</sup> quarter of 1998). Next year, 1999, the growth rate of the share of non-performing loans increased more rapidly. In the end of year 1999 this share was almost 32 % in comparison with 27 % in the end of 1998. Interesting is that this share increased even though the total amount of non-performing loans decreased. Between years 1996 and 1999 this amount grew up continuously (from 257 billion in 1996 to 312 billion in the second quarter of 1999), but in the last quarter of 1999 it decreased from 311 billion CZK to less than 290 billion CZK.

**Figure 1: Ratio of NPLs<sup>2</sup> (in %)**



Source: Capital adequacy Report, CNB

<sup>2</sup> In this figure classified loans category is used instead of non-performing loans category because no reliable reports about non-performing loans are published for these years. The only difference between these two loans categories is that classified loans contain all NPL plus watched loans (loans with overdue arrears between 30-90 days), whether non-performing loans category contain only substandard loans (overdue arrears 90-180 days), doubtful loans (overdue arrears 180-360 days) and loss loans (overdue arrears more than 360 days)(classification by CNB). That's the reason why classified loans are used as an approximation of non-performing loans for these years.

This fact suggests that even when the amount of non-performing loans started to decrease together with the amount of total loans, its share on total loans provided still increased noticeably. To achieve lower share of NPLs, the Czech Republic had to transform considerable amount of these bad loans from commercial banks portfolios to Consolidation Bank which was created for this purpose. This step cleaned banks portfolios and significantly lowered the share of non-performing loans (the biggest decrease occurred in the end of 1999 from 32 % to 28 % in the end of 2000).

### **3.3 Stabilization and economic expansion**

The Czech bank crisis caused that some important institutional and regulatory changes occurred. These changes were supposed to lead to improvement of functioning of the Czech banking system and better allocation of financial resources. The most important changes were the privatization of the Czech commercial banks and entrance of the Czech Republic into the European Union which will be discussed subsequently.

The stabilization of the Czech banking system is visible on the share and also on the amount of non-performing loans. The share of non-performing loans on the total amount of loans had decreasing tendency.

Share of non-performing loans on total loans was decreasing after the loans contraction according to Table 2. During 5 years its value lowered more than three times from 9.22 % in year 2002 to 2.65 % in year 2007. In year 2008 this value raised again due to the beginning of the global financial crisis. Also the amount in CZK was lowering in time. The only exception was year 2006 but this could be caused by high increase in total loans also. Next year, value of non-performing loans decreased again while the value of total loans was still significantly increasing (between years 2006 and 2007 loans value increased by more than 26 %). During the whole time period examined the amount of total loans almost doubled (from 892 billion in year 2002 to 1 784 billion in 2007) which together with decreasing share of non-performing loans indicates improvement in commercial banks behavior. This value

was also increasing in year 2008 but it was accompanied by increase in share of non-performing loans what indicated upcoming financial crisis.

**Table 2: Levels and ratio of NPLs in different loans categories**

		2002	2003	2004	2005	2006	2007	2008
<b>Loans in total</b>	mld. CZK	892.37	950.77	1010.31	1178.67	1413.08	1783.99	2075.69
<b>NPLs in total</b>	mld. CZK	82.26	60.88	49.6	48.28	50.31	47.27	65.73
	%	9.22%	6.4%	4.91%	4.1%	3.56%	2.65%	3.17%
<b>Short-term NPLs</b>	mld. CZK	31.92	30.2	23.29	21.67	21.64	20.76	27.44
	%	3.58%	3.18%	2.31%	1.84%	1.53%	1.16%	1.32%
<b>Medium-term NPLs</b>	mld. CZK	22.64	15.36	12.67	12.9	11.31	9.18	15.1
	%	2.54%	1.62%	1.25%	1.03%	0.8%	0.51%	0.72%
<b>Long-term NPLs</b>	mld. CZK	27.7	15.31	13.64	14.52	17.37	17.33	23.27
	%	3.1%	1.61%	1.35%	1.23%	1.23%	0.97%	1.12%

Source: ARAD data series system, the Czech National Bank

The main part of non-performing loans was created by short-term loans. In comparison with medium-term and long-term loans, this category had the highest percentage share on aggregate non-performing loans and loans in total during the whole examined time period. Share of other two loans categories was quiet similar during this time period but long-term loans had always slight dominance. Examining the absolute values short-term loans experienced permanent decrease until 2008. Same situation experienced medium-term loans with a sharp decrease in value between years 2002 and 2003. Similar sharp decrease occurred in case of long-term loans in year 2003, but between years 2004 and 2005 the total amount of long-term loans started to increase again. This increase could be the reason of rising amount of total non-performing loans in next year, 2006, as was discussed above. In 2008, all three categories experienced significant increase in their shares and also in total amount due to the upcoming financial crisis as was already mentioned.

Based on that, commercial banks started to behave more prudently during providing bank loans and their effort seems to be successful until year 2008. This improvement in the beginning of 2000s is a proof of better effectiveness of the Czech banking sector. This effectiveness was probably caused firstly by improving

banking management after the banking privatization. In the end of 2001, the public shares of the three biggest Czech banks (ČSOB, Česká spořitelna and Komerční banka) were sold to foreign investors. In this way, foreign investors gained control over the 96.2 % of assets of the Czech banking sector by the end of 2005 (Podpiera and Weill, 2007). Second reason, which improved the effectiveness of the Czech banking sector, was the entrance of the Czech Republic to European Union which caused increasing competition in the Czech economy.

Non-performing loans were thus in this after-transformation period mostly influenced by insufficient banking regulation and supervision which didn't defend banks from adverse selection or information asymmetry problem. Banks behaved recklessly and borrowed money to companies without any serious guarantee or information about the company. This behavior led them to serious banking crisis which resulted into loans contraction. The banking system gained its stability roughly 15 years after the transformation.

### **3.3.1 Institutional changes**

After the economic transformation some new and functional institutional framework was needed in the Czech Republic. As the most important changes in the Czech economic system were already mentioned emerging banking regulation and supervision, privatization of the biggest Czech commercial banks and entry of the Czech Republic to the European Union.

#### **3.3.1.1 The origins of banking regulation**

Before 1990, monogamy system of banking with the only National Bank of Czechoslovakia did exist. The SBČS was responsible not only for monetary policy and money circulation management, it also fulfilled commercial banks functions such as loan providing. Until the transformation the institution of banking supervision and regulation was thus unknown. The emergence of dual banking system (central bank and independent commercial banks) became the initial impulse for banking supervision and regulation creation.

In market economy banking sector significantly influences financial and overall economic stability of the country. From this reason banking supervision and regulation has an important objective which was by the Czech National Bank defined as: *“Banking supervision performs supervision over the banking activities implementation and takes care about safety functioning and effective development of a banking system in the Czech Republic.”*<sup>3</sup> For this purpose banking supervision is authorized to set up general regulatory conditions for the banking system entrance, rules of prudent behavior of banks with aim to limit risks undertaken by banks and to control the compliance of these rules by checking financial data reported by banks.

The emergence of bank supervision was a long-term process in developed industrial countries. But in case of the Czech Republic there was only short time available for the bank supervision creation and for more, existing legislative conditions were not sufficient. In the beginning of the transformation process banking legislative was backward especially.

This evolution of banking supervision and regulation can be divided into three time periods. The first period was represented by legislative framework creation in order to make banking supervision functional. For this purpose banking supervision institution was implemented into central bank in 1991. The legislative basics were created in order to define standard activity of this newly founded institution and came into force in 1992. Next period can be characterized as time of banking supervision development. This period started in 1994 when new organizational and legislative changes occurred. They enabled banking supervision to focus more on examination and investigation of banks activities. These evidences from supervisory activities started to be more respected during prudency rules creation. In 1997, systematic pressure to enforcement of prudential behavior was developed and Czech government established a program to support stability of the banking system in the Czech Republic. The third period is characterized by standardization of banking supervision operation. The main aim of these years was

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<sup>3</sup> Rule n. 6/1993 Sb. about CNB

the harmonization of banks legislative and rules of banks behavior with the European Union standards.

### **3.3.1.2 Privatization of the Czech banks**

Another important step to banking and financial stability in the Czech Republic was privatization of the big Czech banks such as Česká spořitelna (ČS), Komerční banka (KB) a Československá obchodní banka (ČSOB). Significant part of these banks was still owned by government and Ministry of Finance. The importance of privatization was mostly clear from the comparison of these big banks and foreign banks. While Czech banks still faced to loans quality problems and insolvency issues, banks owned by foreign investors exhibited profits in the end of 1990s. That was the initial impulse for the Czech Privatization Program creation.

This Privatization Program was accepted by government in 1998. Its aim was to sell governmental and other public shares in Czech banks to foreign investors in order to achieve financial stability in the Czech banking sector. Moreover, foreign investors were supposed to improve banks effectiveness and efficiency which should lead to higher competitiveness in the Czech banking system.

By buying shares in big Czech banks foreign investors got the control over the significant percentage of the Czech banking system. In 2005 they control 96 % of all assets (Podpiera, Weill, Schobert, 2007). The product and technology know-how was improved, banking managements were well educated and the stability of the Czech financial system was recovered.

### **3.3.1.3 Membership in the European Union**

Next important change for the Czech banking system was the entrance of the Czech Republic into the European Union. Its membership obliged the Czech Republic to implementation of supra-national European law into the national legislative.

This step contributed mainly to development of functional banking supervision which is important condition of stability and effectiveness of banking

system. Banking supervision helps to achieve financial stability and so protects banks depositors by implementation of regulatory rules.

Adoption of generally valid European regulatory rules was the important step to financial stability in the Czech Republic. These rules were created by Basel Committee and were valid for all member states of the European Union. After the entrance the Czech Republic had to adopt already valid Banking Directives and also had to implement directives dealing with bank supervision, providing of consumer loans, competition rules and their influence on bank operations, protection of depositors, bank accounting and payment system (Procházka, 2000). These changes didn't affect only financial system but it affected also the Czech legal system.

### **3.4 Global financial crisis**

The Czech economic system stabilized and became more effective after 2000. Situation changed when the global crisis began in the United States in summer 2007. The bursting of the sub-prime mortgage bubble led to the significant financial problems of American financial institutions due to the high share of lower-quality subprime mortgages in their portfolios. This situation resulted in the Lehman collapse on 15<sup>th</sup> September 2008. Because of the extensive international cross-country connections this crisis didn't remain local, but it spread to many other countries in the world. This global financial crisis became unique in comparison with other crisis because of the three main reasons. First, this crisis was unusual by its size and geographical reach; second, it erupted in an advance economy; third, the crisis has been remarkable by its complexity and multiplicity of contagion channels as it spreads quickly through markets via channels that have been much less important only a few years ago (Čihák, 2009).

During the opening stage of the financial subprime crisis the emerging markets, including the Czech Republic, were less affected than advanced countries. But because of the deterioration of advanced economies, strong international connections, persistent market dislocation and rising global risk aversion emerging markets were also significantly affected by this global financial crisis later in 2008

(Frank and Hesse, 2009). This impact of the crisis wasn't the same in all the regions, its influence and consequences differed across the countries due to different local economic conditions in a given countries.

The Czech Republic is one of the countries which were less severely impacted by global financial crisis. The Czech economy is characterized by small banking sector with an important foreign ownership (almost 100 % in 2008). During the transformation period the Czech Republic gained the great experience about market efficiency, banking regulation and supervision and prudent behavior of commercial banks. This lessons from its past caused an emergence of a strong and well-capitalized banking system with a great preconditions to overcome the global financial crisis. In comparison with other Central European countries the Czech banking system had low loan-to-deposit ratio<sup>4</sup> which means that the bank did not rely on the less stable wholesale funding. Therefore financing through interbank markets was not needed and the Czech banking system was mostly self-sufficient. Also the liquidity ratio<sup>5</sup> of the Czech Republic was high (186 % in 2008) which also confirms banking system self-sufficiency in lending (Teplý and Tripe, 2011).

**Table 3: Levels and ratio of NPLs during the crisis**

		2007	2008	2009	2010	2011
<b>Loans in total</b>	mld. CZK	1783.98	2075.68	2102.08	2174.74	2304.31
<b>NPLs in total</b>	mld. CZK	47.26	65.73	110.07	135.84	137.12
	%	2.65%	3.17%	5.24%	6.25%	5.95%

Source: ARAD data series system, the Czech National Bank

Examining the annual growth of the total loans and non-performing loans the influence of the global financial crisis is evident. In 2008, the annual growth of the total loans was 16 % but the non-performing loans grew up by almost 40 %, which means the sharp increase in NPLs. This fact is even more significant in the

<sup>4</sup> In 2008, the Czech Republic's loan-to-deposit ratio was 75.5 %. For a comparison, Latvia's loan-to-deposit ratio was 245 %, Estonia's 197 %, Slovenia's 156.3 %, Hungary's 142 %, Poland's 106 % and Slovakia's 77 % (Teplý and Tripe, 2011).

<sup>5</sup> The liquidity ratio expresses the level of a country's liquid external assets as a percentage on its liquid external liabilities (Teplý and Tripe, 2011).

next year, 2009, when the total loans didn't change much (only by 1.27 %) but the amount of non-performing loans increased rapidly again by more than 67 %. This suggests that emerging markets, the Czech Republic included, were affected by the global financial crisis mainly in late 2008 which subsequently resulted into the increasing amount of NPLs. The same trend was apparent in 2010, but the influence of the crisis already started to diminish slowly in this year as the total loans increased by 3.5 % and non-performing loans by 23.4 %. The effect of the crisis on banking loans in 2011 was not significant. In this year the annual growth of total loans exceeded the annual growth of non-performing loans (almost 6 % for total loans and less than 1 % for NPLs). Based on these data, the influence of the global financial crisis on the Czech banking system is apparent, but the persistence and the intensity of this crisis is milder in comparison with other countries.

### **3.4.1 Loan forbearance in the Czech Republic**

Relatively moderate impact of the global financial crisis was probably also consequence of the strict loan forbearance policy of the Czech National Bank. Generally, European Systemic Risk Board defines the loan forbearance as a situation where: *“One party fails to fulfill its obligations under a given contract and the other party refrains from imposing measures that could, in principle, be taken to punish the violation. A borrower does not pay on time and the lender decides to wait and see, perhaps even to renegotiate the arrangement.”*<sup>6</sup> In this case, banks often accept to refinance the intrinsically insolvent debtors and roll over their loans instead of classify them as non-performing (in default). This type of loan restructuring enables bank to avoid including the bad loans in the financial statements as non-performing loans and allows the bank to maintain the capital adequacy ratio, which is regulated by the banking supervision institutions, on the minimal level required without any significant changes (Watanabe, 2010). For more, it seems to be a solution how to avoid loan losses to bank caused by decrease in the price of collaterals (Chen, Chu, Liu and Wang, 2006). But this large loan forbearance is hardly possible without the banks superior forbearance. To enable banks to

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<sup>6</sup> European Systemic Risk Board (2012): „Forbearance, resolution and deposit insurance“, Reports of Advisory Scientific Committee, No. 1/July 2012

practice this loan forbearance policy to improve their financial statements, the banking sector supervision institution has to be quite tolerant to banks too (European Systemic Risk Board, 2012).

Reactions to this type of the bank behavior differ. Schüle (2006) accepts loan forbearance as a rational choice of the commercial bank in case that the sunk costs of the initial investment are high. But on the other hand, Chen and Chu (2003) argues that this banks behavior can weaken financial institutions and so prolonged the contraction in the real economic activity of the country. In other words, forbearance lending can help to unprofitable, inefficient companies to survive in the markets, which can cause serious problems to the more efficient companies and to their activities (Watanabe, 2010).

In the case of the Czech Republic the loan forbearance is not legally possible. By the Czech National Bank provision n. 9/2002, every restructured loan<sup>7</sup> has to be reported as a non-performing loan. The capital adequacy ratio of the commercial banks thus includes the truthful values of the risk-weighted assets and all the possible threats of loan losses are covered in banks reserves. From this point of view the banking supervision institution forces banks to deal with the bad loans immediately and to include them in their financial statements instantly instead of postponing of this issue for later. This fact was probably also useful during the global financial crisis as it helped to the Czech banks to handle the crisis consequences.

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<sup>7</sup> Restructuring loan is an asset, where the bank provides alleviation to the borrower because it asses a possible loss if it wouldn't do so (ČNB, provision n. 9/2002).

## 4. Econometric analysis

Important historical events were discussed in previous chapter with main focus on changes significantly influencing the evolution of non-performing loans in the Czech Republic. Following chapter represents the main analysis of the thesis. The aim of this part is to analyze mutual influences of different financial indicators and indicators of the Czech economic activity. Based on results obtained we would like to proof general empirical relationships of the variables examined.

Fist part of the chapter focuses on a general model description. The analysis of mutual relationships is done using the method of the Vector Autoregression and Impulse Response Analysis. Theoretical background of vector autoregression model is set and explained, followed by brief introduction to impulse response analysis. Next part devotes to the dataset selection, main mutual relationships hypotheses are included. Final part focuses on empirical application of VAR model on selected variables.

### 4.1 Vector Autoregression (VAR model)

#### 4.1.1 Model Description

Vector autoregression model was firstly introduced by Sims (1980) as a possibility for modeling and describing the dynamic interrelations between different variables. Since then, this model became used often mainly in macroeconomics. The vector autoregression method has been used to examine various mutual relations of macroeconomic variables.

Vector autoregression model is a natural generalization of univariate time series processes. It is systems regression model with more than just one dependent variable which can be considered as a kind of hybrid between the univariate time series models and the simultaneous equations models. For this reason it is often used as a simpler alternative to large-scale simultaneous equations structural models. The advantage of this model is that no variable specification is needed as all variables in vector autoregression model are considered to be endogenous.

Consider an univariate time series  $y_t$ . The autoregression process of order  $p$  (AR( $p$ ) process) can be formalized as follows (Greene, 2003):

$$y_t = \varphi_1 y_{t-1} + \dots + \varphi_p y_{t-p} + \varepsilon_t$$

where  $\varphi_1 \dots \varphi_p$  are parameters and  $\varepsilon_t$  is a serially uncorrelated innovation with zero mean and constant variance. This autoregressive process thus explains the dynamics of a given variable  $y_t$  only by its own past values.

In reality, macroeconomic variables very often interact and influence mutually with each other. From this point of view, vector autoregression models in comparison with AR processes have richer structure as the explained variable is dependent not only on its own lagged values, but it is also dependent on past values of other endogenous variables included in vector autoregression model. The advantage of this model is thus the ability to examine mutual relationships between macroeconomic variables.

Vector autoregression model of order  $p$  (VAR( $p$ )) is a system of  $n$  linear equations with  $n$  endogenous variables  $y_{it}$  where  $t \in T$  is a time index of past realizations of a variable and  $i = 1, 2, \dots, n$ . Each of these  $n$  equations describes the dynamics of one variable in the whole system as a linear function of its own lagged values and past realizations of the remaining variables. This system of equations can be formalized as follows (Lütkepohl, 2005):

$$y_t = v + A_1 y_{t-1} + \dots + A_p y_{t-p} + u_t$$

where  $y_t = (y_{1t}, \dots, y_{nt})'$  is a ( $n \times 1$ ) random vector,  $A_t = (A_1, \dots, A_p)'$  are ( $n \times n$ ) coefficient matrices,  $v = (v_1, \dots, v_n)'$  is a ( $n \times 1$ ) vector of intercepts and  $u_t = (u_{1t}, \dots, u_{nt})'$  is  $n$ -dimensional innovation process, *i.i.d* with zero mean.

This form is called reduced form of a vector autoregression model. It is characterized by the fact that in  $i^{th}$  equation only variable  $y_i$  is non-lagged and is on the left side of the equation. This variable is expressed by the linear function of its own lagged values and of lagged values of the  $n-1$  remaining variables and serially uncorrelated error term. As the right side of the  $i^{th}$  equation consists of only lagged

values of endogenous variables which are predetermined in a time  $t$ , ordinary least squares method can be used for model estimation.

### **4.1.2 Impulse Response Analysis**

As the vector autoregression models represent the correlations between variables, they are often used to analyze certain aspects of the relationships between the variables of interest. Impulse response analysis is one of possibilities for interpretation of models results.

It is often an aim of the examination to investigate how does the variable response to an impulse (innovation shock) in another variable in a system of equations which involves number of further variables as well. In the  $n$ -dimensional system of equations of VAR model it is thus possible to examine mutual interactions of the variables by up to  $n^2$  responses to impulses (each of  $n$  endogenous variables responses to  $n$  impulses in particular equations). With the assumption that the VAR model is stationary, an influence of all  $n^2$  impulses disappears in time, but the persistence of the response to the initial impulse can differ for different variables (Lütkepohl, 2005).

## **4.2 Selection of dataset**

This section deals with the selection of endogenous variables that will be used for the estimation of a reduced form of a VAR model. For this thesis, the selection of variables is inspired by academic papers mentioned in literature review as they are investigating similar topics and using similar methodology.

Econometric analysis of this thesis is mostly based on Nkusu study (2011) in which he examines the mutual relationships of non-performing loans and macrofinancial vulnerabilities in advanced economies. Macroeconomic variables are thus chosen according to this study and other literature reviewed in the beginning of the thesis. As indicators of the Czech Republic competitiveness, GDP and CZK/EUR exchange rate are used similarly as in Nkusu (2011). Next included variables are PRIBOR as an interest rate approximation, inflation and the bank loans portfolio quality represented by rate of non-performing loans to aggregate loans as

real sector indicators. Finally, unemployment rate is the last variable included in the econometric analysis.

Based on data availability, the econometric analysis is done using data for time period starting on March 2003 and ending on January 2013. Dataset chosen is based on monthly frequency in order to increase the total amount of observations. Further, the main reason for using this time period is that unemployment is monthly monitored by Ministry of Labour and Social Affairs since March 2003. For more, non-performing loans are in the Czech Republic effectively monitored and published since year 2002. Earlier data are available but they are inaccurate because of the data consolidation in economic transformation period.

**Table 4: Macroeconomic variables used in VAR model**

TIME SERIES	NOTATION	DEFINITION	UNITS
Aggregate NPLs	<i>NPL</i>	NPLs to gross loans ratio	%
Non-financial corporations NPLs	<i>NPL_C</i>	Non-financial institutions NPLs to gross non-financial institutions loans ratio	%
Households NPLs	<i>NPL_H</i>	Households NPLs to gross households loans ratio	%
Substandard Loans	<i>NPL_S</i>	Loans overdue 90-180 days to gross loans ratio	%
Doubtful Loans	<i>NPL_D</i>	Loans overdue 180-360 days to gross loans ratio	%
Loss Loans	<i>NPL_L</i>	Loans overdue more than 360 days to gross loans ratio	%
Exchange Rate	<i>CZK_EUR</i>	Exchange rate CZK/EUR (monthly average)	Amount of CZK per 1 EUR
GDP	<i>IP</i>	Industrial production index; year-on-year indices (corresponding month of the previous year = 100)	%
Inflation	<i>CPI</i>	Consumer Price Index (average of the year 2005 = 100)	%
Interest Rate	<i>PRIBOR</i>	6-months PRIBOR	%
Unemployment Rate	<i>U</i>	Rate of registered unemployment (the end of the month)	%

Source: ARAD data series system, Czech Statistical Office, Ministry of Labour and Social Affairs

Most of the data is obtained from publicly available statistics of the Czech National Bank, namely from the ARAD, the database of time series. Some other data are based on time series available on the web of the Czech Statistical Office and Ministry of Labour and Social Affairs. Information about inflation, unemployment, exchange rates, interest rates and different categories of non-performing loans are published on monthly basis. Gross domestic product is

published only quarterly, so this variable is approximated by index of industrial production. This index is published monthly on the web of the Czech Statistical Office.

#### **4.2.1 Expected relations**

In this section the general mutual relationships expected between non-performing loans and selected macroeconomic variables are determined. The non-performing loans dynamics change during time, reflecting the fact that the sample period covers years of weak macroeconomic performance as well as years of buoyant economic growth. The empirical analysis thus requires some theoretical statements about supposed interactions between macroeconomic factors and NPLs ratio. The expected signs are following:

- First variable included is an industrial production index as a representation of the gross domestic product, i.e. overall economic activity. Growing economy is more likely connected with rising incomes and employment and reduces financial difficulties. According to this expectation, growing GDP should affect non-performing loans negatively as the rising income should improve personal financial situation.
- Analogical intuition can be used for labor market indicator, unemployment rate. Growing economy should affect the rate of unemployment negatively as it causes an increase in labor opportunities. Therefore, unemployment rate is most likely positively related with NPLs ratios. Increasing job opportunities again improve personal financial situation and most probably decrease unemployment rate as well as the rate of NPLs.
- Next variable examined is interest rate represented by the 6-months PRIBOR. Generally, rising interest rate increases the cost of borrowing. Realized loans are thus more expensive. Therefore, increase in the interest rate can cause financial difficulties to borrowers and their loans can be later categorized as loans in failure. The mutual relationship between interest rate and NPLs is thus expected to be positive.

- The influence of inflation is uncertain as it affects borrowers through different channels, its influence can be eventually positive as well as negative. Based on Phillips curve, increase in inflation leads to lower unemployment. Through this channel, amount of NPLs should decrease. For more, inflation reduces the real value of the debt and thus the mutual relationship on inflation and NPL is expected to be negative in this case. However, higher inflation can also reduce real income and weaken borrowers ability to repay the debt in time. Influence of inflation is thus positive in this case (Nkusu, 2011).
- Last variable included in the dataset examined is the exchange rate. Again, there are two different possibilities how the change in exchange rate can influence non-performing loans. Currency appreciation can weaken the competitiveness of companies oriented on export. Financial situation of these companies starts to deteriorate and can cause financial difficulties which can weaken firms ability to repay the debt. Conversely, borrowers who realize loans in a foreign currency will be better off after the currency appreciation. Thus the relation of exchange rate and NPLs is ambiguous for the non-financial corporations sector. In case of the households sector, exchange rate depreciation might increase NPLs ratio, if the households have loans in foreign currency. However, this is not the case for the Czech Republic, where households foreign currency loans are negligible.

**Table 5: Expected signs of mutual relation of NPLs and selected variables**

MACROECONOMIC VARIABLE	EXPECTED RELATIONSHIP WITH THE NPLs
GDP	negative / -
Unemployment Rate	positive / +
Interest Rate	positive / +
Inflation	ambiguous + / -
Exchange Rate	ambiguous + / -

Source: Author's expectations

## 4.2.2 Time Series Stationarity

An assumption of the vector autoregression model is the stationarity of time series used for estimation. Stationarity of the time series is important mainly for examining the effects of different shocks to the particular variable in a model. If the time series would be non-stationary, the variable doesn't have to adjust to the shock due to the infinitely long memory of the time series and the effect of the shock can be permanent. On the other hand, in the case of stationary time series, the variable adjusts to the shock and the effect of the shock disappears gradually.

In case of VAR models weak stationarity definition is used. Consider time series  $y_t$  where  $t \in T$  is a time index. This time series is stationary if it satisfies conditions:

1.  $E(y_t) = \mu = \text{constant}$
2.  $\text{var}(y_t) = \sigma_y^2 = \text{constant}$
3.  $\text{cov}(y_s, y_t) = \text{cov}(y_{s+h}, y_{t+h})$  for any  $h$

This means that a particular time series process has to be invariant to a time shift for any  $s$  and  $t$ .

When verifying the stationarity of the time series, it is useful to display original time series graphically. Plots of original time series are in Figure 2 in the Appendix. Graphs illustrate that time series of included variables are most probably non-stationary. For more, stationarity of variables is rejected for most variables also by ADF test. The null hypothesis of the ADF test<sup>8</sup> is the presence of the unit roots and therefore the non-stationarity of the time series tested.

Based on the ADF test majority of the variables tested don't satisfy the condition of stationarity. The only stationary variables according to the ADF test are the rate of corporations NPLs and the rate of substandard loans. Hence we transform time series using logarithm. But neither after this transformation have all variables satisfied the stationarity condition. Results of the ADF test applied on transformed time series are summarized in Table 14 in Appendix.

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<sup>8</sup> The critical value of the Student's t-distribution is -1,62 (10% significance level)

**Table 6: ADF test results for stationarity (original time series)**

VARIABLE	TEST STATISTICS
	ADF test
NPL	-1.0739
NPL_C	<b>-1.7505</b>
NPL_H	-1.4861
NPL_S	<b>-2.0387</b>
NPL_D	-0.4677
NPL_L	-0.9218
CZK_EUR	-1.2445
IP	-0.4067
CPI	3.6021
PRIBOR	-0.9179
U	-0.7708

Source: Author's calculations

To get the stationary time series it would be necessary to transform original time series using differences. But the aim of this thesis is not to examine the statistical significance of the coefficients estimated but to investigate the relationships between the variables. The differencing transformation in order to get stationary time series would lose information on any long-run relationships between variables. Therefore some studies of the VAR approach recommend not to difference, but to use original non-stationary time series (Brooks, 2008). Hence the original time series are used for following econometric analysis instead of any transformed time series.

### **4.3 Model Specification**

Reduced form of the vector autoregressive model is specified and estimated in this part. Considering the structure of the equation system in reduced form, method of the ordinary least squares can be used for the model estimation. For more, estimated coefficients will be asymptotically efficient and consistent which means that with increasing size of the sample estimated coefficients converge to the real value of the estimated parameters (Cipra, 2008).

Using selected macroeconomic variables the reduced form VAR model can be formalized as:

$$y_t = v + \sum_{i=1}^p A_i y_{t-i} + u_t$$

where  $y_t = (y_{1t}, \dots, y_{nt})'$  is a (6 x 1) vector of endogenous variables (namely one particular category of non-performing loans rate, industrial production index, index of consumer prices, exchange rate CZK/EUR, 6-month PRIBOR and unemployment rate),  $p$  denotes the optimal number of lags,  $v = (v_1, \dots, v_n)'$  is a (6 x 1) vector of intercepts,  $A_i = (A_{i1}, \dots, A_{in})'$  are (6 x 6) matrices of coefficients and  $u_t = (u_{1t}, \dots, u_{nt})'$  is a (6 x 1) vector of innovation process, which is *i.i.d.* and has zero mean.

To estimate a specific VAR( $p$ ) model, the optimal number of  $p$  lags has to be specified. Using information criteria is the typical way how to determine the proper model with appropriate number of lags used for the estimation. The most common criteria are Akaike Information's Criterion (AIC), Hannan-Quinn Criterion (HQ), Schwarz Bayesian Criterion (SC) and Final Prediction Error.<sup>9</sup>

For the purpose of the analysis, model estimations are done for different categories of NPLs loans ratios. First, the relations of macroeconomic variables and aggregate NPLs are examined. Next, similar analysis is done separately for non-financial corporations and households sector in order to determine possible differences between sectors. Finally, mutual interconnections are investigated with respect to the level of loans failure (substandard loans, doubtful loans and loss loans).

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<sup>9</sup> All these four criteria are available in econometric program JMulti.

## 4.4 Econometric Results

### 4.4.1 Aggregate NPLs model

First analysis focuses on the mutual relations in aggregate model. As endogenous variables are used rate of aggregate NPLs, industrial production index, consumer price index, unemployment rate, exchange rate (CZK/EUR) and 6-months PRIBOR as an interest rate. All the time series used are non-stationary.

The optimal lag length of the model is determined by Akaike information criterion, Final predictor error, Hannan-Quinn criterion and Schwartz criterion.<sup>10</sup> As the majority of variables is non-stationary, unit roots test rejects stability of the model for all estimated models; VAR(10), VAR(9), VAR(2) and VAR(1). The aim of this thesis is to examine interactions between variables, so the correct model is chosen according to the particular impulse response analysis. Important character of the impulse response analysis is whether the shock in one variable influences dependent variables responses permanently (for example in case of random walk variable) or temporarily (in case of the stable model), which means that the initial shock disappears gradually. Responses to impulses in estimated models VAR(10) and VAR(9) cause permanent changes in variables, therefore these models are not appropriate for the purposes of this thesis. On the other hand, shocks in estimated model VAR(2) cause only temporary changes in variables evolution and disappear gradually in case of all variables after 8 years approximately.

Estimated model VAR(2) can be then formalizes for variable NPL as:

$$\begin{aligned} NPL = & v + \alpha_1 IP_{t-1} + \alpha_2 CPI_{t-1} + \alpha_3 U_{t-1} + \alpha_4 CZK\_EUR_{t-1} + \alpha_5 PRIBOR_{t-1} \\ & + \alpha_6 NPL_{t-1} + \beta_1 IP_{t-2} + \beta_2 CPI_{t-2} + \beta_3 U_{t-2} + \beta_4 CZK\_EUR_{t-2} \\ & + \beta_5 PRIBOR_{t-2} + \beta_6 NPL_{t-2} + u_t \end{aligned}$$

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<sup>10</sup> AIC determines 10 lags as optimal, FPE determines 9 lags length of the VAR model as an optimal choice, HC estimation equals to 2 lags and SC determine only 1 lag length to be optimal for estimation.

**Table 7: VAR(2) model for aggregate NPLs**

*VAR system, lag order 2*  
*OLS estimates, observations 2003:03-2013:01 (T=117)*

Legend: Coefficient  
 {p - Value}  
 [t - Value]

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**Lagged endogenous term:**

		<b>CPI</b>	<b>CZK_EUR</b>	<b>IP</b>	<b>NPL</b>	<b>PRIBOR</b>	<b>U</b>
<b>CPI</b>	(t-1)	<b>0.899**</b> {0.000} [8.598]	<b>0.044*</b> {0.070} [1.813]	1.085 {0.317} [1.000]	-0.025 {0.383} [-0.872]	0.040 {0.118} [1.563]	0.013 {0.831} [0.213]
<b>CZK_EUR</b>	(t-1)	2.211 {0.236} [1.184]	<b>1.379**</b> {0.001} [3.178]	-10.743 {0.579} [-0.555]	<b>-1.153**</b> {0.026} [-2.224]	0.314 {0.495} [0.683]	-1.192 {0.279} [-1.082]
<b>IP</b>	(t-1)	0.000 {0.970} [0.038]	0.003 {0.113} [1.587]	<b>0.308**</b> {0.001} [3.212]	<b>0.000*</b> {0.870} [0.164]	<b>0.004*</b> {0.088} [1.705]	-0.001 {0.790} [-0.266]
<b>NPL</b>	(t-1)	0.045 {0.894} [0.133]	-0.038 {0.631} [-0.481]	-1.676 {0.635} [-0.475]	<b>0.807**</b> {0.000} [8.544]	-0.031 {0.713} [-0.368]	0.084 {0.676} [0.418]
<b>PRIBOR</b>	(t-1)	-1.533 {0.378} [-0.881]	-0.103 {0.799} [-0.254]	8.498 {0.638} [0.471]	<b>1.070**</b> {0.027} [2.215]	<b>0.971**</b> {0.023} [2.267]	0.787 {0.443} [0.768]
<b>U</b>	(t-1)	<b>0.522**</b> {0.002} [3.042]	<b>-0.081**</b> {0.042} [-2.037]	-1.833 {0.303} [-1.030]	<b>0.177**</b> {0.000} [3.707]	<b>-0.089**</b> {0.035} [-2.111]	<b>1.217**</b> {0.000} [12.039]
<b>CPI</b>	(t-2)	-0.143 {0.157} [-1.416]	-0.003 {0.903} [-0.122]	<b>-1.970*</b> {0.060} [-1.878]	<b>0.058**</b> {0.038} [2.074]	0.006 {0.825} [0.221]	-0.039 {0.515} [-0.651]
<b>CZK_EUR</b>	(t-2)	0.335 {0.866} [0.168]	<b>-0.786*</b> {0.089} [-1.699]	-8.697 {0.674} [-0.421]	0.553 {0.317} [1.000]	-0.614 {0.211} [-1.252]	-0.507 {0.666} [-0.432]
<b>IP</b>	(t-2)	0.005 {0.558} [0.586]	0.001 {0.468} [0.726]	<b>0.359**</b> {0.000} [3.964]	-0.001 {0.677} [-0.417]	0.001 {0.586} [0.544]	<b>-0.012**</b> {0.020} [-2.333]
<b>NPL</b>	(t-2)	0.004 {0.990} [0.013]	0.005 {0.948} [0.065]	1.388 {0.663} [0.436]	0.053 {0.536} [0.619]	-0.005 {0.945} [-0.069]	0.029 {0.874} [0.158]
<b>PRIBOR</b>	(t-2)	-0.429 {0.817} [-0.232]	0.323 {0.452} [0.751]	10.721 {0.577} [0.558]	-0.495 {0.336} [-0.963]	0.128 {0.779} [0.281]	0.756 {0.488} [0.693]
<b>U</b>	(t-2)	-0.319* {0.071} [-1.805]	0.012 {0.778} [0.282]	2.177 {0.236} [1.186]	<b>-0.099**</b> {0.043} [-2.022]	0.019 {0.669} [0.427]	<b>-0.482**</b> {0.000} [-4.624]

An asterisk (\*) denotes significance at 10% level. A double asterisk (\*\*) denotes significance at 5% level.

Equations for other macroeconomic variables included can be formalized analogically. Estimated model contains 72 coefficients that need to be estimated. Table 7 summarizes results of the estimated parameters together with their t-statistics and p-values of the VAR(2) system of equations. According to the statistical significance, 17 estimated coefficients<sup>11</sup> (approximately 24 % of parameters estimated) are significant in total. However, these coefficients can't be interpreted as elasticities between macroeconomic variables included in the model due to the vector autoregression dynamic structure. Information value of these estimations is thus insignificant (Lütkepohl, 2005).

Next we analyze interconnections and relations between selected macroeconomic variables and aggregate non-performing loans. For this purpose impulse response analysis is used. It reflects the response of a particular variable to the random shock (impulse) in another variable holding all other variables past values constant. This Impulse is usually one standard deviation shock to error terms. For the purpose of identifying the real causal relationships between macroeconomic figures included and NPLs ratio in the estimated VAR(2) model, the simulation of an initial shock and its following influence has to be performed for a certain long time period. For the purpose of this thesis, when the monthly data are used, the time period of 36 months is chosen and describes the development of the economy over 3 years. Particular results of the impulse response analysis can be found in the Figure 3 in the Appendix.

Obtained results confirm the hypothesis of the negative relationship between NPLs ratio and gross domestic product represented by industrial production index. However, the negative response occurs only after 2 months. The negative effect of the random shock in GDP reaches the peak after approximately 12 months, so it takes the whole year to get the full reflection of the initial impulse. After that, the influence of the shock gradually disappears. This result corresponds with the findings presented in Nkusu (2011). Similar results obtained Fofack (2005) in case of selected African countries or Hoggarth, Sorensen and Zicchino (2005) who tested the British banking system. Also Babouček and Jančar (2005) tested this

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<sup>11</sup> 5% significance level

hypothesis for the Czech dataset. But based on their econometric analysis the negative relation between GDP and NPLs ratio was not confirmed, which is in contradiction with our findings.

Also the assumption of the positive relation between NPLs ratio and unemployment rate is confirmed. The initial impulse in unemployment causes the significant increase of aggregate NPLs ratio. The maximal impact of the random shock occurs after approximately 6 months. After that the NPLs ratio starts to decrease again with the almost linear tendency until it reaches its initial value. The validity of this hypothesis was already confirmed for the Czech Republic by Babouček and Jančar (2005). This finding is also consistent with Nkusu (2011). The only difference is that the response of NPLs to change in unemployment rate is in our case larger. According to Nkusu, the response of the NPLs is weaker.

Similarly, the hypothesis of the positive relation between interest rate and aggregate NPLs ratio is on the basis of obtained results confirmed. For our dataset, the impulse from interest rate represented by 6-months PRIBOR causes significant increase in NPLs ratio. This positive development in NPLs reaches its maximum value after approximately 8 months. Then it starts to decline and returns back to the initial value after 36 months, i.e. 3 years. The initial positive development in aggregate NPLs ratio corresponds with findings presented by Khemraj and Pasha (2009) who confirmed this general positive relation in case of Guyana. Also Hoggart et al. (2005) found the positive linkage between interest rate and write-offs in the British banking system, where the write-offs can be considered as NPLs approximation.

Response of the aggregate NPLs ratio to increase in consumer price index is slightly ambiguous. Initially, level of aggregate NPLs ratio starts to decrease in the 1<sup>st</sup> two months. In the 3<sup>rd</sup> month the change in the NPLs development occurs and the influence of the initial inflation shock is positive. For more, this positive effect continues in following 14 months and then it starts to decrease slowly. This finding means that increasing inflation weakens borrowers ability to repay the debt as it reduces personal real income. This result of positive relation corresponds to Nkusu

(2011), but the final influence of the initial impulse is weaker than in Nkusu. Similar findings get also Babouček and Jančar (2005) in their thesis dealing with interconnections of different variables of the Czech economic system.

The last macroeconomic variable examined is the real exchange rate. As we are using CZK/EUR exchange rate where EUR figures as a base currency, positive shock in exchange rate development corresponds to the home currency (CZK) depreciation. In the case of the Czech Republic, final effect of currency depreciation to aggregate NPLs ratio is negative change in development. Aggregate NPLs ratio decreases in following 6 months when the negative development reaches its peak and then it starts to slowly return to the initial value. Final interconnection of home currency appreciation and NPLs ratio is thus positive. This result is in contradiction with Nkusu (2011). In his econometric analysis of advanced economies the final influence of the exchange rate impulse represented by appreciation on the rate of non-performing loans is strictly negative. On the contrary, Fofack (2005) and Khemraj and Pasha (2009) confirm positive relation of exchange rate and NPLs ratio in case of selected African countries and Guyana. Babouček and Jančar (2005) also tested hypothesis of the deterioration of banks loan quality in response to currency appreciation, but their analysis didn't confirm the assumption.

Aggregate NPLs ratio also exhibits an autoregressive behavior. The initial shock in NPLs influences positively the rate of aggregate NPLs in upcoming years. This influence gradually disappears after approximately 3 years. This relatively persistent feature in change of NPLs ratio development can be also influenced by the banks write-offs policy. This result of autoregressive behavior also corresponds with findings presented in Nkusu (2005). In his thesis testing advanced economies, sharp increase in aggregate NPLs ratio leads to the almost linear feedback response on itself. For more, this response continues into the fourth year after the initial shock. This finding greatly corresponds to our results, where the autoregressive reaction of NPLs is also almost linear.

Impulse response analysis also shows reactions of macroeconomic variables on an impulse in aggregate NPLs ratio. This random shock causes initial positive

changes in development of unemployment rate and inflation. On the contrary, initial negative development is apparent in case of industrial production index, interest rate and exchange rate, but according to following development, the influence of NPLs ratio on industrial production index value is rather ambiguous. The negative impact of NPLs ratio impulse is in case of industrial production index only small and short-term.

#### **4.4.2 NPLs by sector**

This part analyzes mutual interactions between NPLs and selected macroeconomic variables separately for the non-financial corporations sector and households sector. Subsequently, results obtained for particular sectors are compared in order to investigate differences in these sectors.

##### **4.4.2.1 Non-performing loans of non-financial corporations**

We examine the non-financial corporations sector first. Variables included corresponds with the variables from the aggregate non-performing loans model, the only difference is that variable aggregate NPLs ratio is replaced by non-performing non-financial corporations loans ratio. As in the previous model, majority of the variables used is non-stationary, the only stationary time series is the rate of non-financial corporations NPLs.

To determine proper model with optimal lag length, information criteria are used.<sup>12</sup> Non-stationarity of variables again leads to rejection of the stability of all four models suggested; VAR (10), VAR(4), VAR(3) and VAR(1). As the variables mutual interaction is the point of our interest, the most appropriate model is chosen according to impulse response analysis functions. Impulse responses in models VAR(10) and VAR(4) lead to permanent changes in variables, so these models are not useful for our causal analysis. Other two models, VAR(3) and VAR(1), exhibit temporary responses to initial impulses in impulse response analysis. As the VAR(3) needs shorter time for variables recovery after the random shock in the economy, this model is estimated.

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<sup>12</sup> AIC suggests again 10 lags length as optimal, FPE determines 4 lags, HC estimation equals to 3 lag length as optimal and SC determines 1 lag length as an optimal model lag length.

Estimated model VAR(3) for non-financial corporations sector can be formalized similarly as the model for aggregate NPLs:

$$\begin{aligned}
 NPL_C = & v + \alpha_1 IP_{t-1} + \alpha_2 CPI_{t-1} + \alpha_3 U_{t-1} + \alpha_4 CZK\_EUR_{t-1} + \alpha_5 PRIBOR_{t-1} \\
 & + \alpha_6 NPL\_C_{t-1} + \beta_1 IP_{t-2} + \beta_2 CPI_{t-2} + \beta_3 U_{t-2} + \beta_4 CZK\_EUR_{t-2} \\
 & + \beta_5 PRIBOR_{t-2} + \beta_6 NPL\_C_{t-2} + \gamma_1 IP_{t-3} + \gamma_2 CPI_{t-3} + \gamma_3 U_{t-3} \\
 & + \gamma_4 CZK\_EUR_{t-3} + \gamma_5 PRIBOR_{t-3} + \gamma_6 NPL\_C_{t-3} + u_t
 \end{aligned}$$

Equations for the rest of variables used in a vector autoregression model can be written analogically. In model VAR(3) 108 coefficients are estimated. Summary of estimated parameters and their t-statistics and p-values is reported in Table 8. Statistically significant are 25 parameters<sup>13</sup> (almost 25 % of parameters estimated).

**Table 8: VAR(3) for non-financial corporations NPLs**

<i>VAR system, lag order 3</i>							
<i>OLS estimates, observations 2003:03-2013:01 (T=116)</i>							
Legend: Coefficient							
{p - Value}							
[t - Value]							
<b>Lagged endogenous term:</b>							
		<b>CPI</b>	<b>CZK_EUR</b>	<b>IP</b>	<b>NPL_C</b>	<b>PRIBOR</b>	<b>U</b>
<b>CPI</b>	(t-1)	<b>0.932**</b>	0.033	0.673	-0.037	0.030	0.031
		{0.000}	{0.150}	{0.508}	{0.446}	{0.218}	{0.605}
		[9.702]	[1.439]	[0.662]	[-0.761]	[1.231]	[0.518]
<b>CZK_EUR</b>	(t-1)	<b>3.196*</b>	<b>0.965**</b>	-17.026	<b>-2.459**</b>	-0.091	-0.736
		{0.070}	{0.021}	{0.362}	{0.005}	{0.840}	{0.504}
		[1.812]	[2.310]	[-0.912]	[-2.788]	[-0.202]	[-0.668]
<b>IP</b>	(t-1)	-0.006	0.002	<b>0.192**</b>	0.002	0.002	0.003
		{0.540}	{0.393}	{0.045}	{0.652}	{0.321}	{0.586}
		[-0.613]	[0.855]	[2.003]	[0.451]	[0.992]	[0.544]
<b>NPL_C</b>	(t-1)	0.108	-0.012	2.694	<b>0.772**</b>	-0.005	0.168
		{0.604}	{0.805}	{0.223}	{0.000}	{0.928}	{0.199}
		[0.518]	[-0.247]	[1.219]	[7.395]	[-0.090]	[1.283]
<b>PRIBOR</b>	(t-1)	-2.350	0.398	11.361	<b>2.440**</b>	<b>1.477**</b>	0.194
		{0.154}	{0.309}	{0.515}	{0.003}	{0.000}	{0.851}
		[-1.425]	[1.018]	[0.651]	[2.958]	[3.513]	[0.188]
<b>U</b>	(t-1)	<b>0.852**</b>	<b>-0.117**</b>	-1.685	<b>0.250**</b>	<b>-0.132**</b>	<b>1.170**</b>
		{0.000}	{0.011}	{0.413}	{0.010}	{0.008}	{0.000}
		[4.376]	[-2.530]	[-0.818]	[2.571]	[-2.655]	[9.604]

<sup>13</sup> 5% significance level

<b>CPI</b>	(t-2)	-0.128 {0.331} [-0.972]	0.041 {0.186} [1.322]	0.313 {0.822} [0.226]	0.053 {0.423} [0.802]	0.050 {0.134} [1.497]	-0.033 {0.690} [-0.398]
<b>CZK_EUR</b>	(t-2)	-2.546 {0.327} [-0.980]	0.269 {0.662} [0.437]	41.415 {0.132} [1.506]	1.201 {0.355} [0.924]	0.379 {0.567} [0.573]	0.038 {0.982} [0.023]
<b>IP</b>	(t-2)	-0.001 {0.885} [-0.145]	0.000 {0.850} [0.189]	<b>0.171*</b> {0.071} [1.804]	<b>-0.007*</b> {0.095} [-1.669]	0.000 {0.950} [0.062]	-0.009 {0.121} [-1.552]
<b>NPL_C</b>	(t-2)	<b>-0.643**</b> {0.013} [-2.488]	0.065 {0.290} [1.059]	0.701 {0.798} [0.256]	-0.063 {0.623} [-0.491]	0.046 {0.483} [0.701]	-0.123 {0.447} [-0.760]
<b>PRIBOR</b>	(t-2)	2.312 {0.336} [0.963]	<b>-1.054*</b> {0.064} [-1.852]	-30.409 {0.231} [-1.197]	-1.337 {0.265} [-1.113]	<b>-1.213**</b> {0.047} [-1.983]	0.749 {0.618} [0.499]
<b>U</b>	(t-2)	<b>-1.118**</b> {0.000} [-3.857]	0.039 {0.569} [0.569]	0.049 {0.987} [0.016]	-0.194 {0.181} [-1.339]	0.050 {0.500} [0.674]	<b>-0.578**</b> {0.001} [-3.187]
<b>CPI</b>	(t-3)	-0.109 {0.259} [-1.129]	<b>-0.042*</b> {0.069} [-1.818]	<b>-1.699*</b> {0.096} [-1.666]	0.007 {0.885} [0.145]	<b>-0.047*</b> {0.056} [-1.908]	-0.033 {0.582} [-0.550]
<b>CZK_EUR</b>	(t-3)	2.766 {0.147} [1.451]	<b>-1.060**</b> {0.019} [-2.348]	<b>-43.840**</b> {0.030} [-2.174]	-0.120 {0.900} [-0.126]	<b>-0.997**</b> {0.040} [-2.053]	-0.713 {0.550} [-0.598]
<b>IP</b>	(t-3)	0.005 {0.598} [0.527]	0.002 {0.430} [0.790]	<b>0.330**</b> {0.000} [3.573]	-0.004 {0.354} [-0.928]	0.001 {0.615} [0.503]	<b>-0.014**</b> {0.010} [-2.568]
<b>NPL_C</b>	(t-3)	<b>0.529**</b> {0.004} [2.915]	-0.059 {0.173} [-1.364]	-2.926 {0.127} [-1.525]	<b>0.176*</b> {0.053} [1.938]	-0.046 {0.316} [-1.004]	0.044 {0.700} [0.385]
<b>PRIBOR</b>	(t-3)	-2.415 {0.172} [-1.365]	<b>1.287**</b> {0.002} [3.068]	<b>36.256*</b> {0.053} [1.936]	0.388 {0.661} [0.439]	<b>1.245**</b> {0.006} [2.760]	0.274 {0.804} [0.248]
<b>U</b>	(t-3)	<b>0.742**</b> {0.000} [3.852]	-0.030 {0.518} [-0.647]	0.669 {0.743} [0.328]	0.071 {0.460} [0.740]	-0.026 {0.594} [-0.532]	0.114 {0.346} [0.943]

An asterisk (\*) denotes significance at 10% level. A double asterisk (\*\*) denotes significance at 5% level.

Next we analyze mutual interactions of variables by examining the simulation of an initial shock in a particular time series and its following influence on other variables. As well as in the model for the aggregate non-performing loans, impulse response analysis is performed for 36 months to identify interconnections of macroeconomic indicators correctly. Results of the impulse response analysis for the VAR(3) model are summarized in the Figure 4 in Appendix.

As presented Bofondi and Ropele (2011) in their study investigating the interactions of loans quality and macroeconomic variables in Italy, GDP has a strongly negative relation with the NPLs ratio in non-financial corporations sector. But similarly as in case of aggregate NPLs ratio this negative influence is visible only after 1 month which means that the transmission of the initial impulse into the rate of non-financial corporations NPLs takes some time. Generally, improving economic situation reflected by increasing GDP thus leads to the decrease of rate of NPLs in a given economic sector. Based on the impulse response analysis, this decrease reaches its peak after approximately 12 months.

Hypothesis suggesting positive relation of NPLs ratio and unemployment rate is also confirmed by our analysis. Higher unemployment rate influences NPLs ratio of non-financial corporations positively. This positive and significant influence is the most radical in the first 2 months, then the value of unemployment rate slightly fluctuates and after one year it starts to decrease again. Financial difficulties probably force companies to cost-cutting and lowering of jobs positions and thus increase unemployment. For more, these financial problems will lead to the deterioration of debt paying ability of the companies, which can lead to the worsening of non-financial corporations loans quality. This finding corresponds to Bofondi and Ropele (2011).

Similarly, positive interconnection between non-financial corporations NPLs ratio and interest rate is also confirmed. Shock in PRIBOR influences the development of NPLs significantly positively. This result corresponds with findings presented by Bofondi and Ropele (2011). For the Italian banks, this relation is also strictly positive. This finding confirms our suggested hypothesis that increasing interest rate increases costs of borrowing and thus worsens financial situation of companies.

Next macroeconomic variable examined is inflation represented by consumer price index. For the Czech economy, inflation exhibits mostly positive influence on the non-financial corporations NPLs ratio development. The only exception is the first month when the development of non-financial corporations

NPLs ratio is influenced negatively by inflation impulse. After that the influence is strictly positive in following two years.

Last interconnection analyzed is the influence of exchange rate shock on rate of corporate NPLs development. Based on the results obtained, depreciation of the home currency causes decrease in NPLs ratio. As the Czech corporate sector is highly export-oriented, currency depreciation improves their international competitiveness. This development also influences positively corporations incomes and thus lowers the NPLs ratio. From this point of view, currency appreciation and non-financial corporations NPLs ratio has positive interconnection.

Non-financial corporations NPLs ratio also reports autoregressive behavior. Shock in NPLs slowly disappears after more than 3 years. For more, impulse response analysis shows that NPLs ratio has feedback effect on the majority of macroeconomic variables examined. On the contrary with the case of the aggregate NPLs ratio, rate of non-financial corporations NPLs affects positively the initial development of GDP. For more it affects positively also the unemployment rate. The rest of variables examined (interest rate, inflation and exchange rate) are influenced ambiguously. The initial responses are low and short-term, and these variables development fluctuates close to the initial value mostly.

#### **4.4.2.2 Non-performing households loans**

Next analysis is focused on a households sector. The only change in comparison with the initial model for the aggregate economy is the replacement of the aggregate NPLs ratio by non-performing households loans ratio. All of the variables used are non-stationary again.

For the determination of the optimal model lag length, information criteria are calculated.<sup>14</sup> Unit root test rejected the stability of all 4 models suggested; VAR(10), VAR(9), VAR(2) and VAR(1). Similarly as for non-financial corporations sector, the most appropriate model is determined with emphasis on impulse response analysis and the duration of the random shocks. Temporary response to

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<sup>14</sup> In case of the households sector, AIC suggests 10 lags again, FPE determines 9 lags as optimal, HC chooses 2 lags and finally SC selects only 1 lag an optimal lag length for model estimation.

initial impulse is evident in case of VAR(2). Models VAR(10) and VAR(9) exhibit permanent influence. Therefore the VAR(2) model is used for our estimation.

Estimated model VAR(2) for households sector can be formalized as:

$$NPL_H = v + \alpha_1 IP_{t-1} + \alpha_2 CPI_{t-1} + \alpha_3 U_{t-1} + \alpha_4 CZK\_EUR_{t-1} + \alpha_5 PRIBOR_{t-1} + \alpha_6 NPL\_H_{t-1} + \beta_1 IP_{t-2} + \beta_2 CPI_{t-2} + \beta_3 U_{t-2} + \beta_4 CZK\_EUR_{t-2} + \beta_5 PRIBOR_{t-2} + \beta_6 NPL\_H_{t-2} + u_t$$

**Table 9: VAR(2) model for households NPLs**

<i>VAR system, lag order 2</i>							
<i>OLS estimates, observations 2003:03-2013:01 (T=117)</i>							
Legend: Coefficient							
{p - Value}							
[t - Value]							
<b>Lagged endogenous term:</b>							
		<b>CPI</b>	<b>CZK_EUR</b>	<b>IP</b>	<b>NPL_H</b>	<b>PRIBOR</b>	<b>U</b>
<b>CPI</b>	(t-1)	<b>0.892**</b> {0.000} [8.428]	<b>5.030*</b> {0.059} [1.886]	107.601 {0.367} [0.902]	3.982 {0.423} [0.802]	<b>4.630*</b> {0.100} [1.646]	0.130 {0.985} [0.019]
<b>CZK_EUR</b>	(t-1)	0.015 {0.367} [0.902]	<b>1.498**</b> {0.000} [3.498]	-10.155 {0.596} [-0.530]	0.589 {0.460} [0.739]	0.443 {0.327} [0.981]	-1.385 {0.205} [-1.267]
<b>IP</b>	(t-1)	0.000 {0.902} [0.123]	0.003 {0.119} [1.557]	<b>0.326**</b> {0.001} [3.381]	-0.005 {0.198} [-1.288]	<b>0.004*</b> {0.084} [1.726]	-0.001 {0.802} [-0.251]
<b>NPL_H</b>	(t-1)	0.000 {0.866} [-0.168]	-0.039 {0.463} [-0.735]	1.378 {0.565} [0.575]	<b>0.818**</b> {0.000} [8.197]	-0.026 {0.651} [-0.452]	0.176 {0.199} [1.285]
<b>PRIBOR</b>	(t-1)	-0.010 {0.543} [-0.609]	-0.216 {0.589} [-0.541]	7.865 {0.660} [0.440]	-0.444 {0.551} [-0.597]	<b>0.848**</b> {0.044} [2.012]	0.977 {0.338} [0.958]
<b>U</b>	(t-1)	<b>0.005**</b> {0.003} [2.934]	<b>-0.085**</b> {0.033} [-2.128]	-1.884 {0.289} [-1.060]	0.070 {0.346} [0.942]	<b>-0.090**</b> {0.032} [-2.143]	<b>1.234**</b> {0.000} [12.169]
<b>CPI</b>	(t-2)	-0.135 {0.183} [-1.331]	-0.638 {0.803} [-0.249]	<b>-197.890*</b> {0.084} [-1.729]	-1.205 {0.800} [-0.253]	0.464 {0.864} [0.172]	-2.822 {0.666} [-0.432]
<b>CZK_EUR</b>	(t-2)	0.005 {0.789} [0.268]	<b>-0.816*</b> {0.078} [-1.762]	-9.419 {0.649} [-0.455]	-0.899 {0.297} [-1.042]	-0.651 {0.183} [-1.333]	-0.455 {0.701} [-0.385]

<b>IP</b>	(t-2)	0.000 {0.606} [0.515]	0.002 {0.427} [0.795]	<b>0.360**</b> {0.000} [3.953]	0.003 {0.480} [0.706]	0.001 {0.517} [0.648]	<b>-0.012*</b> {0.018} [-2.361]
<b>NPL_H</b>	(t-2)	0.000 {0.849} [0.191]	0.007 {0.890} [0.138]	-1.435 {0.522} [-0.640]	0.041 {0.663} [0.436]	-0.011 {0.830} [-0.214]	-0.045 {0.725} [-0.352]
<b>PRIBOR</b>	(t-2)	-0.005 {0.763} [-0.302]	0.339 {0.431} [0.788]	11.364 {0.555} [0.590]	0.661 {0.409} [0.825]	0.146 {0.747} [0.323]	0.737 {0.502} [0.671]
<b>U</b>	(t-2)	-0.003 {0.101} [-1.638]	0.007 {0.862} [0.173]	1.875 {0.312} [1.011]	-0.037 {0.629} [-0.483]	0.010 {0.814} [0.236]	<b>-0.468**</b> {0.000} [-4.417]

An asterisk (\*) denotes significance at 10% level. A double asterisk (\*\*) denotes significance at 5% level.

Linear equations for the rest of macroeconomic variables used in a model can be formalized analogically. Table 9 summarizes all 72 estimated coefficients, t-statistics and p-values of parameters are also included. From all 72 estimated parameters only 12 parameters are statistically significant<sup>15</sup> (approximately 16 %).

Impulse response analysis for VAR(2) is computed subsequently. Again, observations are performed for 3 years. Results of the impulse response analysis for the VAR(2) model are summarized in the Figure 5 in Appendix.

Impulse response analysis confirms the negative relation of households NPLs ratio and GDP. The only exception is the development between second and third month, when the NPLs ratio increases slightly. After the fourth month the development is influenced negatively again. Increasing level of GDP improves the overall economy and probably causes increase of population incomes. This also includes improvement of households financial situation, which leads to decrease in level of households NPLs as their ability to repay the debt will be better. This result corresponds with Rinaldi and Sauchis-Arellano (2006) and their findings for selected Euro area countries. Also Bofondi and Ropele (2011) confirm this relation for Italian households.

The development of households NPLs ratio is influenced by the interest rate mostly positively as the shock causes increase in households NPLs ratio during the

<sup>15</sup> 5% significance level

first 10 months when the rate of households NPLs ratio reaches its peak. The only exception is the first month when the ratio development is negative but insignificant. After 10 months the influence of interest rate seems to weaken and the households NPLs ratio starts to decrease to its initial value. Positive relation between households NPLs and interest rate present also Rinaldi and Sauchis-Arellano (2006) so our result corresponds with their finding.

Positive interconnection is also confirmed between households NPLs ratio and unemployment rate. This ratio increases rapidly during the first quarter, then remains approximately stable and starts to decrease again after 14 months. This finding corresponds with hypothesis suggested before and also corresponds with findings presented in Bofondi and Ropele (2011). Increasing unemployment worsens households financial situation. Higher unemployment rate thus causes that more households are not able to service their debts realized and therefore more loans are categorized as loans in failure.

The influence of shock in inflation causes positive change in NPLs ratio development. During the 1<sup>st</sup> three months the value of households NPLs ratio increases rapidly. Increasing inflation probably reduces personal real incomes and thus worsens households financial situation. Consumers don't have appropriate financial possibilities to repay debts and costs of borrowing so they fail in repayments. Therefore the level of households NPLs increases after the inflation increase. This result is in contradiction with findings presented by Bofondi and Ropele (2011). For the Italian households they find out negative influence of inflation on NPLs which together with positive relation between households NPLs and unemployment rate confirms the Phillips curve theory. Unfortunately, this theory is not confirmed in case of the Czech households. On the contrary, similar positive connection between NPLs and inflation as in CR case present Rinaldi and Sauchis-Arellano (2006) in study examining selected European countries.

The last variable included in the analysis is the exchange rate. Based on impulse response analysis, during the 1<sup>st</sup> two months the development of the NPLs ratio is influenced positively, but this effect is small and temporary. After that,

home currency depreciation causes negative development in households NPLs ratio in upcoming 6 months when this decrease reaches its peak. After that, the value of households NPLs starts to increase to the initial value. Final relation between currency appreciation and NPLs ratio is thus positive. However, households in the Czech Republic prefer loans in a home currency so the linkage between exchange rate and loan quality in households sector is rather indirect.

Next, we examine the feedback effect of households NPLs ratio shocks on the macroeconomic variables. Positive reaction on the rate of NPLs impulse exhibits GDP and unemployment rate. But in case of GDP this effect is only small and temporary in the beginning. On the contrary, negative reaction occurs in development of interest rate, inflation and exchange rate. In case of inflation this negative influence is short-term and insignificant. Households NPLs ratio exhibits an autoregressive behavior also.

#### 4.4.2.3 Results comparison of non-financial corporations and households sector

This part compares results obtained separately for the non-financial corporations and sector of households. But as the initial models estimated for both sectors are based on unit roots tests unstable, it is needed to take these results with caution.

**Table 10: Comparison of households and non-financial corporations sector**

IMPULSE IN VARIABLE	EXPECTED RELATIONSHIP WITH THE NPLs	NON-FINANCIAL CORPORATIONS	HOUSEHOLDS
<i>IP</i>	-	-	-
<i>U</i>	+	+	+
<i>PRIBOR</i>	+	+	+
<i>CPI</i>	-/+	+	+
<i>CZK_EUR</i>	-/+	+	+

Source: Author's results

Suggested hypothesis is confirmed in both sectors for macroeconomic indicator GDP approximated by the industrial production index. This fact implies absence of intersectoral differences. The only difference is that the negative

influence of GDP is larger and more rapid in non-financial corporations sector. This is probably due to the direct link of the used industrial production index to the companies performance.

Also the positive impact of unemployment rate is confirmed in both sectors. Generally, the hypothesis that increasing unemployment rate causes financial difficulties leading to the increase in value of NPLs is confirmed. The speed and size of the change in NPLs ratio is similar in both sectors, the only difference is the fluctuation in ratio development in non-financial corporations sector between 2<sup>nd</sup> and 6<sup>th</sup> month. On the contrary, the development in households sector is smooth.

Also the effect of interest rate impulse corresponds with theoretical hypothesis in case of both sectors. Expected impact of the impulse, the positive change in rate of NPLs, is confirmed. The increase in rate of NPLs is more rapid and higher in case of the non-financial corporations sector. On the contrary, households sector exhibits lower positive change in NPLs ratio development in comparison to the non-financial corporations sector.

The theoretical mutual relation of inflation and NPLs is ambiguous. But in the Czech Republic, the effect of reduction of the real income probably dominates over the other theoretical effects. In both sectors, households and non-financial corporations, positive effect of inflation on the NPLs development is confirmed. Decreasing real income value weakens ability of both sectors to meet their obligations and thus increases the rate of non-financial corporations NPLs as well as households NPLs. In both cases response on inflation impulse is long-term. The only difference is that the development in non-financial corporations sector is negative in the first month, in case of households sector this development is immediately positive. Also the change in development is higher in households sector. The change in development of non-financial corporations NPLs ratio is slower. It takes almost 2 years to reach the peak, households NPLs rate reaches the peak after 4 months and then starts to decrease.

Also exchange rate is not suggesting any significant intersectoral differences. For the non-financial corporations sector as well as for households sector the

relation of NPLs ratio and currency appreciation is positive. The only difference is that reaction of households sector is slower and smaller than the reaction of non-financial corporations sector on exchange rate impulse.

Based on the comparison of the results obtained for both sectors, no significant intersectoral differences are evident in the Czech Republic. Both sectors react on the random shocks in macroeconomic variables similarly, only visible differences are the extent and the speed of particular responses. For more, empirical findings confirm theoretical hypotheses about general variables interconnections in case of both sectors; non-financial corporations sector and households sector.

#### **4.4.3 NPLs by the level of failure**

Mutual interconnections between macroeconomic variables and particular categories of non-performing loans divided according to the level of loans failure are analyzed next. For this model the set of endogenous variables is created by selected macroeconomic variables which were included in previous models and by three groups of NPLs ratio; substandard loans ratio, doubtful loans ratio and loss loans ratio.<sup>16</sup> All categories of NPLs are included in the estimated vector autoregression model simultaneously in order to determine which category is influenced by which macroeconomic indicator the most.

We are using mainly non-stationary time series, the only stationary time series is substandard loans ratio. Based on information criteria<sup>17</sup>, only models VAR(10) or VAR(1) seems to be optimal with respect to optimal lag length. As the impulse response analysis exhibits permanent changes in variables development for model VAR(10) due to the instability of the model estimated, model VAR(1) is used for the estimation even though it is instable as well. Random shocks in the VAR(1) model influence particular variables only temporarily (initial shocks influence disappears in 9 years in maximum) so this model is more appropriate for our analysis in comparison with VAR(10).

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<sup>16</sup> Criteria of categorization are described in part 4.2 Selection of Dataset

<sup>17</sup> AIC, FPE and HC are all equal to 10, Schwartz criterion determine 1 lag as optimal lag length for the model estimation.

Estimated model VAR(1) can be thus formalized as:

$$NPL_S = v + \alpha_1 IP_{t-1} + \alpha_2 CPI_{t-1} + \alpha_3 U_{t-1} + \alpha_4 CZK\_EUR_{t-1} + \alpha_5 PRIBOR_{t-1} \\ + \alpha_6 NPL\_D_{t-1} + \alpha_7 NPL\_L_{t-1} + \alpha_8 NPL\_S_{t-1} + u_t$$

**Table 11: VAR(1) model for NPLs according to failure**

VAR system, lag order 1									
OLS estimates, observations 2003:03-2013:01 (T=118)									
Legend: Coefficient									
{p - Value}									
[t - Value]									
Lagged endogenous term:									
		CPI	CZK EUR	IP	NPL D	NPL L	NPL S	PRIBOR	U
<b>CPI</b>	(t-1)	<b>0.779**</b> {0.000} [14.869]	0.043 {0.550} [0.598]	<b>-1.431**</b> {0.012} [-2.506]	0.000 {0.955} [0.056]	0.007 {0.557} [0.587]	0.000 {0.971} [0.036]	0.016 {0.246} [1.160]	-0.055 {0.125} [-1.534]
<b>CZK_EUR</b>	(t-1)	-0.032 {0.437} [-0.778]	<b>0.802**</b> {0.000} [14.132]	-0.593 {0.192} [-1.306]	<b>-0.013**</b> {0.019} [-2.350]	0.008 {0.349} [0.937]	-0.003 {0.722} [-0.356]	-0.007 {0.530} [-0.628]	0.024 {0.399} [0.843]
<b>IP</b>	(t-1)	-0.003 {0.630} [-0.482]	-0.002 {0.780} [-0.280]	<b>0.621**</b> {0.000} [8.834]	-0.001 {0.131} [-1.510]	-0.001 {0.389} [-0.861]	-0.001 {0.443} [-0.767]	<b>0.008**</b> {0.000} [4.574]	<b>-0.012**</b> {0.006} [-2.741]
<b>NPL_D</b>	(t-1)	0.692 {0.116} [1.572]	0.749 {0.211} [1.251]	5.529 {0.249} [1.154]	<b>0.829**</b> {0.000} [14.089]	-0.044 {0.645} [-0.461]	<b>0.328**</b> {0.000} [3.853]	0.168 {0.156} [1.418]	-0.091 {0.762} [-0.303]
<b>NPL_L</b>	(t-1)	<b>0.287**</b> {0.047} [1.984]	<b>0.420**</b> {0.033} [2.135]	-0.044 {0.978} [-0.028]	-0.006 {0.748} [-0.322]	<b>0.901**</b> {0.000} [28.857]	-0.027 {0.334} [-0.966]	0.008 {0.828} [0.218]	0.032 {0.748} [0.322]
<b>NPL_S</b>	(t-1)	<b>-0.590**</b> {0.020} [-2.331]	<b>-0.695**</b> {0.044} [-2.017]	-1.135 {0.681} [-0.412]	0.005 {0.891} [0.137]	0.069 {0.207} [1.263]	<b>0.782**</b> {0.000} [15.959]	-0.106 {0.120} [-1.555]	0.140 {0.421} [0.805]
<b>PRIBOR</b>	(t-1)	<b>0.485**</b> {0.006} [2.723]	<b>-0.524**</b> {0.031} [-2.160]	-0.258 {0.894} [-0.133]	-0.012 {0.616} [-0.502]	-0.001 {0.973} [-0.034]	0.026 {0.459} [0.741]	<b>0.851**</b> {0.000} [17.683]	0.123 {0.312} [1.010]
<b>U</b>	(t-1)	<b>0.175*</b> {0.051} [1.954]	-0.131 {0.284} [-1.071]	0.590 {0.546} [0.604]	<b>0.024**</b> {0.044} [2.011]	0.012 {0.542} [0.609]	<b>0.057**</b> {0.001} [3.260]	<b>-0.069**</b> {0.004} [-2.849]	<b>0.951**</b> {0.000} [15.471]

An asterisk (\*) denotes significance at 10% level. A double asterisk (\*\*) denotes significance at 5% level.

Table 11 summarizes estimated coefficients and their t-statistics and p-values. Using 5% level of significance, 22 coefficients out of 64 coefficients estimated are significant (approximately 34 % of all parameters). Using this model VAR(1) we will try to determine mutual linkages of macroeconomic variables and NPLs by impulse response analysis. Graphical results of particular impulse responses are attached as Figure 6-8 in Appendix.

Improving economic situation characterized by the increase in GDP represented by industrial production index exhibits the same influence on all three

non-performing loans categories. Higher GDP negatively impacts the development of substandard loans ratio as well as the development of doubtful and loss loans ratio. This change is the most rapid in case of doubtful loans where it takes approximately 4 months to reach the peak of the decreasing tendency. On the contrary, negative development of substandard and loss loans is slower, the minimum level is in case of substandard loans rate reached after 8 months, loss loans rate exhibits its minimum level after almost a year. The biggest decrease in ratio of NPLs occurs in substandard loans category.

As well as in case of the GDP impulse, also the unemployment rate impulse confirms the general hypothesis for all three categories analyzed. This positive relation causes the biggest increase in rate of substandard loans category. Higher unemployment causes mostly an emergence of new substandard loans in comparison with other two categories as the level of failure of this category represents the most recent non-performing loans. The peak of the positive development is in case of the substandard loans ratio and doubtful loans ratio reached after approximately 8 months. In case of the loss loans ratio it takes almost a year to get the maximal effect of the impulse response.

Until now the analysis of NPLs exhibited the positive relation between NPLs ratio and interest rate on the aggregate level as well as on the level of sectors (non-financial corporations and households). This positive interconnection is predominantly confirmed for all categories examined now as well. Positive influence is the most significant in case of substandard loans category. On the contrary, the development of loss loans category is visibly positively influenced after almost 4 months, the first quarter doesn't exhibit any significant changes. The last category, doubtful loans, is initially influenced negatively during the first month. But this decrease in NPLs ratio is small and temporary. In the second month the ratio development starts to exhibit positive changes and reaches the maximum value after approximately 1 year.

The influence of consumer price index shock as an approximation of the inflation change shows mostly negative influence on all NPLs categories. The only

positive development is evident in loss loans category and it seems to be quite long-term. However, the NPLs ratio of substandard and doubtful loans reacts negatively on the inflation impulse. This negative development is visible after 4 months in case of doubtful loans, in case of substandard loans it takes 2 months to observe some negative change in NPLs ratio. In both cases this influence is small and disappears after approximately 3 years.

The influence of exchange rate is according to literature ambiguous. Until now the analysis exhibits positive interconnection of NPLs ratio and home currency appreciation. This fact is also mainly confirmed in case of NPLs categorized by the level of failure. The only exception is the loss loans category where the development is influenced wholly negatively. Change in substandard and doubtful loans category is similar in size, but the change in development is more rapid in case of doubtful loans where it takes 3 months to reach the peak. On the contrary, substandard loans are influenced slowly. It reaches the peak after almost 6 months.

Finally, all three non-performing loans categories exhibit autoregressive behavior as well as NPLs ratios in previous analysis. However, the feedback effects on macroeconomic variables differ for particular loan categories. The substandard loans initial feedback effect is predominantly negative on almost all variables included. On the contrary, the effect of doubtful loans on other macroeconomic indicators is mostly strictly positive. Results for loss loans category are mixed. It has positive effect on consumer price index, unemployment rate and exchange rate, very small positive effect is evident also in case of interest rate. On the contrary, negative change in development shows industrial production index. For more details, see Figures 6-8 in Appendix.

**Table 12: Results of NPLs by level of failure**

IMPULSE IN VARIABLE	EXPECTED RELATIONSHIP WITH THE NPLs	SUBSTANDARD LOANS	DOUBTFUL LOANS	LOSS LOANS
<i>IP</i>	-	-	-	-
<i>U</i>	+	+	+	+
<i>PRIBOR</i>	+	+	+	+
<i>CPI</i>	-/+	-	-	+
<i>CZK_EUR</i>	-/+	+	+	-

Source: Author's results

## 4.5 Discussion of Results

The aim of this thesis is to analyze transmission mechanisms and mutual interconnections between NPLs ratio as an indicator of banks loan portfolio quality and different macroeconomic variables. The model of vector autoregression is used to investigate these relations for aggregate NPLs as well as for different non-performing loans categories. Using the impulse response analysis the examination brought some interesting results.

**Table 13: Summary of results**

MACROECONOMIC VARIABLE	EXPECTED SIGNS	AGGREGATE NPLs	NON-FINANCIAL CORPORATIONS NPLs	HOUSEHOLDS NPLs	SUBSTANDARD LOANS	DOUBTFUL LOANS	LOSS LOANS
<i>IP</i>	-	-	-	-	-	-	-
<i>U</i>	+	+	+	+	+	+	+
<i>PRIBOR</i>	+	+	+	+	+	+	+
<i>CPI</i>	-/+	+	+	+	-	-	+
<i>CZK_EUR</i>	-/+	+	+	+	+	+	-

Source: Author's results

Majority of the general assumptions is confirmed on the aggregate level as well as on the level of sectors. Expected relations are also evident in particular NPLs categories according to level of failure with only few exceptions.

The positive influence of GDP on NPLs ratio is unambiguously confirmed for all NPLs categories examined. This means that higher income level improves the

ability of borrowers to repay their debts in any category included. Similarly significant result brought the analysis of interconnection of unemployment rate and NPLs ratio. Increasing unemployment generally worsens financial possibilities of the households and thus causes the increase of non-performing loans rate in any category. These two relations with NPLs ratio indirectly support Okun's law<sup>18</sup> in case of the Czech Republic. The third basic relation confirmed is the connection of NPLs and interest rate. Generally, increasing interest rate increases costs of borrowing and thus the repayment of the debt is more expensive after the interest rate change. This fact causes an increase in rate of NPLs in all categories examined in case of the Czech Republic.

Other two general assumptions were ambiguous according to the theory. Based on our investigation the positive effect of the inflation on NPLs ratio is confirmed for the majority of NPLs categories. The only exceptions are substandard and doubtful loans categories where the resulting influence of the inflation shock on NPLs ratio is negative. But this negative influence on the ratios development is according to the impulse response analysis results small, very close to zero. Therefore generally it is evident that in case of the Czech Republic, increasing inflation mainly reduces real incomes and thus worsens the ability of borrowers to service their debts. Also the relation of home currency appreciation and the NPLs ratio seems to be positive for the majority of NPLs categories. The only exception is in this case loss loans category where the effect of currency depreciation on NPLs ratio is positive.

However, it is desirable to point out some limitations and shortcomings of the vector autoregression model employed. Firstly, the number of observations is limited due to the availability of data. Non-performing loans are properly measured and published since 2002 due to the previous transmission period which influenced the development of the Czech economy significantly. For more, unemployment rate is monthly recorded since the March 2003, which is also quite limiting for our

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<sup>18</sup> Negative relation between unemployment rate and economic growth which is represented by the level of gross domestic product.

analysis. This limited number of observations subsequently causes limitations in lag length included in the model.

Another problem is the non-stationarity of the time series used causing the subsequent instability of the models estimated. In order to get stationary time series we would have to difference time series. But this transformation would lead to lose of information on any long-run relationship between variables. Also the residual analysis doesn't support the assumption of uncorrelated residuals.<sup>19</sup> Correlated residuals can thus cause certain results distortions.

As the only limited number of macroeconomic indicators is involved in model examination, the omitted variables problem can occur. Omitting some important variables can cause distortions in the estimated model and results obtained. According to Lütkepohl (2005), misspecification of the model and not including of any significant variable can lead to distortions mainly in impulse response analysis. In addition, the impulse responses in our models estimated rarely bring strongly significant results according to confidence intervals.

The empirical analysis evidence confirms expectations regarding the macroeconomic factors and NPLs ratio development in the Czech Republic. However, all results obtained have to be considered with caution due to the abovementioned data and model's limitations.

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<sup>19</sup> Results of LM tests and Portmanteau tests for particular models are included in Appendix in Table 15.

## 5. Conclusion

Recent global financial crisis reminded the importance of the examination of interconnections between macroeconomic performance and non-performing loans. The aim of this thesis is to analyze mutual linkages between loans quality indicators represented by NPLs ratio and selected macroeconomic indicators and to bring additional information to the limited number of studies regarding this problematic in the case of the Czech economy.

This thesis is devoted mainly to the empirical analysis, but it also pays brief attention to institutional issues of the development of the Czech banking system since the transformation period. Economic transformation in the Czech Republic was relatively quick process but it was accompanied by many problems, mainly institutional, which were negatively influencing the development of loans quality subsequently. In the beginning, Czech banking system was dealing mainly with the insufficient legislative and institutional framework. Following emergence of effective banking regulation and supervision, privatization of Czech banks and membership in the European Union are the most important institutional changes which led to the stabilization and emergence of effective banking system.

The econometric investigation was mainly focused on the evaluation of the bank loans portfolio quality in the Czech Republic over past 10 years, in the time period starting from March 2003 to January 2013. The method of vector autoregression and impulse response analysis was used to determine mutual interconnections of selected macroeconomic variables and banks loans portfolio quality. As a measure of the loans quality, share of non-performing loans on the gross loans was employed. To get more specific results, linkages between NPLs and macroeconomic performance were not investigated only on the aggregate level. Empirical analysis was done separately for non-financial corporations and households sector to detect possible intersectoral differences also. For more, vector autoregression approach was used to estimate interconnections of macroeconomic performance and particular loans categories divided by the level of loans failure.

The outcomes from the vector autoregression models have detected some interesting linkages between loans portfolio quality and macroeconomic performance. The impulse response analysis for the aggregate NPLs indicated that increasing unemployment, interest rate and exchange rate cause significant deterioration in banks loans quality. Also increasing inflation influences the development of NPLs ratio positively. On the contrary, negative relationship was found between GDP and the NPLs ratio indicating that an improvement in economic activity also improves the banks loans quality.

Similar results were found also on the sectoral level. Both sectors (non-financial corporations and households sector) exhibited the same linkages between banks loans quality and particular macroeconomic variables similarly as in case of aggregate NPLs. Generally, the impulse response analysis indicated positive linkage between NPLs ratio and unemployment rate, interest rate, inflation and exchange rate. Positive effect on banks loans quality has the improvement in GDP. These findings didn't confirm any intersectoral differences as both sectors react on particular macroeconomic shocks in the same way. The only differences of sectoral results were the extent of the quality improvement and the fact that some responses were visible with a short delay.

Majority of suggested hypotheses were also confirmed for particular loans categories divided according to the level of failure (substandard, doubtful and loss loans). Positive shock in GDP leads to decrease in share of NPLs in all three categories. The response of NPLs ratios to the shock in unemployment rate supports the hypothesis that rising unemployment worsens the loans portfolio quality. Negative effect of interest rate on the loans quality was also confirmed for all three categories. Surprising were findings regarding the index of consumer prices. Loss loans reacted on the inflation shock positively as did aggregate NPLs, non-financial corporations NPLs and households NPLs. However, reaction of doubtful and substandard loans on this shock was negative. But according to impulse response analysis, these changes in development were very small, close to zero. The interconnection of exchange rate and substandard and doubtful loans was positive which corresponds with findings for aggregate NPLs and sectoral NPLs.

Surprisingly, the only loan category reacting on the currency appreciation negatively was the loss loans category.

The econometric analysis contributed to comprehension of the mutual linkages between loans portfolio quality and macroeconomic performance. Generally, favorable macroeconomic environment such as improving GDP, lower unemployment and lower interest rate contributes to the loans quality improvement. However, used vector autoregression approach has its limitations which can affect final results obtained. Therefore our findings have to be taken with this consideration.

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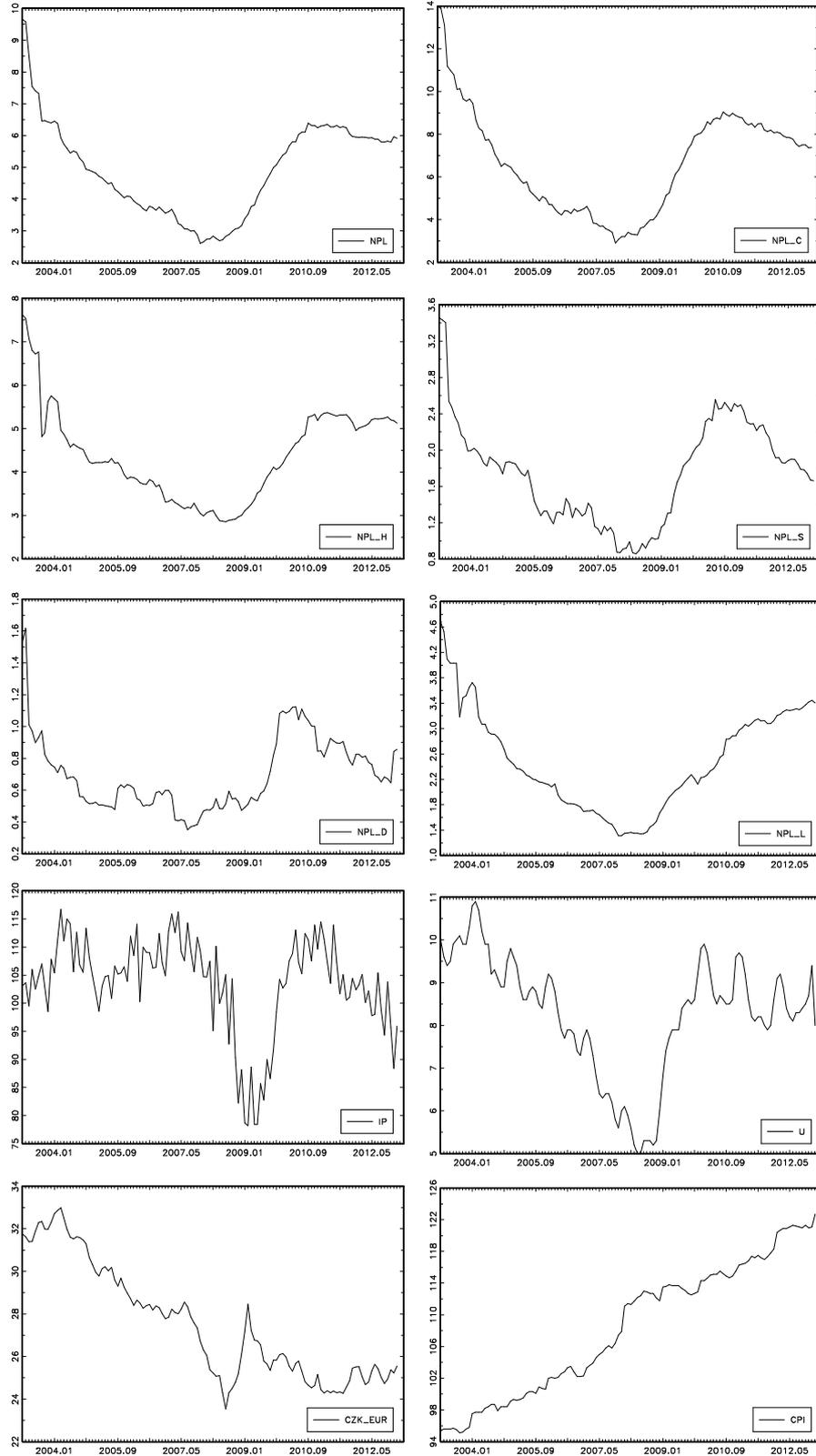
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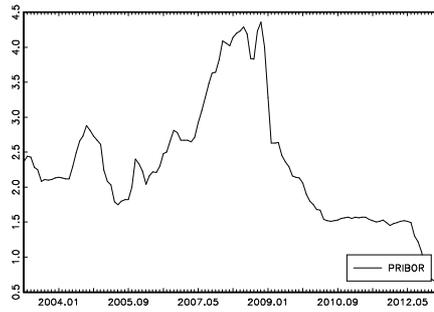
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# Appendix

Figure 2: Plot of original time series





Plotted are monthly data for the time period March 2003-January 2013. NPL, NPL\_C, NPL\_H, NPL\_S, NPL\_D and NPL\_L are a percentage ratio on aggregate loans, PRIBOR and U are in percentage, IP and CPI are in index numbers and CZK\_EUR is quoted as an amount of CZK per one EUR.

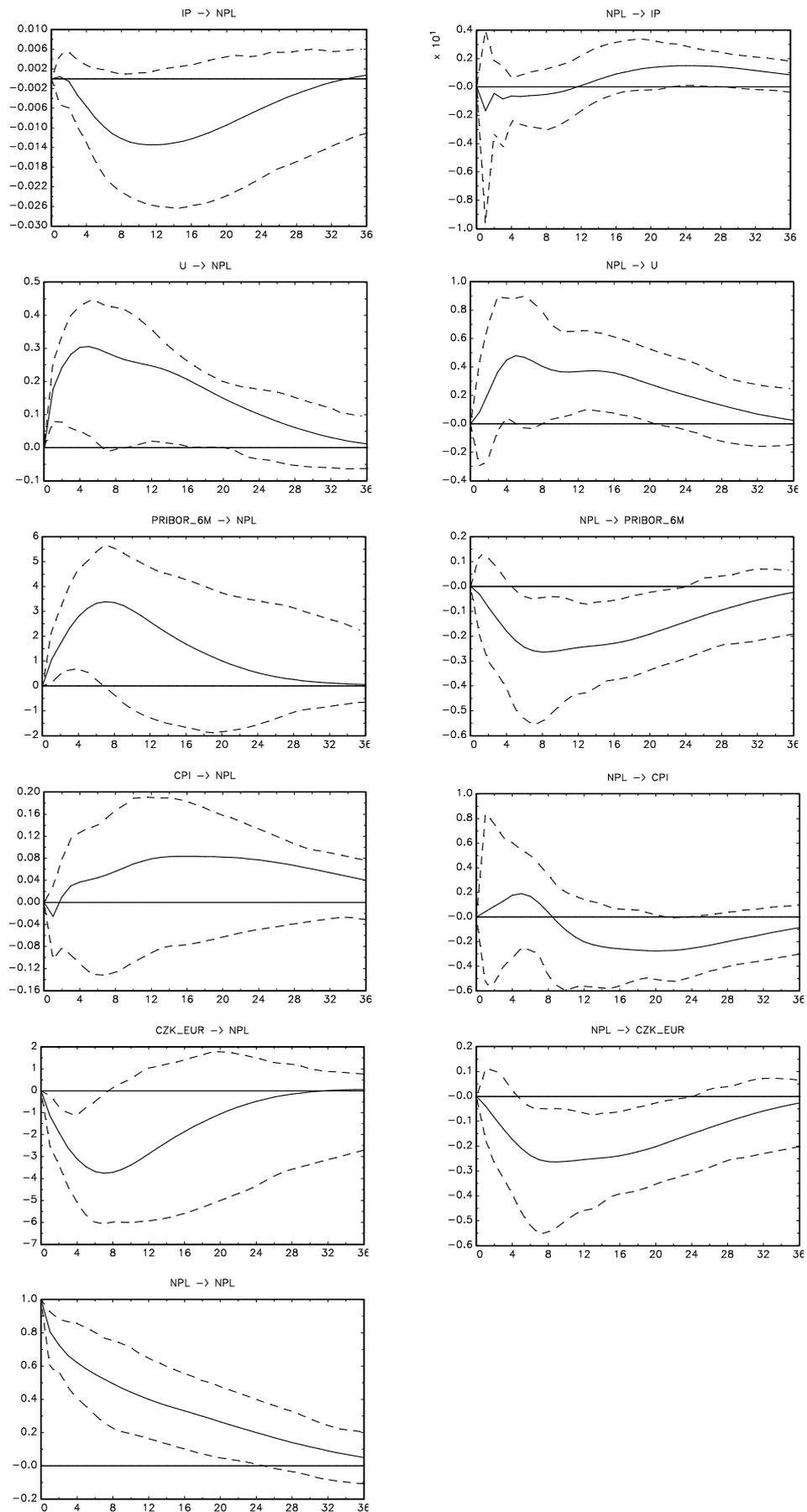
**Table 14: Test for stationarity of transformed time series (logarithm)**

VARIABLE	TEST STATISTICS
	ADF test
NPL_In	-0.6831
NPL_C_In	-1.0239
NPL_H_In	-1.0310
NPL_S_In	<b>-2.0363</b>
NPL_D_In	-0.9471
NPL_L_In	-0.6416
CZK_EUR_In	-1.0876
IP_In	-0.3324
CPI_In	3.6514
PRIBOR_In	-0.9459
U_In	-0.6145

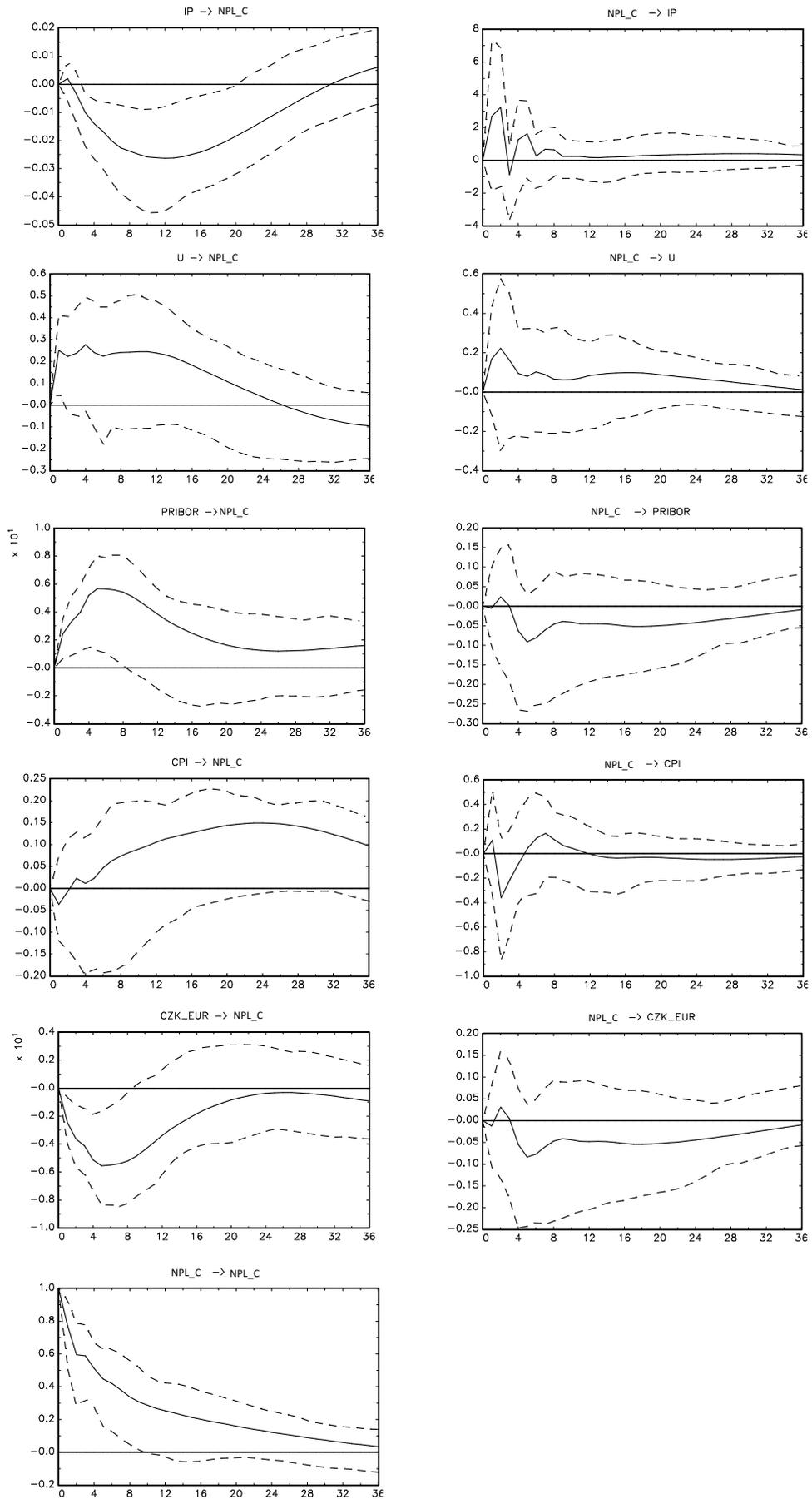
Source: CNB, author's calculation

The null hypothesis of the ADF test is the presence of unit root in the time series. This null hypothesis is rejected if the t-statistic is smaller than critical value -1.62 (10 % significance). When the null hypothesis is not rejected, the time series has a unit root and thus is non-stationary.

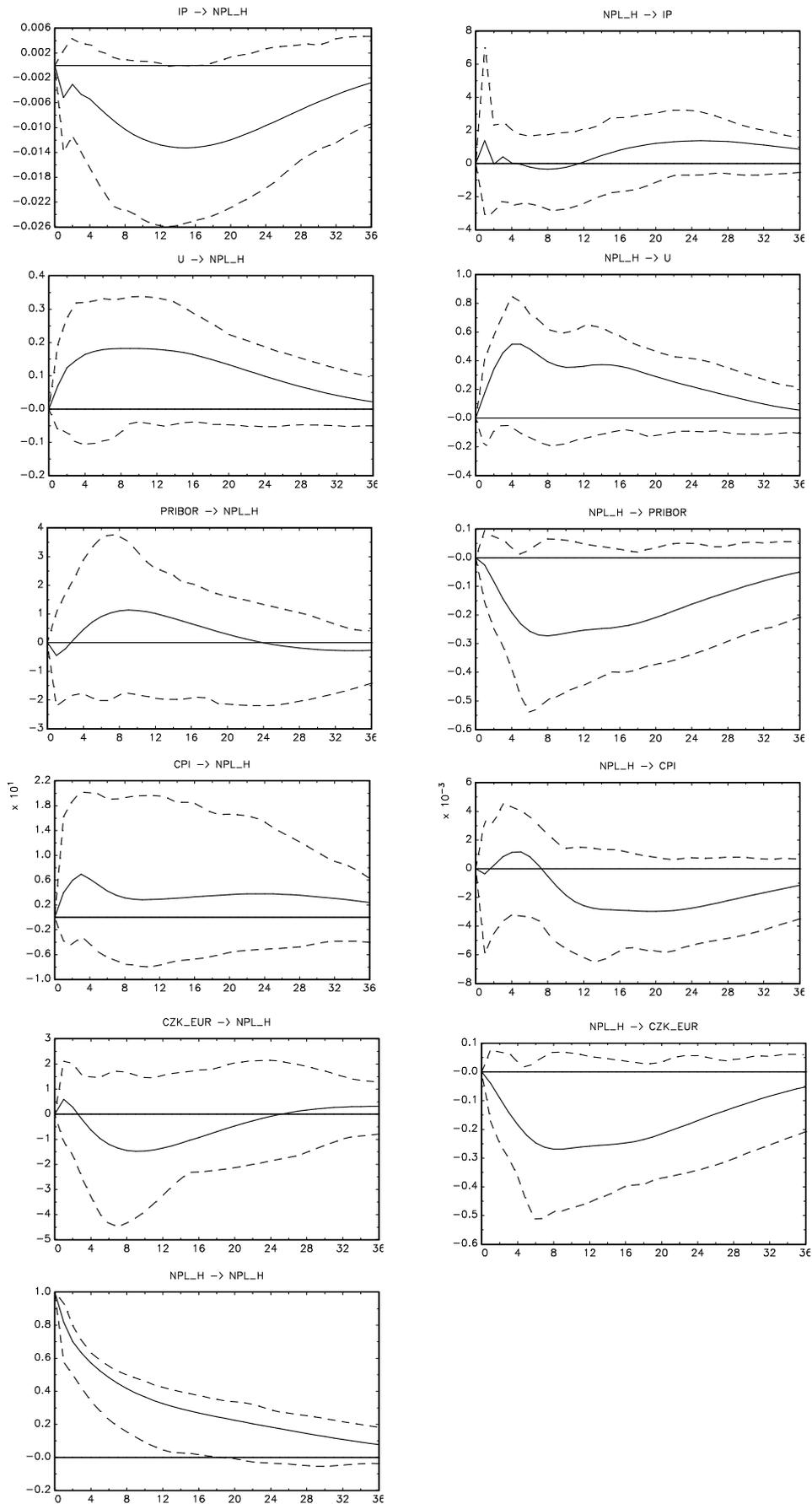
**Figure 3: Impulse response analysis of aggregate NPLs**



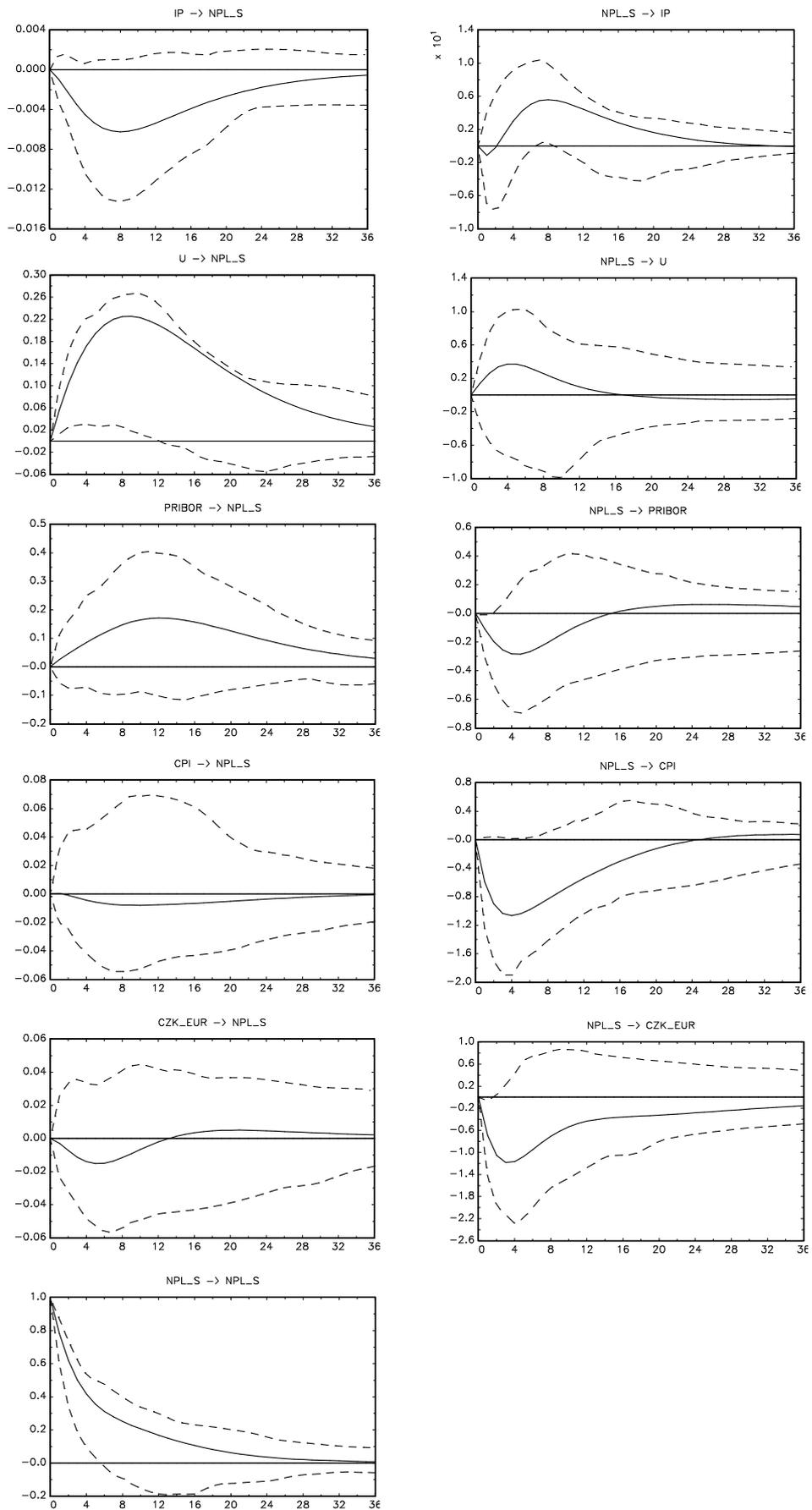
**Figure 4: Impulse response analysis of non-financial corporations NPLs**



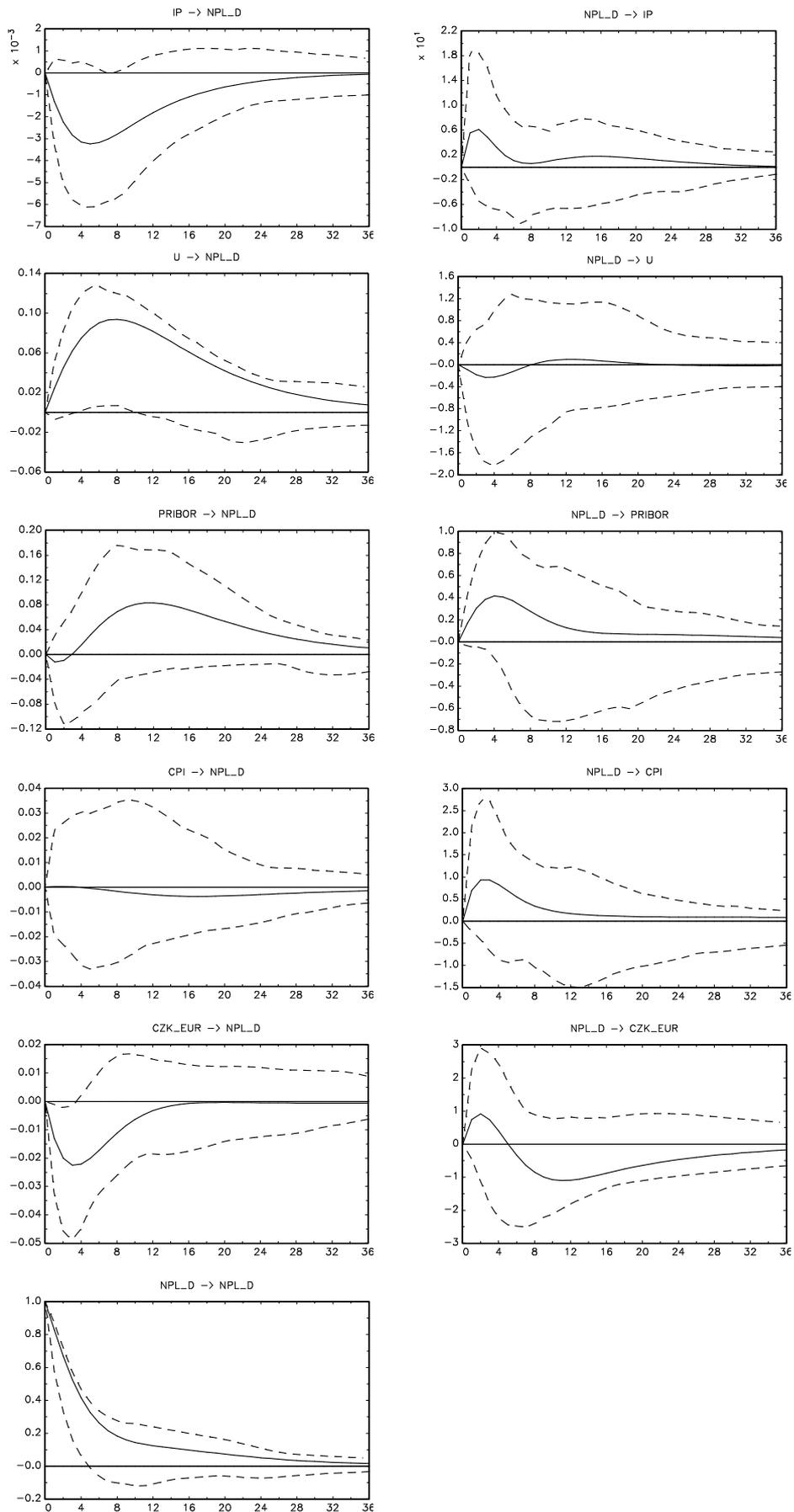
**Figure 5: Impulse response analysis of households NPLs**



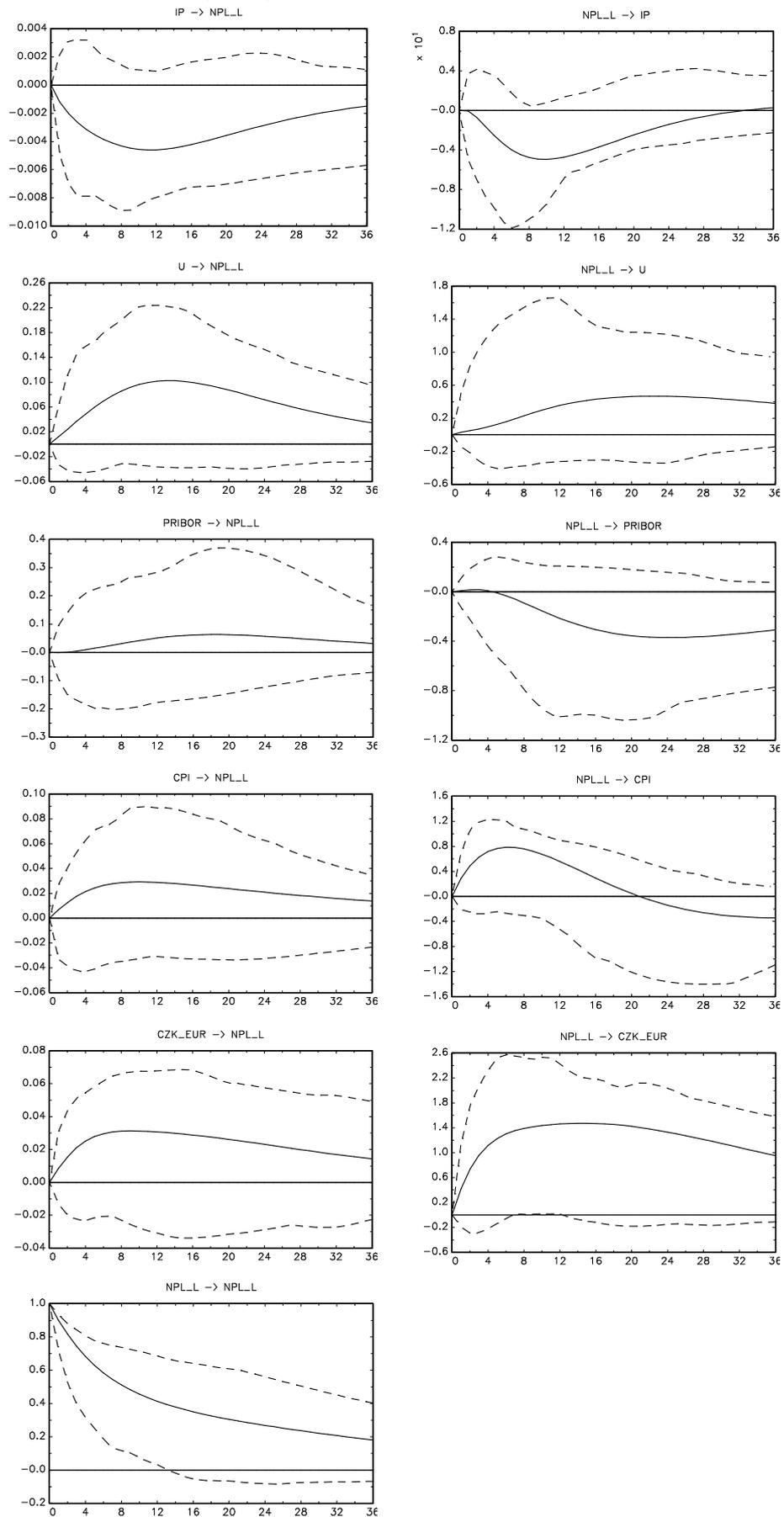
**Figure 6: Impulse response analysis of substandard NPLs**



**Figure 7: Impulse response analysis of doubtful NPLs**



**Figure 8: Impulse response analysis of loss NPLs**



**Table 15: Residual analysis of estimated VAR models**

VARIABLE	P-VALUES	
	Portmanteau test	LM test
Aggregate NPLs VAR(2) model	0.0001	0.0000
Non-financial corporations NPLs VAR(3) model	0.0034	0.0000
Households NPLs VAR(2) model	0.0000	0.0000
NPLs by failure VAR(1) model	0.0000	0.0000

Source: Author's calculation

The null hypothesis of the Portmanteau test is that residuals are not autocorrelated. If the p-value is smaller than 0.0500, then the residuals are autocorrelated on the 5% level of significance.

The null hypothesis of LM test is the noncorrelation of model residuals. If the p-value is smaller than 0.0500, then the residuals are autocorrelated on the 5% level of significance.