JEL Classification: E32, E44, E51, G21
Keywords: non-performing loans, macroeconomic determinants, bank-specific determinants, Czech, Generalised Method of Moments

Empirical Panel Analysis of Non-Performing Loans in the Czech Republic. What are their Determinants and How Strong is Their Impact on the Real Economy?*

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Abstract

This paper examines the link between determinants of non-performing loans (NPLs)and their macroeconomic impact in the Czech Republic, using two complementary approaches. First, we explore macroeconomic and bank-specific determinants of NPLs for a panel of 22 banks from the Czech Republic, using annual data for the period 2005-2016.For our analysis, we apply difference Generalised Method of Moments. Empirical results provide evidence that the most important macroeconomic factors influencing NPLs are GDP growth, inflation, and unemployment. As for the bank-specific determinants, we found that return on assets, return on equity growth of gross loans, and equity to total assets ratio, size of the banks and foreign ownership have an impact on the amount of NPLs. Second, we investigate the feedback between NPLs and its macroeconomic determinants. The results suggest that the real economy responds to NPLs, and the analysis also indicates that there are strong feedback effects from macroeconomic conditions, such as domestic credit to private sector, GDP growth, unemployment, and inflation, to NPLs.

1. Introduction

Information on the banks' loan quality is an important issue that has aroused the interest of the public as a user of banking services, the public as a potential investor in banks' equity, the banks' management, the financial markets, the banking supervisors and regulators, and academic circles. This interest has intensified significantly in the last two decades. Deregulation, technological change and the globalisation of goods and financial markets, the financial crisis of the 1990s, the global economic crisis of 2008–2009, and the European debt crisis of 2011–2012 have all had an impact on banks' loan quality.

One of the most common indicators used to identify the banks' loan quality is the ratio of non-performing loans (NPLs). An increase in this ratio may signal a deterioration in banking sector results (Mörttinen et al.,2005). Experience shows that a rapid build-up of NPLs plays a crucial role in banking crises (Demirgüç-Kuntand Enrica,1998).

* We thank the anonymous referees for insightful comments that benefited the paper.

This experience has been confirmed during the last few years, i.e., since the onset of the global financial crisis in 2007–2008, with the levels of NPLs having increased significantly across countries. In fact, according to analysts, the amount of NPLs is expected to increase dramatically in the coming years, affecting the liquidity and profitability of banks and, thereby, the financial stability of the banking systems (Makri et al.,2014).

There is a rapidly growing number of empirical studies that analyse factors that influence the NPLs (Blaschke and Jones, 2001; De Nicoló et al.,2003; Quagliariello, 2003; Hoggarth et al.,2005; Fofack, 2005; Babouček and Jančar, 2005; Espinoza and Prasad,2010; Klein,2013). All these authors have proposed a variety of different macroeconomic and institutional factors as possible determinants of NPLs.

Although, as we have seen, there are many studies that analyse the determinants of NPLs in many countries and regions, not many authors include the Czech banking sector in their research. Only six studies examine the determinants of NPL sin the Czech Republic (BaboučekandJančar2005; Podpiera and Weill, 2008; Jakubík, 2007; Kanyinji, 2014; Melecky et al., 2015). Almost all of these studies have certain similar characteristics. Namely, in these studies, some of the authors used only macroeconomic variables (Šulganová,2016; Babouček andJanèar,2005; Jakubík, 2007; Melecky et al., 2015).Also, all studies that have analysed determinants of NPLs in the Czech Republic have used aggregate data for the whole banking system of each country, and not disaggregated data (examination of individual data for each bank). The determinants of NPLs of Czech banks were analysed in five panel countries' studies – Skarica (2013), Klein (2013), Jakubík and Reininger (2013), Erdinc and Abazi (2014).

In this context, the Czech Republic may provide an interesting case study. The economy of the Czech Republic is one of wealthiest and the most stable among the Central and Eastern European (CEE) countries. It is one of the most developed transition economies, with a GDP per capita standing at 18,500 USD in 2016, which is 80 per cent of the EU average. Its population of 10.5 million inhabitants boasts a well-educated workforce –72 per cent of the population being of employable age, from 15 to 64 years –and a well-developed infrastructure. In 2017, it registered unemployment of approximately 3.4 per cent, the lowest of the 28 EU member states.

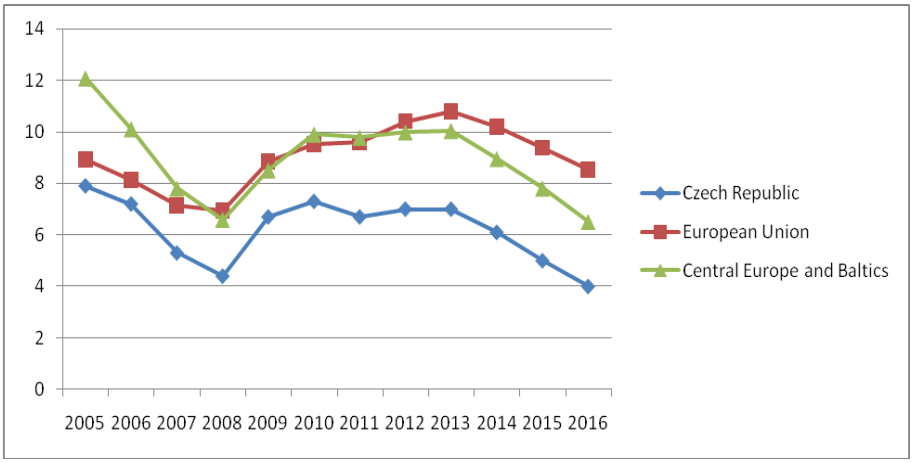
After joining the European Union in 2004, the Czech Republic economy has been closely integrated with the EU, and it is now very open to the outside world. According to the World Bank, trade accounted for 152% of GDP in 2017.At the same time, the Czech Republic is classified in first place among the CEE countries in terms of FDI stock and per capita inflows. Therefore, economic growth in the Czech Republic is strongly influenced both by export demand and by inflows of foreign direct investment (FDI). After experiencing robust growth of around 6% from 2005–2007, the Czech Republic felt the impact of the global economic slowdown in 2009. The economy contracted in real terms by 4.1% in 2009 as the country's main export markets fell into recession, leading to a significant drop in external demand. Then, the economy fell into another recession, due both to a slump in external demand and to the government's austerity measures. Nevertheless, the country recovered by the second half of 2013, with solid growth through the next few years (Figure 1).

Figure 1 Real GDP Growth in Czech Republic, European Union and Central Europe and the Baltics (2005-2016)

Source: World Bank.

The decline of real GDP in 2009 was followed by increasing unemployment. This decline particularly affected labour-intensive sectors, such as construction, manufacturing, and retail services. This effect was initially dampened somewhat, as some companies kept excess staff on the payroll until the depth of the crisis became evident. In 2010, the unemployment rate had risen to 7.2% (Figure 2). Unemployment began to decline sharply in early 2013.

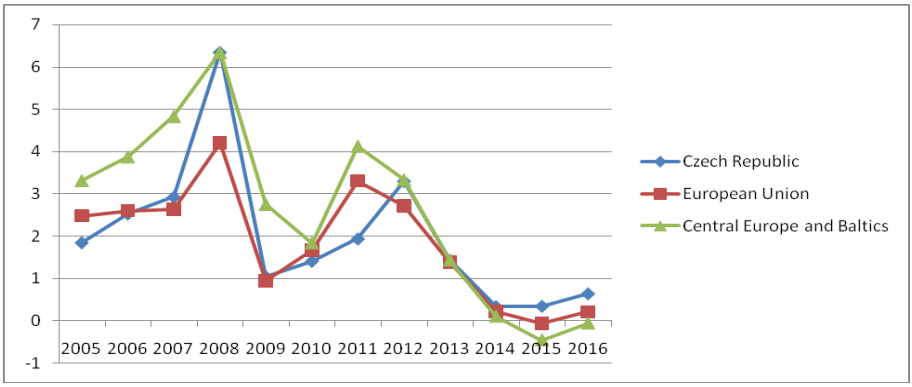
Figure 2 Unemployment in Czech Republic, European Union and Central Europe and the Baltics (2005-2016)



Source: World Bank.

The Czech economy can be, in the long run, characterised as a low-inflation economy. Until 2008, inflation moved in the interval from 2 to 2.8%. In 2008, it recorded an increase of 6.3%, which was caused by several factors – higher oil prices, increased demand for food from Asian countries, and the government reform of public finances. Another peak was reached during the second recession. In 2012, an increase in the rate of inflation was mainly driven by the growth of administrative measures, in particular by an increase of the reduced rate of value added tax. Since then the rate of inflation has been going down (see Figure 3).

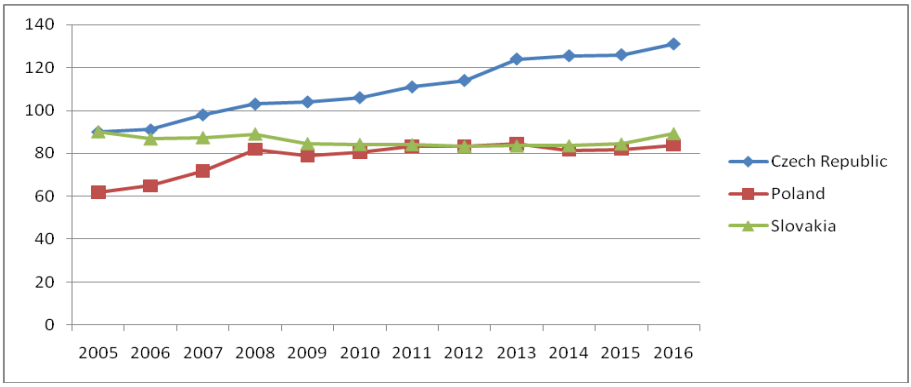
Figure 3 Inflation in Czech Republic, European Union and Central Europe and the Baltics (2005-2016)



Source: World Bank.

Banks' relative indicators reflect well the weight of the banking sector and its impact on the national economy (Levine et al., 2000). Studying the dependencies, (Kendall, 2009; Zhang et al., 2012) economists use relative indicators, such as Assets to GDP, or the depth of the financial sector (measured by the ratio of credit to GDP).

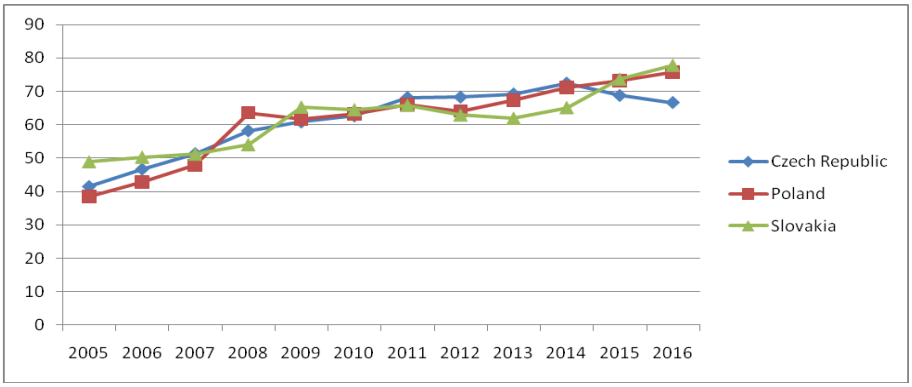
Figure 4 Bank Assets (As % of GDP) in Czech Republic, Poland and Slovakia (2005-2016)



Source: World Bank.

In developed countries, bank assets are at least two times higher than GDP, while this indicator is usually less than 100%for (post)transition countries. In Figure 4, we can see that bank assets as a share of GDP reached 131 % in the Czech Republic in 2016, which is 4.11 % more than in the previous year. Historically, bank assets as a share of GDP in the Czech Republic reached an all-time high of 131 % in 2016 and an all-time low of 86.3 % in 2004. To compare this to the Czech Republic's main peers, bank assets as a share of GDP amounted to 84.2% in Slovakia and 83.9 % in Poland in 2016. According to these criteria, the banking sector in the Czech Republic has achieved a solid result, and it has been ranked 14th within the group of 71 countries (Australia, Poland, Slovenia, and the United Kingdom, among others) as a share of GDP, 30 places above the position recorded 10 years ago.

Figure 5 Loans/GDP in Czech Republic, Poland and Slovakia (2005-2016)

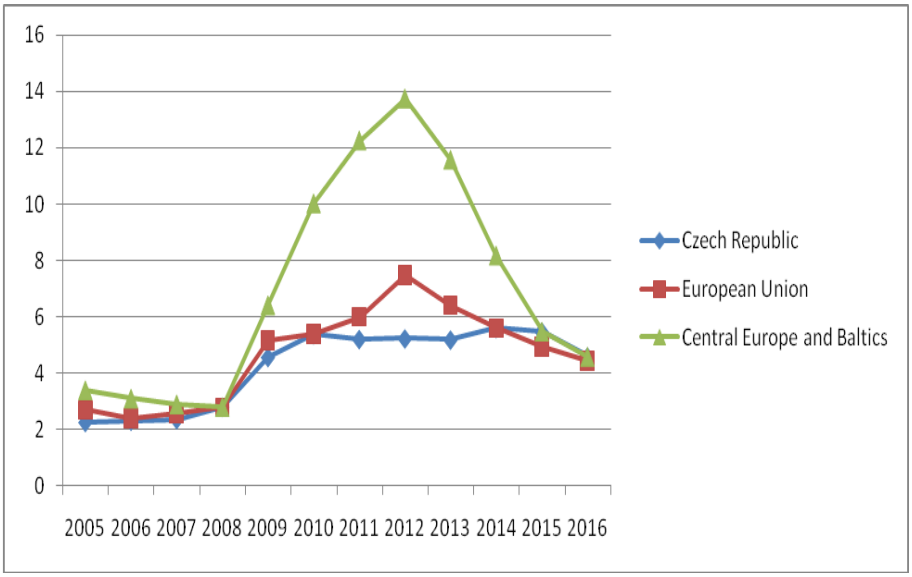


Source: World Bank.

The indicator loans/GDP ratio (depth of the financial sector) shows how much the banking sector contributes to economic growth. Usually, the increase of banks' loans leads to an increase in GDP growth (Kendall, 2009). As we can see from Figure 6, the loans/GDP ratio has been constantly increasing in the period 2005–2016. The only exceptions are 2009 and 2012, when there was a slight decrease of this indicator. Therefore, in the Czech Republic, the loans/GDP ratio and GDP have been growing almost constantly in the analysed period. This shows that the banking sector has supported the Czech Republic's economy.

As we can see from Figure 6, the ratio of NPLs has remained almost static over the years. The Czech banking sector was one of the few in the CEE region that did not need any exceptional measures during the global crisis. Even through 2008–2010, banks were liquid and profitable and reported capital ratios above requirements. In 2016, NPLs were approximately 4.5%, which is comparable to NPL levels in the EU, and they fell below 4 percent in 2017.

Figure 6 Growth of Non-Performing Loans in Czech Republic, European Union and Central Europe and the Baltics (2005-2016)



Source: World Bank.

Bearing in mind the aforementioned studies, this study offers some novelties. In this paper, according to the best knowledge of the authors, we use for the first time an unbalanced panel with a longer time series of data, from 2005 to 2016, for 22 banks in the Czech Republic (the banks are listed in Table A1 in the *Appendix*). The selected period is determined by the need to encompass a period of relative boom, (i.e., upswing of economy, downfall, economic crisis), as well as its recovery. As we previously mentioned, the exceptions are five studies, which analyse the Czech Republic in a panel data se but within the countries of Central, Eastern, and South-eastern Europe (CESEE), and not as a single country. Among the main advantages of panel data, compared to other types of data, is the fact that that the approach allows testing and adjustment of the assumptions that are implicit in cross-sectional analysis (Maddala,2001). The short time series, poor availability, and poor quality of the data have been the common reasons for refraining from analysis of the Czech banks. We have addressed these concerns by selecting a more recent time period, including the ups and downs of the economic and credit cycles, while making use of better data availability. We also employ a thorough data preparation process by eliminating inconsistencies, consolidating the existing information, and filling in the data gaps for banks with more significant market share by using the banks' public reports. The main advantage of balance-sheet models is that they are intuitive and easy to implement. According to Otašević (2013) the estimated coefficients can be used to assess the potential impact on the banking sector under hypothetical scenarios Furthermore, this researcher's focus on the bank level data eliminated the aggregation bias problem and allowed the researcher to disentangle the effects of various internal determinants (as controlled by the banks' management) on NPLs On the basis of the studies of Louzis

et al. (2010) and De Bock and Demyanets (2011), we have applied a dynamic panel data set using a difference Generalised Method of Moments (GMM) model to explain the determinants of NPLs in the Czech Republic.

The second objective of the study is to evaluate the impact of NPLs on the real economy through a vector auto-regression (VAR) analysis, which includes five endogenous variables (NPL, domestic credit to private sector, GDP growth, unemployment, and inflation) to assess how the increase in NPLs in the Czech Republic is likely to affect economic activity in the period ahead.

The structure of the paper is as follows. After the Introduction, Section 2 gives an overview of the literature on empirical findings relevant to the determinants for NPLs and on empirical evidence related to the feedback effects of NPLs on the real economy. The sources of the data employed, as well as the methodology, are presented in Section 3. Section 4 shows the empirical results of determinants, while Section 5 evaluates the feedback effects from NPLs on the real economy through a VAR analysis and discusses the results. Section 6 concludes the paper and gives policy recommendations.

2. Literature Review

In this section, we first overview the literature on empirical findings relevant to the determinants for NPLs, after which we overview the empirical literature related to the feedback effects of NPLs on the real economy.

2.1 Determinants of Non-Performing Loans

Research related to studying of determinants of banks' credit risk has gained importance in the last few years, especially after the financial crisis of 2007–2008 (Khemraj and Pasha,2009). However, when it comes to the modelling in this field, there is no universally accepted rule or principle to be used as a basic tool in all studies.

Nkusu (2011) classifies the literature on NPLs into three parts: the first part focuses on explaining the NPLs in credit institutions in the country, demonstrating the role of macroeconomic performance, quality of management, and political choices (Espinoza and Prasad, 2010; Louzis et al., 2010). The second part of the literature analyses the relationship between NPLs and macro-financial conditions (Castro, 2012; Klein, 2013; Louzis et al., 2010; Quagliarello,2007). The third part of the literature focuses on either explaining or predicting NPLs at the macro level. These aggregates may relate to either total loans in one economy (total debt) or certain types of loans (Nkusu, 2011; Rinaldi and Sanchis-Arellano, 2006).

Empirical results of the above-mentioned studies differ because of the differences in databases, time periods, and the different specifics of each of the countries. However, there are some common elements that allow categorising the determinants of banks' NPLs. NPLs are usually measured by the ratio of NPLs to total loans. The internal determinants usually include bank-specific variables, such as size of the bank, ownership of the banks, equity to total assets ratio, return on assets and growth of gross loans. The macroeconomic determinants include GDP growth, unemployment, exchange rate, interest rate, and inflation. Since the purpose of this paper is not to make a review of the empirical literature, we focus on the literature that is directly relevant to the present paper, following two main criteria. First, we give a

short summary of the empirical literature that emphasises the determinant of NPLs in the Czech Republic. Second, we cover papers that either have the same regional focus – countries from CESEE –to which the Czech Republic belongs, or that have analysed determinants of NPLs in the countries neighbouring the Czech Republic.

Babouček and Jančar (2005) used an unrestricted VAR model to empirically investigate how a set of macroeconomic variables (unemployment, exports, imports, real GDP growth, CPI, credit growth rate, and real effective exchange rate) of the Czech economy and the functioning of its credit channel affected the NPLs of the Czech banking system from 1993 to 2004. Their paper suggests a positive association of NPLs with CPI and unemployment. They also concluded that appreciation of the real effective exchange rate has no influence on NPLs, while growth in GDP slows the growth of NPLs. Melecky et al. (2015) reach the same conclusion, although they were using a different method (Bayesian estimation of instrumental variables) and a different period (1993–2014). Their results highlight the importance of economic growth, inflation, and unemployment as the most influential factors behind the soundness of the banking system. Unlike Babouček and Jančar (2005) they also find that real depreciation of the koruna is a response to the rising credit risk.

Analysing almost the same period as Babouček and Jančar (2005), Jakubík (2007) investigated the impact of a set of explanatory variables – real GDP, the loan to GDP ratio, real effective exchange rates, unemployment, real interest rate, and CPI – on NPLs in the Czech banking sector. Unlike Babouček and Jančar (2005), Jakubík used quarterly data, from Q1 1997 to Q3 2005, and used Merton's approach to analyse the data. The results from this study confirm the importance of macroeconomic determinants. Specifically, they suggest that the corporate default rate is significantly determined by growth in the loan to GDP ratio and real effective exchange rate appreciation, whereas, in the case of households, growth in interest rate and unemployment leads to a decline in NPLs.

Podpiera and Weill (2008) analysed the same period as did Babouček and Jančar (2005) but using quarterly data from 1994 to 2005. Unlike the aforementioned studies, they used different determinants (see in the Appendix). They conclude that there is strong evidence in favour of the bad management hypothesis and propose that regulatory authorities in emerging economies should focus on managerial performance to enhance the stability of the financial system (by reducing NPLs).

According to our findings the studies of Kanyinji (2014) and Šulgánová (2016) are among the latest that analyse the determinants of NPLs in the Czech Republic. Both studies used almost the same data. Kanyinji used monthly data from February 2002 to July 2014, applying a multivariate regression model, while Šulganová used quarterly data from 2002Q1 to 2015Q1, implementing a dynamic linear autoregressive distributed lag model. Kanyinji and Šulgánová both used macroeconomic, financial, and bank-specific determinants. Kanyinji's empirical results suggest that the spread of bank's lending and deposit rates, the M2 monetary aggregate, gross capital formation, gross external debt, and the Czech's Koruna to US dollar exchange rate significantly affect changes in NPLs. The results obtained by Šulgánová indicate that, from macroeconomic determinants of NPLs, the real economic growth affects NPLs after 8 and 10 quarters, while, in the case of inflation, the estimated coefficient has a value of 0.05 and t affects NPLs after 5 quarters. According to empirical results, rising

unemployment seems to have adverse effects on NPLs after 2 years. Changes in the exchange rate were approximated by changes in the nominal exchange rate of the Czech koruna to euro.

According to our best knowledge, two relevant studies have analysed NPLs in countries neighbouring the Czech Republic; these are Glogowski (2008), for Poland and Zeman and Jurča (2008), for Slovakia. Both studies have analysed macroeconomic determinants of NPLs. The results from both studies indicate that macroeconomic determinants have a significant impact on NPLs (for details see Appendix). Fainstein and Novikov (2011) reach the same conclusion in a study of the banking systems of three Baltic States (Estonia, Latvia, and Lithuania), using a different methodology. Their results highlight the importance of economic growth and interest rates as the most influential factors behind the soundness of the banking

From the panel studies who have analysed CESEE countries we separate out three studies: Klein (2013), Jakubík and Reininger (2013), and Škarica (2014). Jakubík and Reininger and Škarica analysed only macroeconomic determinants, while Klein analysed macroeconomic, global, and bank-specific determinants. Although the methodologies used by Jakubík and Reininger and Škarica differed from each other, the results from both studies show that economic growth is the main driver that is negatively correlated with NPL development. Also, Klein shows that real GDP growth is a significant determinant of NPLs. His results indicate that bank-specific determinants also have an impact on NPLs (see *Appendix* in Table A2).

2.2 Feedback Effects

According to Klein (2013) the impact of the real economy on NPLs is explained by weakening the borrowers' capacity to repay their debt, while the feedback from NPLs to the real economy is often identified through the credit supply channel. Mohd et al. (2010), identify two additional mechanisms: the high costs associated with managing high NPLs and the lower capital that results from provisioning. Both contribute to lower credit supply and, therefore, may have implications for economic activity. The feedback effects from NPLs to the real economy may also work through non-credit supply channels. According to Myers (1977), debt overhang can discourage companies from investing in new projects, since future profits will be shared with the banks. Several studies have examined the feedback effects from the banking system to the real economy from a cross-country perspective.

Nkusu (2011), using the panel vector autoregressive (PVAR) model, analysed 26 advanced economies in the period 1998–2009. He found that adverse shocks to asset prices, macroeconomic performance, and credit to the private sector led to a worsening loan quality. He also found that higher NPLs led to a decline in house prices, credit-to-GDP ratio, and GDP growth.

De Bock and Demyanets (2012), using aggregate macroeconomic and credit indicators, analysed the determinants of bank asset quality in 25 emerging countries during 1996–2010. They found that economic activity slows down when NPLs increase, while the exchange rate tends to depreciate.

Klein (2013) analysed 16 CESEE economies in the period 1998–2011. He found that an increase in NPLs is a response to macroeconomic conditions, such as GDP growth. Also, his results indicate that there are feedback effects from the banking

system on the real economy. Specifically, increase in NPLs has a significant impact on real GDP growth, unemployment, inflation and credit as a share of GDP.

Kjosevski and Petkovski (2017) analysed the feedback effects from the banking sectors of Baltic countries on the real economy in the period 2005–2014, using PVAR methodology. Their results suggest that the real economy responds to NPLs and that there are strong feedback effects from macroeconomic conditions, such as domestic credit to private sector, GDP growth, unemployment, and inflation to NPLs.

3. Data and Methodology

This section identifies the sources of our data, presents the data, and describes the regression models that we used to investigate the effects of internal and external factors on NPLs.

3.1 Data Source and Sample Characteristics

In our study, we used an unbalanced panel with 22 banks in the Czech Republic. The data are based on annual frequency for 2005–2014. According to Rinaldi and Sanchis-Arellano (2006), unbalanced panel data include more observations and their results are less dependent on a particular period.

Data used in the empirical analysis came from two main sources. The data for the bank-specific determinants (equity to total assets ratio, ROA, number of employers, ownership, and growth of gross loans) were collected from the Bankscope database of Bureau van Dijk. The financial information was derived from balance sheets, income statements, and notes from the annual reports. Bankscope had up to 16 years' worth of data available, which covered the total sample period. Furthermore, data for the size variable were also obtained from Bankscope. The data for macroeconomic determinants – unemployment, percentage of total labour force, GDP growth (annual percentage), inflation, consumer prices (annual percentage), and domestic credit to private sector (percentage of GDP) –were obtained from the World Development Indicators database. The selection of the variables included in the paper is inspired by the previously reviewed literature, where selected determinants were usually used. Also, we used selected determinants due to availability of the data.

Before attempting to identify potential internal and external determinants of NPLs, it is necessary to identify the dependent determinant. In the literature to date there is no internationally harmonised definition that has been applied in all or most countries of the world for a considerable period of time. Rather, efforts towards harmonising NPL definitions have been gathering steam only in recent years, in the wake of the financial and economic crisis (Jakubík andReininger,2013). In this context, it is worth mentioning that Bankscope reports the level of "impaired loans", which may be different than the official classification of NPLs. "Impaired loans" is an accounting concept, which reflects cases in which it is probable that the creditor will not be able to collect the full amount that is specified in the loan agreement, while "NPL" is a regulatory concept, which primarily reflects loans that are more than 90 days past their due date (Report of the Working Group on NPLs in CESEE, 2012). Acknowledging these differences, we follow Klein (2013) and treat "impaired loans" as NPLs. In this analysis, our dependent variable will be the logit transformation of the ratio of impaired (NPLs) to total (gross) loans, as this transformation ensures that the dependent variable

spans the interval (-∞;+∞) (as opposed to between 0 and 1) and is distributed symmetrically (Salas and Saurina 2002; Espinoza and Prasad, 2010).

Within our presentation of the independent determinants, we considered both bank-specific determinants and the macroeconomic characteristics. Factors that we used as control determinants, which may explain the NPLs of banks, included the following (*Appendix* Table A3):

- Macroeconomic determinants: Real GDP growth – GDPG; Inflation – INF; Unemployment – UN; Domestic credit to private sector (% of GDP) – DCPS;
- Bank-specific determinants: Ratio of equity to total assets – ETA; Return on assets –ROA; Number of employers as a measure of bank's size – SIZE; Ownership of the banks – Domestic ownership – DOM, Foreign ownership – FOR; Growth of gross loans – GGL;

Macroeconomic Determinants

At the core of all previously mentioned studies, the variables related to GDP are the main macroeconomic determinants of NPLs. In this context, several variations of this determinant, such as the annual growth rate of real GDP, the production gap, and the growth of income per capita, are well known in the literature. However, the real GDP growth rate is by far the most common macroeconomic determinant used (e.g., Babouček and Jančar 2005; Jimenez and Saurina,2005; Quagliarello, 2007; Jakubík, 2007; Marcuccia nd Quagliariello,2008, 2009; Castro,2012; Nkusu, 2011; Klein, 2013; Beck et al.,2013). Hence, we also include the annual growth rate of real GDP in our analysis. Thus, we want to examine the effect of the prevailing economic cycle on the credit risk. According to Nkusu (2011), the growing economy associated with the growth of the general level of income and reduced financial stress and, hence, GDP growth, should be negatively correlated with NPLs.

To reflect the price stability in the model, we follow Kavkler and Festic (2010) and Donath et al. (2014) and include the inflation as the general consumer prices' rate; however, its impact on NPLs is not clear. On the one hand, higher inflation can make debt servicing easier by reducing the real value of outstanding loans, but, on the other hand, it can also weaken borrowers' ability to service debt by reducing their real income. Gunsel (2008) and Rinaldi and Sanchis-Arellano (2006) find a positive correlation between the inflation rate and NPLs in North Cyprus and Euro Zone countries. Also, in the studies by Kavkler and Festic and Donath et al., the results indicate that inflation was a significant and positive determinant of NPL in the Baltic States. Babouček and Jančar (2005) also found a positive correlation. Conversely, Sofoklis and Nikolaidu (2011) found a negative correlation between inflation and credit risk in the Tunisian and Romanian banking sectors. Bofondi and Ropele (2011), in the case of the Slovenian and Italian banking systems, did not find any influence of inflation on credit risk. Therefore, the relationship between inflation and NPLs may be ambiguous.

Domestic credit to the private sector (% of GDP) is a macroeconomic variable included as a determinant that shows the level of indebtedness of the private sector in the economy. High levels of debt make debtors much more vulnerable to adverse shocks that directly affect their income and, therefore, their ability to service their obligations (Pesola, 2005; Nkusu, 2011). According to Pesola (2001), instability in the

financial system becomes visible when the level of indebtedness is growing continuously, and then unfavourable shocks are more strongly experienced. Hence, we expect a positive correlation with the NPLs.

Regarding unemployment, it is rational to suppose that an increase in unemployment should influence negatively the cash flow streams of households and increase the debt burden. With regards to firms, increases in unemployment may signal a decrease in production as a consequence of a drop in effective demand. This may lead to a decrease in revenues and a fragile debt condition. Several empirical studies have investigated the relationship between unemployment and NPLs, and they have found it to be positive (Babouček and Jančar 2005, 2005; Jakubík, 2007; Bofondi and Ropele, 2011; Godlewski, 2008; Makri et al., 2014). Therefore, we expect that an increase in unemployment will lead to an increase in NPLs.

Bank-Specific Determinants

The share of equity in total assets is an important determinant of NPLs. According to the "moral hazard" hypothesis, discussed by Keeton and Morris (1987), banks with relatively low capital respond to moral hazard incentives by increasing the riskiness of their loan portfolio, which, in turn, results in higher NPLs, on average, in the future. In this case, the connection with NPLs is negative (Berger and DeYoung, 1997; Salas and Saurina,2002; Klein, 2013). On the other hand, according to Quagliarello (2007), as the risk appetite of the bank is higher, the greater is the share of capital to existing shareholders invested in the bank, in order to convince other shareholders to invest in and support the bank. And, hence, the connection can be positive. A positive connection was discovered by Rajan and Dahl (2003), Boudriga et al. (2009), and Espinoza and Prasad (2010). With these determinants, according to empirical research and theory, we expected an ambiguous correlation with NPLs.

Several authors have considered the influence of banks' past performance measured by profitability (ROA) on future problem loans ratios. It is expected that banks that are more profitable will have lower levels of NPLs (Swamy, 2012), and, hence, the connection is negative. According to Boudriga et al. (2009), inefficient banks with lower profitability are tempted to resort to less reliable and risky placements to increase profitability and/or meet the demands of regulatory authorities. The negative correlation between bank performance (profitability) and credit risk is confirmed by Godlewski (2004). In this area again, we will return to Berger and DeYoung (1997), who explain the second hypothesis of "bad management" by ROA. Specifically, poor performance of the company can be linked to characteristics of managers that result in decreased profitability (expressed by the low ROA or equity). This further motivates managers to lend to riskier borrowers, which, in the end, leads to growth of NPLs. Apart from these factors, we will follow (Makri et al.,2014) and examine ROA as a measure of profitability Banks' profitability is linked to the risk-taking behaviour of banks. As highly profitable banks have fewer incentives to engage in high-risk activities, ROA is expected to display a negative sign.

The size of the bank is the next determinant that will be included in our model. According to Scildback (2017), there are several indicators that determine the size of a bank. These include revenue, equity capital, total assets, net income, number of customers, number of employees, and number of branches. For the purposes of our

study, we will use the total number of employees in each of the banks. We choose the number of employees because, from the consumer's perspective, more of each of the other attributes is likely to be a good thing. Branch density and geographic diversification embody the size of the overall bank network and, therefore, the convenience to the consumer. The number of employees per branch captures some of the quality provided at the branch, since the larger the number of branch staff, the shorter the waiting times and the greater the availability of valued human interaction. Bearing this in mind. bank size could reflect bank strength and ability to cope with the problem of information asymmetry, resulting in a lower level of NPLs. Conversely, smaller banks have fewer resources to realise credit analysis efficiently. Moreover, bank size may be an indicator of diversification opportunities, an increase of which should lower bank risk. Consequently, we expect a negative relationship between bank size and NPLs.

Several studies document that ownership of the bank is associated with NPLs. Levine (1996) suggests that foreign shareholding improves both the supply and the quality of financial services, enhances the overall supervisory environment, and eases the access to international financial markets. Furthermore, foreign ownership improves human capital through the presence of foreign managers who bring better skills and technologies, particularly in developing countries (Lensink and Hermes, 2004). This international expertise will also lead to improved local competencies through training and knowledge transfer. Empirically, Barth et al. (2002) find a negative effect of foreign ownership on NPLs in a cross-countries' analysis. They highlight that foreign banks raise loan quality in a country and may lead to improvement in domestic banks' credit quality

The credit policy of the bank plays an essential role in determining the subsequent levels of NPLs. To maximise the short-run benefits, managers seek to rapidly expand credit activities and may, hence, take inadequate credit exposures (Castro, 2012; Beck et al., 2013; Klein, 2013). Several studies, such as Dash and Kabra (2010) indicate the presence of a positive correlation between credit growth and NPLs. However, other studies, such as Salas and Saurina (2002), Quagliarello (2007) Boudriga et al. (2009), Dash and Kabra (2010), and Swamy (2012) have found a negative correlation between these two determinants, which may be the result of some specificity, regulation, and background in different banking systems that make banks more conservative and cautious in the spread of credit supply (Quagliarello,2007). Therefore, the effect of individual credit growth can be in both directions.[1]

Table 1 presents descriptive statistics for the determinants involved in the regression model. Key figures, including mean, standard deviation, and minimum and maximum values, are reported. This table gives an overall description about data used in the model and serves as a data screening tool to spot unreasonable figures. According to Table 1, there were observations missing in all macroeconomic and bank specific determinants. This is mainly due to unreported figures in annual financial reports from some banks and a lack of macroeconomic data for the Czech Republic. Also, from Table 1, we can see that NPLs variable have mean value of 6.664, which

[1] In *Appendix* (Table A4) we have provided a list of variables and studies where are utilized.

goes to the maximum of 53.290 and minimum of 0.110. The high maximum value is due to the period when the data is collected, which covers the years of the world economic and financial crisis, the effects of which spilled over the Czech banking system, with some banks being affected more than others. Furthermore, from Table 1 we can see that ROA and GGL have negative values. These results also confirm the fact that banks in the Czech Republic were affected by the global economic crisis. From the macroeconomics variables, only GDPG has a negative value and only GDPG has significant variations between the minimum and the maximum. The other macroeconomic variables do not have very large oscillations in their values during the period analysed.

One of the assumptions of the linear regression model is that there is no multicollinearity among the independent (explanatory) determinants. If correlation between explanatory determinants is high, estimation of the regression coefficients is possible, but with large standard errors and, as a result, the population values of the coefficients cannot be estimated precisely. According to Kennedy (2008) multicollinearity is a problem when the correlation is above 0.80, which was not the case here. The correlation among the selected variables is broadly in line with economic theory: NPLs were negatively correlated with GDP growth and the change in credit to GDP ratio and positively correlated with the change of unemployment and inflation.

The matrix shows that, in general, the correlation between the other determinants was not strong, suggesting that multicollinearity problems were either not severe or non-existent.

Table 1 Descriptive Statistics

	NPL	*GDPG*	*DCPS*	*INF*	*UN*	*ROA*	*GGL*	*ETA*	*SIZE*	*DOM*	*FOR*
Mean	6.66451	2.63202	45.01662	2.00815	6.29583	0.66473	20.96689	10.63890	1564.7	100	89.62
Median	4.72000	2.71304	47.72774	1.64045	6.68500	0.81200	11.48000	8.26000	330	100	99
Maximum	53.29000	6.87654	52.31169	6.35099	7.93000	2.06900	193.44000	98.66000	10760	100	100
Minimum	0.11000	-4.84179	29.47205	0.33719	4.39000	-8.41300	-20.75000	0.83000	31	100	53.2
Std. Dev.	6.79674	3.24996	6.97405	1.60296	1.05737	1.24771	25.94562	9.98969	2.99579	0	1.52757
Obser	178	242	242	242	242	212	198	223	242	84	180

Table 2 Correlation Matrix

	NPL	*ETA*	*ROA*	*GGL*	*SIZE*	*FOR*	*DOM*	*GDPG*	*UN*	*INF*	*DCPS*
NPL	1	0.16379	0.14889	-0.54483	0.49000	0.02311	-0.07138	-0.81379	0.67918	-0.06989	0.20336
ETA	0.16379	1	0.46269	0.10753	0.32511	-0.03917	0.08430	-0.09449	-0.40856	0.67341	-0.18799
ROA	0.14889	0.46269	1	0.11531	0.04343	-0.01705	0.40510	-0.00355	-0.02882	0.64799	-0.33387
GGL	-0.54483	0.10753	0.11531	1	-0.13228	-0.00319	0.49721	0.69426	-0.15835	0.47291	-0.85084
SIZE	0.49000	0.32511	0.04343	-0.13228	1	-0.01260	-0.05116	-0.26173	0.42770	0.24182	0.13845
FOR	0.02311	-0.03917	-0.01705	-0.00319	-0.01260	1	-0.03679	-0.01310	0.03202	-0.01009	0.01350
DOM	-0.07138	0.08430	0.40510	0.49721	-0.05116	-0.03679	1	0.18151	-0.25903	0.43836	-0.69627
GDPG	-0.81379	-0.09449	-0.00355	0.69426	-0.26173	-0.01310	0.18151	1	-0.36815	0.08833	-0.41592
UN	0.67918	-0.40856	-0.02882	-0.15835	0.42770	0.03202	-0.25903	-0.36815	1	-0.30090	-0.07616
INF	-0.06989	0.67341	0.64797	0.47291	0.24182	-0.01009	0.43836	0.08833	-0.30090	1	-0.40930
DCPS	0.20336	-0.18799	-0.33387	-0.85084	0.13845	0.01350	-0.69627	-0.41592	-0.07616	-0.40930	1

Source: Autor's calculations.

3.2 Methodology

In this study, to analyse the determinants that affected the NPLs in the Czech Republic, we conducted panel data analysis on a sample of 22 banks from 2005 to 2016. Hsiao (1986) listed several advantages of panel data compared to other types of data. Specifically, panel data give more information, more variability, less collinearity among other variables, a greater degree of freedom, and more efficiency. Also, panel data can not only capture and measure effects that are not detectable in cross-section time-series analysis but also provide a platform on which to test more complicated behavioural models.

Rinaldi and Sanchis-Arellano (2006) and Louzis and Metaxas (2012) suggested that the NPL ratio may follow a unit root process hinting at a possible cointegrating relation, we performed a preliminary panel unit root test. According to Campbell and Perron (1991), standard unit root tests can have low power against stationary alternatives for important cases. As an alternative, in this paper, we tested for stationarity of the panel, using Maddala and Wu Fisher tests for unbalanced panels.

To provide consistent and unbiased results, in our preliminary stage we implemented four alternative estimation techniques.[2]

Next, we follow Salas and Saurina (2002), Louzis and Metaxas (2012) and Klein (2013) and assume that the share of NPLs in the loan portfolio is closely related to its values in previous periods, because NPLs cannot be immediately written off and may remain on banks' balance sheets for up to several years. In other words, the NPL ratio shows a tendency to persist over time. To test the persistence of NPLs, we use the previous year's NPLs' rate (NPLt-1) as an independent variable, and we expect a positive correlation. The inclusion of lagged terms of the dependent variable on the right-hand side of the equation violates the exogeneity assumption for regressors. These dynamic relations are given by the following equation, and our first econometric model is expressed as follows:

$$y_{it} = \alpha_i y_{i,t-1} + \alpha_i BANK_{i,t} + \alpha_i MAC_{i,t} + \varepsilon_{it} \quad (1)$$

where y_{it} denotes the aggregate NPLs to total gross loans, *BANK*denotes the bank-specific variables, and *MAC*denotes the macroeconomic factors. Note that *i* corresponds to the examined bank of the sample and *t* to the year, while ε denotes the error term.

Due to the shortcomings of the previous three models, and to provide consistent and unbiased results, we implement the difference GMM estimation, which is based on first differences and was introduced by Arellano andBond (1991). The first-differentiated equation is then estimated by using lags of the potential predetermined and endogenous explanatory variables. These lags are used as instrumental variables in the transformed equation and serve as proxy for the true observations. Hence, the difference GMM estimator eliminates the problem of autocorrelation and endogeneity by removing the fixed effect in the error item and by using lags of the explanatory variables as instruments.

[2] The results of ordinary least squares, fixed, and random effects models are available upon request. Our baseline choice is difference GMM, and we treat the remaining models only as robustness checks.

Arellano and Bond (1991) proposed one- and two-step estimators. In this paper, we use the one-step GMM estimator, since Monte Carlo studies have found that this estimator outperforms the two-step estimator both in terms of producing a smaller bias and a smaller standard deviation **(**Judson and Owen, 1999).

Furthermore, we follow Beck et al. (2013) and Makri et al. (2014) and consider the macroeconomic variables as being strictly exogenous; we also treat the bank-specific regressors as weakly exogenous and use one lag for both bank-specific and macroeconomic regressors, targeting to capture the dynamics of explanatory variables over the previous year. Therefore, our next econometric model is expressed as follows:

$$y_{it} = \alpha_i y_{i,t-1} + \alpha_i BANK_{i,t_{-1}} + \alpha_i MAC_{i,t} + \varepsilon_{it_{-1}} \quad (2)$$

The validity of chosen instruments for parameters' estimation can be tested using the Hansen test. Accepting the null hypothesis means that the chosen instruments are valid. The second group of tests refers to tests of serial correlations in the differenced residuals – [first-order (AR1) and second-order (AR2) serial correlation]. The first-order autocorrelation in the differenced residuals does not imply that the estimates are inconsistent (Arellano andBond,1991). However, the second-order autocorrelation would imply that the estimates are inconsistent. We also report Wald tests of the joint significance of both the coefficients and the dummies, which validates the use of such determinants in our equation.

4. Empirical Results

In this section, we begin with analysis of the results of the panel unit root tests. The results of this test are presented in Table A2. The unit root analysis, according to ADF and PP Fisher-type tests, indicates that null hypothesis of non-stationarity can be rejected for all our determinants, and we treat all them as non-stationary variables at their levels.

Table 3 Panel Unit Root Tests

Test variables	*Stationarity*	*ADF-Fisher Chi square*	*PP-Fisher Chi square*
NPL	Level	99.340***	117.431***
GDPG	Level	205.422***	164.631***
INF	Level	100.287***	98.021***
UN	Level	86.274***	28.741*
DCPS	Level	42.706*	14.506*
NLTA	Level	68.220*	101.425***
ETA	Level	44.906*	98.560***
ROA	Level	62.325*	67.690***
SIZE	Level	34.584*	68.426***
DOM	Level	52.472*	78.547***
FOR	Level	72.454**	81.236***

Source: Autor's calculations.
Notes: ***, **, * denote statistical significance at the 1, 5, 10 percent level respectively.

Next, in Table A3, we present the results of the GMM model by including a lagged dependent variable and lagged (one lag) for macroeconomic regressors.

Notwithstanding these issues, several specifications have been tried with different combinations of macro and bank-specific variables. The variables presented

in Table 4 turned consistently significant in almost all regressions, and this is why we report only these results. In addition, the signs and significance of the variables are almost identical, regardless of the estimation method, confirming the robustness of our results.

Table 4 Estimation Results

Variables	*GMM*	
	Coefficient	*Standard Error*
C	0.653**	0.034
NPL(-1)	0.408***	0.073
GDPG	-0.119	0.019
DCPS	0.061	0.031
INF	-0.080**	0.011
UN		
ROA	-0.015*	0.073
GGL(-1)	0.012***	0.040
SIZE	-0.037	0.054
FOR	-0.004	0.086
Number of observations	190	
Hansen test (p-value)	0.52	
Test for AR(1) errors	0.085	
Test for AR(2) errors	0.684	

Source: Autor's calculations.
*Notes: :****, **, * denote statistical significance at the 1, 5, 10 percent level respectively.

The results presented in Table 4 broadly confirm that both bank-level and macroeconomic factors play a role in affecting the banks' asset quality. The models seem to fit the panel data reasonably well, having fairly stable coefficients. The Hansen test shows that the chosen instruments are valid (with a*p*-value of 0.43). The estimator ensures efficiency and consistency, provided that the residuals do not show serial correlation of order two (even though the equations indicate that negative first order autocorrelation is present, this does not imply that the estimates are inconsistent). Inconsistency would be implied if second-order autocorrelation was present (Arellano andBond,1991), but this case is rejected by the test for AR (2) errors.

The high positive and statistical significances of the lagged dependent variable confirm the dynamic character of the model's specification. The values of lagged NPLs between 0.63 suggest that a shock to NPLs is likely to have a prolonged effect on the banking system. These results are similar to those found by previous studies, as in Jimenez and Saurina (2005) where the lagged NPLs' value was 0.55 and Erdinc and Abazi (2014), where the values of lagged NPLs were between 0.52 and 0.54.

Starting with macroeconomic indicators, we found evidence in both models that growth in GDP has a significant and negative impact on NPLs. The results provide evidence that change in economic activity affects the NPLs with a certain delay, but, usually, when analysed on an annual basis, the impact is attributed to the contemporaneous growth rate of real GDP (Beck et al.,2013), as is the case with our GMM model. These results are consistent with the results of Louzis et al. (2010), where values of GDP growth were between 0.25 and 0.46, (Nkusu, 2011; Klein, 2013; Makri et al.,2014).

Furthermore, based on our estimations, our results suggest a negative relationship between inflation and NPLs. The negative results could be explained by the fact that higher inflation reduces the real value of debt and, thus, facilitates the debtor in repayment of debt. In this context, inflation influences both real interest rates, and, thus, in the broadest sense, economic activity. In Erdinc and Abazi (2014) the values of inflation were between -0.28 and -0.051), while, in Makri et al (2014), the values were between -0.059 and 0.081.

As we expected, unemployment has a positive and statistically significant impact on NPLs. Specifically, when a person loses his source of income he cannot repay his loan, which contributes to higher NPLs. Similarly, regarding enterprises, the rise of unemployment could lead to a decline in production due to the fall in effective demand. Also, as we used annual data, the significant impact of unemployment NPLs was in the current period, because, according to Louzis et al. (2010), a rise of unemployment affects households' ability to service their debts, and firms cut their labour costs with a three-month time delay. Our results are consistent with the findings of Nkusu (2011), where the results were between 0.20 and 0.24,

The effects of the other bank-specific determinants are in line with expectations. The coefficients of ROA indicate that profitability has a significant impact on NPLs. The negative relationship confirms the hypothesis that less profitable banks, in general, take a higher credit risk, which is consistent with the empirical results from Erdinc and Abazi (2014) with values between -0.34 and -0.55. These results demonstrate the validity of the hypothesis of "bad management", reflected in the reduced profitability, which, in turn, motivates managers to go for an increased risk exposure, therefore creating the growth of bad loans.

The negative relationship between size and bad loans indicates that larger banks are more able to solve problems of information asymmetry than are their smaller counterparts. With skilled employees and qualitative information bases, larger banks are more effective in conducting credit analysis and monitoring their debtors. Although bank size can also serve as an indicator of bank diversification opportunities, this explanation for the relationship between size and credit risk is less applicable in analysed banking systems in comparison to those in advanced economics. Specifically, banks in the Czech Republic concentrate mainly on credit activities. The same result is found by Salas and Saurina (2002), Godlewski (2005), and Louzis et al. (2011).

The results of credit growth indicate a statistically significant explanationpower with the expected positive sign on the NPLs. As we have said before, theory and empirical research point to an expected positive relationship between credit growth and NPLs, certainly with a certain delay.

Furthemore, foreign ownership has a positive effect on reducing the degree of bank problem loans. It appears that foreign ownership appears to contribute to the reduction of NPLs. This result corroborates the findings of Levine (1996) and Barth et al. (2002), who highlight the positive impact of foreign shareholding on financial outcomes. Another plausible explanation for this result is that banks with foreign participation are subject to more stringent control due to a more restrictive regulatory framework (from their home regulatory authorities) than are domestic banks, which are supposed to have weaker institutions. Furthermore, as noted by Lensink and Hermes (2004), foreign ownership contributes to improved human capital and

management efficiency as it brings superior skill, technologies, and risk management practices, particularly in developing countries.

Regarding variable ETA, which determines the risk behaviour of banks, we observe that it is statistically significant and displays a positive sign. This result indicates that banks with high capital adequacy ratios are usually involved in high risk activities, creating risky loan portfolios, and, therefore, high NPL rates.

5. The Macroeconomic Impact of NPLs

In this section, we explore the impact of the NPLs on the real economy in the Czech Republic. We have followed the study of Klein (2013) and estimated linkages among NPLs on the banking system as a whole, domestic credit to the private sector, GDP growth, unemployment, and inflation.

5.1 Methodology

To estimate the impact from the NPLs in this paper, we follow Babouček and Jančar (2005) and have applied a VAR methodology. According to Klein (2013), the advantage of this methodology is that it does not require any a priori assumptions on the direction of the feedback between variables in the model. As a result, we estimated VAR based on the following model:

$$C_t = \Gamma_0 + \sum_{s=1}^{n} \Gamma_i C_{t-s} + \varepsilon_{i,t} C_{i,t} = [NPL_t DCPS_t UN_t GDPG_t INF_t] \qquad (3)$$

where $C_{i,t}$ is a vector of five endogenous variables. The variable $NPL_{i,t}$, is the ratio of NPLs to total loans of the overall Czech banking system in year t, $DSPS_t$ is domestic credit to private sector, $GDPG_t$ is Real GDP growth, UN_t is the unemployment rate, and INF_t is the inflation rate. The dynamic behaviour of the model was assessed by using impulse-response functions (IRFs), which described the reaction of one variable in the system to innovations in another variable in the system while holding all other shocks at zero. The shocks in the VAR were orthogonalised using Cholesky decomposition, which implies that variables appearing earlier in the ordering were considered more exogenous, while those appearing later in the ordering were considered more endogenous. Specifically, we focused on the orthogonalised IRF, which showed the response of one variable of interest (NPLs) to an orthogonal shock in another variable of interest (macroeconomic determinants). By orthogonalising the response, we were able to identify the effect of one shock at a time, while holding other shocks constant. In this specification, we followed the study of Klein (2013), who proposed a related identification scheme where GDP growth, unemployment, and inflation affected NPLs only with a lag, while NPLs had a contemporaneous effect on economic activity, mainly through credit. Therefore, NPLs appear first in the ordering, and DCPS, UN, GGDP, and IN appear later (in this order).

5.2 Results

In this section, we begin with analysis of the results of the VAR methodology. As shown in Table A3, the unit root analysis, according to Fisher-type tests, indicated that null hypothesis of non-stationarity could be rejected for all our determinants. Next, we continued with a reasonably general lag structure and selected the most parsimonious specification according to several information criteria: Akaike (AIC), Schwartz (SC), and Hannan and Quinn (HQ). The left panel of Table 1 summarises the results for the lag selection. Mindful associated with the relatively short time span of our data (20 years), we used 2 lags based on the selected information criteria (AIC, SC, and HQ).

Table 5 Information Criteria

Lag	*AIC*	*SC*	*HQ*
0	14.75439	15.84671	15.42843
1	6.54274*	6.95275*	8.32659*

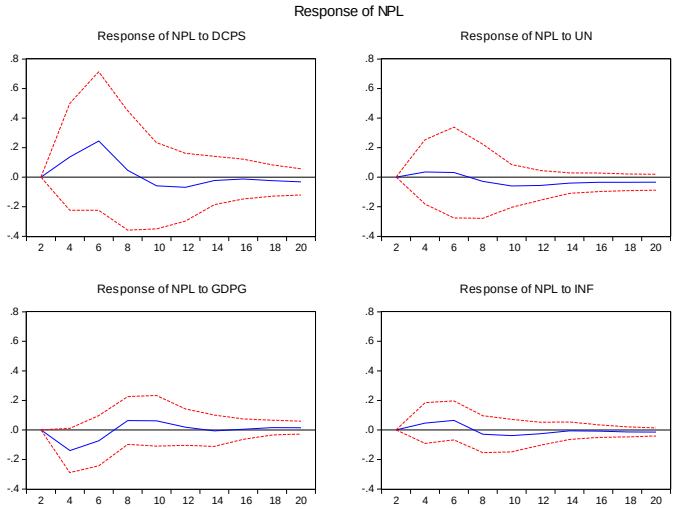
Source: Author's calculations.

The IRF for our model is presented in Figure 1. The presented IRFs reflect responses of NPLs for one standard deviation shock to selected macroeconomic variables (CPS, UN GGDP and IN) and the impact of a shock of NPLs to macroeconomic variables. The red lines around the IRFs represent 90% confidence intervals.

From Figure 1, we can see the response of NPLs to shocks in other variables: an increase of 1 percentage point in GGDP led to a cumulative decline of 1.9 percentage points in NPLs. Also, an increase of 1 percentage point in CPS, UN, and IN led to an increase of 2.4, 0.5, and 0.8 percentage points, respectively, in NPLs.

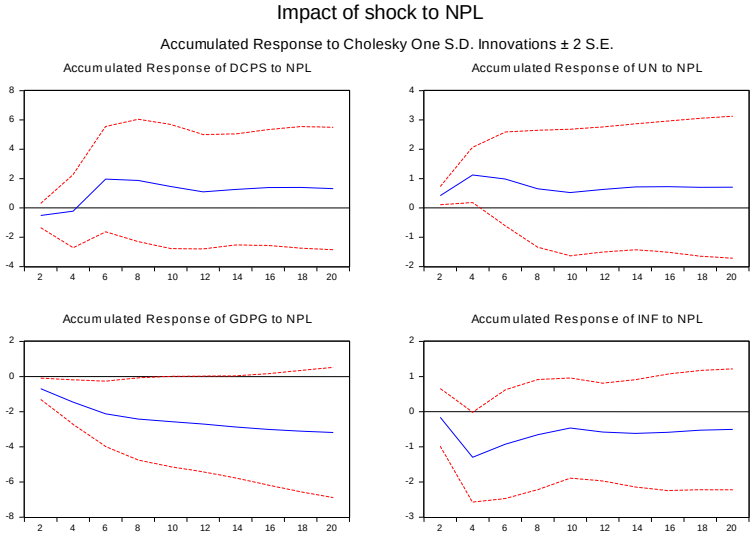
Impact of a shock to NPLs: An increase in NPLs had a negative and significant effect on real GDPG and INF, while contributing to higher CPS and UN. The results showed that, if NPLs increased by 1 percentage point, the GGDP declined by 2.9 percentage points, while IN declined by 1.6 percentage point (over 4 years). Such a shock also resulted in an increase of approximately 2 percentage points in CPS (over 4 years), and an increase of UN of 1.5 percentage points (over 4 years).

Figure 7 Impulse-Response Functions



Source: Author's calculations.

Figure 8 Impulse-Response Functions



Source: Author's calculations.

6. Conclusions

In this paper, using difference Generalised Method of Moments, with data ranging from 2005 to 2016, we have analysed the macroeconomic and bank-specific determinants of non-performing loans (NPLs) for a panel of 22 banks from the Czech Republic. Our findings are largely consistent with the literature. Specifically, we have found that, amongthe macroeconomic determinants, the growth of GDP, inflation, and unemployment have the strongest effect on NPLs. Furthermore, we have also found that return on assets, growth of gross loans, size of the banks, foreign ownership and equity to total assets ratio, as bank-specific determinants, have an influence on NPLs.

The negative relationship between economic growth and growth of NPLs confirms the fact that, in times of expansion, the credit ability of economic agents grows, which has positive effects on the timely servicing of their debt and, hence, lower level of credit risk for banks. In this context, we should also consider the results from the domestic credit to the private sector and the growth of gross loans, given that our empirical analysis found that increases of these determinants have a positive impact on the growth of NPLs. In other words, these results suggest that high private debt burdens make borrowers more vulnerable to adverse shocks affecting their wealth or income, which raises the chances that they would run into debt servicing problems. Hence, their actual adverse effect reflected in the growth of NPLs has come with a certain delay, which has been confirmed by the results in this paper, where we have found a negative relationship between NPLs and credit growth (with a time lag of one year).

The negative results with a one-year lag for inflation indicate that, at first, higher inflation enhances the loan repayment capacity of borrowers by reducing the real value of outstanding debt. However, banks' managers anticipate higher inflation, which, in turn, implies that interest rates are being appropriately adjusted, weakening the loan repayment capacity of the borrowers.

This paper also finds that NPLs in the CzechRepublic are sensitive to other bank-specific factors. Higher quality of the banks' management, as measured by the previous period's profitability, leads to lower NPLs, while moral hazard incentives, such as low equity, tend to worsen NPLs. In other words, more profitable banks have a better-quality loan portfolio, which is to be expected, given that the managers manage the banks efficiently and are less likely to engage in risky lending practices that would jeopardise the balance sheets and the reputation of the bank. On the other hand, the managers of less profitable banks respond to moral hazard incentives by increasing the riskiness of their loan portfolio, which, in turn, results in higher NPLs on average in the future. The results show that size has a negative effect on NPLs, indicating that larger banks are more able to solve problems of information asymmetry than are their smaller counterparts. With skilled employees and qualitative information bases, larger banks are more effective in credit analysis and monitoring their debtors. Also, the results show thatforeign ownership contributes to lower NPLs, because foreign ownership improves human capital and management efficiency in the banks bybringing better skills, technologies, and risk management practices.

Regulators can use this connection on the micro level to detect potential banks that would accept a greater credit risk to improve their profit performance. This allows

room for timely response, if required, and strengthens both risk management and the assignment of specific prudential measures for the bank.

The examination of the feedback effects between the NPLs and economic activity confirms the macro-financial linkages in the Czech Republic. The results suggest that an increase in NPLs has a significant impact on GDP growth, inflation, private credit, and unemployment, thus validating the notion that healthy and sustainable growth cannot be achieved without a sound and resilient banking sector

The paper'sfindings offer severalpolicy implications. First, the regulatory authorities could use the results of this study to detect banks with potential for a sharp build-up of NPLs in the future. Second, to avert future financial instability, regulators should place greater emphasis on risk management systems and procedures followed by banks.Third, regulators need to streamline banks to better manage risk, taking into accountthe characteristics of individual banks. A better understanding of the individual factors that make some banks more resilient than others to adverse economic trends can prevent a rise of credit risk and, thus, reduce negative feedback between the financial sector and the real economy.

Future research may broaden the scope of the examination. First, there is a lack of available data on selected determinants for a longer period. The existence of long time series of data would enable more accurate and more reliable results to be obtained. Second, future research could be based on taking into account the situation in some other Central and Eastern European countries. Third, in this paper, the distribution of loans between household and enterprise loans is not taken into consideration. Finally, the research may be improvedby including either other macroeconomic determinants (monetary aggregates, stock prices, and exchange rate) or bank-specific factors (size, loans-to-assets ratio, etc.).

APPENDIX

Table A1 List of Banks in the Sample

1	Air Bank as
2	Ceska Sporitelna a.s.
3	Ceskomoravska Stavebni Sporitelna as-CMSS as
4	Ceskomoravska Zarucni a Rozvojova Banka a.s.-Czech Moravian Guarantee and Develpoment Bank
5	Ceskoslovenska Obchodni Banka A.S.- CSOB
6	Czech Export Bank-Ceska Exportni Banka
7	Equa Bank a.s
8	Expobank CZ a.s.
9	Factoring KB, a.s.
10	Fio Banka A.S.
11	Hypotecnibankaa.s.
12	J&T Banka as
13	Komercni Banka
14	Modra pyramida stavebni sporitelna as
15	PPF banka a.s.
16	Raiffeisen stavební sporitelna AS
17	Raiffeisenbank akciova spolecnost
18	Sberbank CZ as
19	Stavební Sporitelna Ceské Sporitelny as
20	Unicredit Bank Czech Republic and Slovakia AS
21	Wuestenrot hypotecni banka as
22	Wüstenrot – stavebni sporitelna AS

Table A2 Summary of Selected Empirical Studies of Determinants of Non-Performing Loans

Author(s)	*Variables*	*Sample*	*Methodology*	*Results*
Babouček and Jančar (2005)	Unemployment, Exports, Imports, Real GDP growth, CPI, Credit growth rate and Real effective exchange rate	Czech banking sector over the period from 1993 to 2004	Unrestricted VAR model	The paper suggests positive association of NPLs with CPI andunemployment, appreciation ofreal effective exchange rate has no influence on NPLs, while growth in GDP declines the growth of NPLs
Jakubík (2007)	Real GDP, The loan to GDP ratio, Real effective exchange rates, Unemployment. Real interest rate and CPI	Czech banking sectorover the period fromQ1 1997 to Q3 2005	Merton's approach	The results suggested that corporate default rate issignificantly determined by the growth in loan to GDP ratio and real effective exchange rate appreciation whereas in case of households, growth in interest rate andunemployment leads to decline in NPLs.
Podpiera and Weill (2008)	Loans, Investment Assets, Price of Labor, Price of physical capital, Price of borrowed funds, Total costs, Interest revenues	Czech banking sector using quartely data from 1994 to 2005	The Granger Causality Model	This study support the "bad management" hypothesis, according to which deteriorations in cost efficiency precede increases in non-performing loans, and reject the "bad luck" hypothesis, which predicts the reverse causality.

Kanyinji (2014)	Gross Domestic Product, Monetary aggregate: M1 and M2, Lending for house purchase, Czech Koruna to US dollar, Gross External Debt, Unemployment, Spread: Lending-Deposit, Gross Capital Formation	Czech banking sectorusing time series monthly data from February 2002 to July 2014	Multivariate regression model	Spread of bank's lending anddeposit rates; M2 monetary aggregate; gross capital formation; gross external debt; and the Czech's Koruna to US dollar exchange rate significantly affect changes in nonperformingloans.
Melecky et al., (2015).	Growth of real gross domestic product, Unemployment, Inflation, Level of lending interest rates, The effective exchange rate of the Czech crown/EUR, openness of the economy	Czech banking sector for the period 1993–2014	Bayesian estimation method	Positive effect of economic growthand income effect of the exchange rate. They also find a significant negative effect of lending rates on the financial condition of borrowers. The effects of inflation andunemployment are also significant and negative.
Šulgánová (2016)	Gross domestic product (in the 2005 prices), inflation, unemployment, the aggregate lending rate, the exchange rate of the Czech koruna to euro (CZK/EUR), credit growth, the lending in foreign currencies, the interest rate margin, loans to assets ratio, the Herfindahl-Hirschman Index (HHI).	Czech banking system in the period 2002Q1-2015Q1	Dynamic linear autoregressive distributed lag (ARDL) model	The results obtained in their study indicate that from macroeconomic determinants of non-performing loans the real economic growth is affecting NPLs after 8 and 10 quarters. In the case of inflation, the estimated coefficient has value of 0.05 and t affect NPL after 5 quarters. Rising of unemployment have adverse effects on non-performing loans. Changes in exchange rate were approximated by changes in the nominal exchange rate of the Czech koruna to euro.
Glogowski (2008)	Real GDP growth, lending rate for loans to households and corporations, borrower debt burden, bank-level credit growth, share of real estate loans in loans to households	108 Polish banks in the period from 1996 to 2006	Panel fixed and random effects models	The author finds evidence on the importance of the set of macroeconomic variables consisted of real GDP growth, real interest rates and unemployment
Zeman and Jurča (2008)	Real GDP, exports, the output gap,oil prices, industrial production, M1, CPI, nominal exchange rates and nominal interest rates	Slovakian bankig sector using quarterly data from 1995 to 2006	Multivariate regression analysis	They found that real GDP, the nominal interest rate and exchange rate are the most important influencing variables on the NPL dynamics.
Fainstein and Novikov (2011)	Unemployment rate, real GDP growth and banks' aggregated loan growth, the growth rate of the real estate market	Baltic countries using quarterly data for the period from (depending on the country) Q3 1997/ Q1 2002/Q1 2004 to Q4 2009.	Vector-error-correction model (VECM) for each of these three countries	Their results show real GDP growth as the most significant determinant of NPL growth in all three countries and that real estate market growth plays an important role in two of these countries (Latvia and Lithuania).

Klein (2013)	Four explanatory bank-level variables (equity-to-assets ratio, return on equity, loan-to-assets ratio, and the loans growth rate; three country specific variables (inflation, the change in exchange rate vis-à-vis the euro, and the change in unemployment rate); and two "global variables (the Euro zone's GDP growth, and the global risk aversion captured by the implied volatility of the Standard & Poor's 500 stock market index (*VIX*).	CESEE (Bosnia and Herzegovina, Bulgaria, Hungary, Croatia, Czech Republic, Estonia, Latvia and Lithuania) for the period 1998–2011	Fixed effect model, difference GMM and system GMM	Obtained results suggest that higher unemployment rate, exchange rate depreciation (against the euro) and higher inflation contribute to higher NPLs while higher Euro area's GDP growth results in lower NPLs. Higher global risk aversion (VIX) was also found to increase the NPLs. The impact of bank-specific factors suggest that equity-to-asset ratio and return on equity (ROE) are negatively correlated with the NPLs while excessive lending (measured by loan-to-asset ratio and the past growth rate of banks' lending) leads to higher NPLs.
Jakubik and Reininger (2013)	Real GDP, Private sector credit-to-GDP ratio, National stock index, Exchange rate, weighted by foreign currency share	CESEE countries (Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, Russia, Slovakia and Ukraine)	Difference GMM model and System GMM model	Their results show that economic growth is the main driver that is negatively correlated with NPL development. Other important determinants of NPL change are also identified: past credit growth and exchange rate changes coupled with the share of foreign currency loans in total loans.
Škarica (2014)	Real GDP growth, unemployment rate, nominal effective exchange rate, harmonized index of consumer prices, share prices index and the 3-month money market interest rate	Selected European emerging markets (Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Romania and Slovakia) using quarterly data in the period from September 2007 to September 2012	The fixed effects approach	The results suggest that the primary cause of high levels of the NPLs is the economic slowdown, which is evident from statistically significant and economically large coefficients on GDP, unemployment and the inflation rate.

Table A3 List of Selected Variables in the Model

Variables	*Explanatory of variables*	*Frequency*	*Source*
LNPL	Logit transformation of ratio of impaired (NPLs) to total (gross) loans	annual	Bankscope
GDPG	GDP growth (annual %)	annual	World Bank
INF	Inflation, consumer prices (annual %)	annual	World Bank
UN	Unemployment, total (% of total labor force)	annual	World Bank
DCPS	Domestic credit to private sector (% of GDP)	annual	World Bank
ETA	Ratio of equity to total assets	annual	Bankscope
ROA	Return on assets	annual	Bankscope
GGL	Growth of gross loans of each individual bank (annual %)	annual	Bankscope
SIZE	Total number of employers in the banks	annual	Bankscope
Ownership	Percentage of ownership with ownership (domestic or foreign) exceeding 51%	annual	Bankscope

Table A4 List of Variables and Studies Where are Utilized

GDP growth	Babouček and Jančar, 2005;Jimenez and Saurina, 2005; Quagliarello, 2007; Jakubík, 2007; Marcucci and Quagliariello, 2008, 2009; Castro, 2012; Nkusu, 2011; Klein, 2013; Beck, et al., 2013
Inflation	Kavkler and Festic, 2010;Donath et al., 2014; Gunsel2008; Rinaldi and Sanchis-Arellano, 2006; Sofoklis and Nikolaidu, 2011; Babouček and Jančar; 2005; Bofondi and Ropele, 2011
Unemployment	Babouček and Jančar, 2005; Jakubík, 2007; Bofondi and Ropele, 2011; *Godlewski,*2008; Makri et al., 2014
Domestic credit to private sector	Pesola, 2005; Nkusu, 2011
Ratio of equity to total assets	Berger and DeYoung, 1997; Salas and Saurina, 2002; Klein, 2013; Quagliarello, 2007; Rajan and Dahl,2003; Boudriga et al., 2009; Espinoza and Prasad, 2010.
Return on assets	Makri et al., 2014; Godlewski, 2004; Swamy 2012; Makri et al., 2014; Boudriga et al., 2009
Growth of gross loans	Castro, 2012; Beck et al., 2013; Klein, 2013; Salas and Saurina, 2002; Quagliarello, 2007; Boudriga et al., 2009; Dash and Kabra, 2010; Swamy, 2012
Size of the banks	Godlewski (2005), and Louzis et al. (2011)
Ownership	Salas and Saurina (2002); Micco et al. (2004); Novaes and Werlang (1995)

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