The Lag Length Structure of Banking Determinants of Non-performing Loans in the Czech Republic

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Abstract
The paper is focused on the modeling of an aggregate credit risk whereby the monitoring of this risk is an important part of macroprudential analysis. Concretely, the aim of the paper is to identify the length of time lags of banking determinants on non-performing loans ratio in the Czech banking system in the period 2002Q1-2015Q1. The aim of the paper is fulfilled with the usage of dynamic linear autoregressive distributed lag (ARDL) model. The preliminary empirical results indicate that the goodness of fit using only the banking determinants is modest. Therefore, the paper also controls for the macroeconomic development. Among banking determinants, the shortest time lag was identified with Herfindahl-Hirschman Index (5 quarters). The rest of the chosen banking determinants influence non-performing loans ratio after a longer time period. Concretely, in the case of loans to assets ratio it is 8 quarters, in the case of FX lending it is 8 and 10 quarters, in the case of interest rate margin it is 5 and 9 quarters, and finally, in the case of credit growth it is 6 and 9 quarters.

Keywords: aggregate credit risk, banking determinants, ARDL model, empirically motivated time lags, the Czech banking system
JEL codes: G21, G28, E32

1. Introduction

Last financial and subsequent economic crisis has highlighted the lack of readiness of countries to monitor and evaluate credit risk, materialization of which led banking systems of some countries to a state of a crisis. The monitoring of systemic risks, including credit risk, is an aim of the macroprudential analysis. Along with other economic policies, macroprudential policy is considered to be the main component of policies maintaining financial stability (see e.g. Frait and Komárková, 2011).

The aim of the paper is to identify the lag length structure of banking determinants of non-performing loans (NPLs) in the Czech banking system in the period 2002Q1-2015Q1. In the other words, the paper aims to identify the approximate time period which has passed since the changes in selected banking determinant influence non-performing loans ratio (NPLR). The non-performing loans are chosen to be an ex-post indicator of aggregate credit risk as they are commonly used in the relevant empirical literature (e.g. Podpiera (2006); Festić et al. (2011); Louzis et al. (2012) ; Castro (2013) or Szarowská (2014) among others). In general, non-performing loans are perceived as a problematic loans which are characterized with delayed payments of principal and/or interests. The definition of non-performing loans is not uniformed but generally accepted one is provided by IMF (2007) when loan is considered to be non-performing if payments are past due more than 90 days.

The rising volume of non-performing loans, i.e. the materialization of aggregate credit risk, indicates deterioration in quality of banks` loan portfolios, and possible future loan losses and erosion of banks` capital. From the other point of view, accumulation of non-performing loans restricts consumption of households and investment of companies, with the further adverse effects on banking industry. For instance, in the case of feedback effect, the erosion in capital tightens credit standards and restricts access to new loans with further dampening of economic activity. Thus, the mutual relationship between real economy and financial system is the key component when defining the macroprudential policy. Committee on the Global Financial System (CGFS) takes interactions

between real and financial part of economy into account in its definition of systemic risk. This is perceived as a risk of deterioration of financial intermediation caused by worsening of some or all parts of financial system with a further adverse impact on real economy (CGFS, 2010).

This paper focuses on the banking determinants of aggregate non-performing loans in the Czech economy, controlling also for macroeconomic development. Shu (2002) claims that indicators of banking stability refers to the soundness of banking system at the particular time, while the macroeconomic credit risk factors provide an information about possible future imbalances. To our knowledge, there is no empirical study focused solely on the various banking determinants of non-performing loans in the Czech Republic. The one exception is the commonly cited work of Podpiera and Weill (2008), which investigates relation between assets quality and cost-efficiency, and also capital adequacy.

The rest of the paper is organized as follows. Section 2 describes determinants of non-performing loans with focus on banking determinants. Section 3 presents data and Section 4 methodology used in empirical analysis. Section 5 discusses empirical results and Section 6 concludes.

2. Determinants of Non-performing Loans

When researching determinants of non-performing loans, empirical studies usually distinguish between two main categories of NPLs determinants: macroeconomic and banking. Few of the studies also focus on the institutional factors (see e.g. Boucher Breuer, 2006). With the usage of microeconomic (i.e. bank-level) data the relation between non-performing loans and their determinants can be analytically written as follows:

$$NPLs_{i,t} = \alpha + \beta X_{i,t} + \gamma Z_{i,t} + \delta Y_{i,j,t} + u_{i,t}, \qquad (1)$$

where $NPLs_{i,t}$ refers to the volume of non-performing loans of the country *i* in the time *t*. $X_{i,t}$ is the vector of macroeconomic determinants, which drive formation and accumulation of systemic risks stemming from the macroeconomic imbalances. Thus, macroeconomic determinants are influencing every institution in financial (banking) system. $Z_{i,t}$ is a set of indicators capturing the stability of financial (banking) system of the country *i* at the time *t*. The examples are indicators such as quality and sector concentration of assets, indebtedness of economic subjects, exposures to the market risks, etc. $Y_{i,j,t}$ represents a group of bank-specific factors for the bank *j*, country *i* and time *t*. Bank-specific determinant describes a particular institution, and it is related to idiosyncratic risk. The commonly incorporated bank-specific factors measure profitability or cost-efficiency of individual bank. Finally, α is a constant, β, γ, δ are vectors of regression coefficients and $u_{i,t}$ is an error term.

Salas and Saurina (2002) or Louzis et al. (2012) emphasize the role of macroeconomic determinants when investigating banking determinants of NPLs. In this study, the development in macroeconomic environment is captured by real economic growth (REG), inflation (INFL), lending rate (LR), nominal exchange rate of Czech koruna to euro (NER) and unemployment (UNP). We assume real economic growth to have positive impact on volume of NPLs. Conversely, rising lending rate and unemployment are supposed to have adverse (negative) effects. The resulting effects of rising inflation and exchange rate (i.e. depreciation in the Czech koruna) are ambiguous. For more detailed description of impact of macroeconomic determinants on NPLs (e.g. capturing the two opposite effects of exchange rate) see Melecký et al. (2015).

The indicators, which are usually monitored when assessing the financial stability, could be divided into three groups: (i) internal indicators covering profitability, cost-efficiency, capital adequacy and quality of banks` balance sheets (e.g. capital adequacy, interest rate margin, return on assets or return on equity, etc.); (ii) indicators of contagion, e.g. spreads between highest and lowest interbank interest rates, which affect the cost to income ratio; (iii) external indicators influenced by, for example, macroeconomic environment: share of loans to GDP, net open position in foreign currencies against the capital, geographical or sectoral distribution of loans or an amount of loans denominated in foreign currencies (Mörttinen et al., 2005).

This study investigates banking determinants on the aggregate level, i.e. it employs selected banking characteristics relevant for the Czech banking system. These determinants are following: credit growth (CG), interest rate margin (IRM), loans to assets ratio (LAR), ratio of loans denominated in foreign currencies in total loans (FX) and Herfindahl-Hirschman Index (HHI). The selection of banking determinants is inspired by relevant empirical literature, however, to a large extend it also is limited by data availability.

Excessive credit growth (credit boom) is considered to be an important leading indicator of future problems in financial sector. Empirical literature captures the relationship between credit growth and the volume of non-performing loans whereby changes in lending dynamics affect volume of NPLs with a certain time lag. Excessive credit expansion may lead to an increase in credit risk in the future, especially in periods when credit growth is unsustainable and financial institutions, in periods of excessive optimism, grant loans to riskier clients. Thus a number of potentially non-performing loans originates in an expansionary phase of economic cycle (e.g. Jiménez and Saurina 2006; Festić and Bekő 2008; Festić and Repina, 2009; Espinoza and Prasad, 2010; Festic et al., 2011). Excessive credit growth also stimulates aggregate demand, and in the case of exceeding the potential level of output, can cause overheating of economy. This might have macroeconomic implications in the terms of higher inflation, current account deficit, rising interest rates and appreciation of real exchange rate (Geršl and Jakubík, 2010). Excessive credit growth is usually characterized as a deviation from its equilibrium level. Geršl and Seidler (2011) or Buncic and Melecky (2014) deal with estimating this equilibrium level of credit. For example in converging economies, where strong credit growth is coupled with dynamic economic growth, dynamic lending might not necessarily represent excessive credit growth.

The frequently used indicators of profitability of banks are the net interest margin, the net income or the ratio of revenues to expenditures (Sundararajan et al., 2002). Furthermore, the indicators such as return on equity or return on assets measure the efficiency with which bank uses either capital or assets to generate revenues. High levels of profitability indicators are assumed to help prevent banking failures so the volume of non-performing loans should be decreasing. This implies negative relationship between profitability and NPLs. The profitability indicators are also used to test the phenomenon of income smoothing. In this case the relationship between indicators of profitability and NPLs is assumed to be positive – i.e. given behavior of banks supports the growth of non-performing loans (Głogowski, 2008).

The share of loans in total assets (loans to assets ratio) is usually used as a variable capturing the willingness of banks to take risks. This indicator is usually positively correlated with banking problems, causing increase in non-performing loans, and in the severe cases even the bank insolvency as a result of a long-term bad management (Männasoo and Mayes, 2009).

The share of loans denominated in foreign currencies in total loans (FX lending) captures an indirect credit risk associated especially with unsecured FX exposures. Depreciation of domestic currency increases an amount owed and therefore has an adverse impact on the debt burden. Bordo et al. (2010) confirmed that financial crisis associated with a high proportion of debt in foreign currencies significantly affect the loss of output in economy. Brown and de Haas (2010) investigated determinants of FX debt and confirmed that lending in foreign currencies is strongly determined by macroeconomic environment. Pann et al. (2010) focused on loans denominated in foreign currencies in Central, Eastern and Southeastern Europe (CESEE) and confirmed the growing FX indebtedness as a major sign of credit boom that preceded the last financial crisis.

The higher is a concentration of banking sector, the banks generally have more resources for lending. If it is connected to providing loans to less creditworthy clients, it might be subsequently reflected in a higher loan losses and lower capital adequacy of banks. Based on this assumption, increased concentration of banking industry negatively influences financial stability (Festić and Repina, 2009; Festić et al., 2011). For example, a volume of assets of 4 largest banks in the total amount of assets of the whole banking sector can be viewed as an indicator of market concentration. The negative impact of rising concentration on NPLs in banking industry is associated with an assumption that shareholders of large banks insufficiently control their market discipline, based on the presumption of either explicit or implicit bailout guarantees by the governments in the case of banks` failure (e.g. Chaibi and Ftiti, 2015). There is also an opposite view postulating that large banks have more opportunities for diversification and effective risk management, which would act favorably on

the volume of problem loans, and the relationship between market concentration and non-performing loans would be inversely proportional (e.g. Zribi and Boujelbéne, 2011). This study employs Herfindahl-Hirschman Index, which measures concentration of lending of banking industry, whereby higher values of this index indicate higher concentration in lending (i.e. lending is concentrated among fewer banks in the industry).

3. Data and Methodology

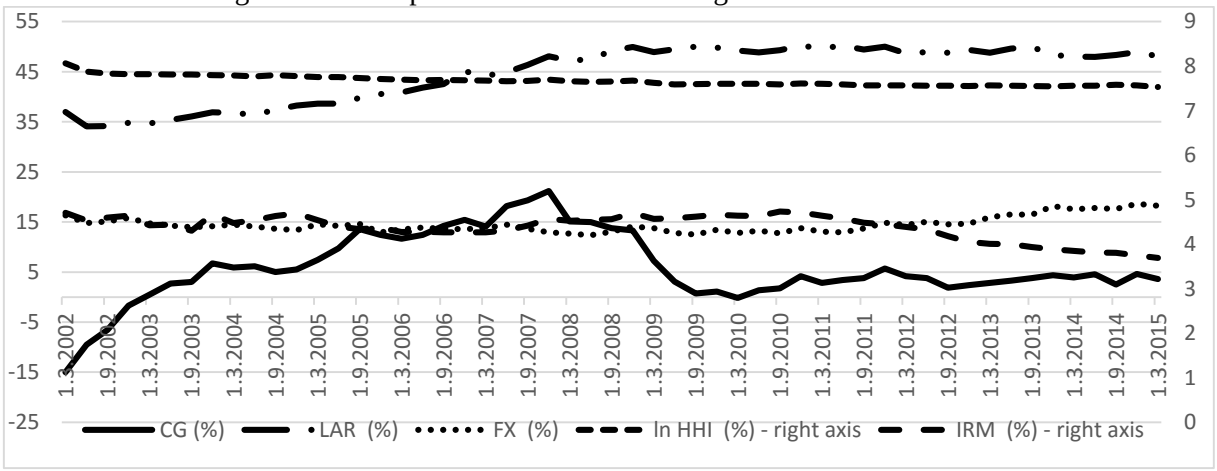
The quarterly data used in this analysis cover the period from 2002Q1 to 2015Q1, i.e. the data sample contains 53 observations. The data capture changes in the Czech banking sector assets quality (approximated by ratio of non-performing loans to total loans, NPLR), macroeconomic development and selected aggregate banking determinants. The whole data sample was obtained from the database ARAD provided by the Czech National Bank (CNB). The length of time series is limited because publicly available data of non-performing loans start at the beginning of year 2002, and also data describing development in the Czech banking sector in the selected period are scarce.

As it is recommended in the literature, when estimating the influence of banking determinants on non-performing loans, the development in the real economy should be also controlled. Concretely, in this study, real economic growth is calculated as a year-on-year change of gross domestic product (in the 2005 prices, seasonally adjusted). Inflation is a year-on-year change of consumer price index (2005=100). The unemployment rate is following the definition of ILO. The aggregate lending rate is approximated by the weighted average of lending rates in the households and non-financial companies sectors. The exchange rate development is captured by changes in nominal exchange rate of the Czech koruna to euro (CZK/EUR). The real exchange rate was also considered but after the checking for multicolinearity between nominal and real exchange rate, and real exchange rate and inflation, the nominal exchange rate was finally preferred.

The time series for the banking determinants were measured as following. The credit growth (CG) is calculated as a year-on-year change of loans granted to residents and non-residents by banks operating on the Czech banking sector market. The lending in foreign currencies (FX) is measured as a ratio of loans denominated in FX currencies in total loans granted. The interest rate margin is a difference between lending and deposit rate (as the lending and deposit rates are available only for sectors of households and non-financial companies, the aggregate values were approximated by the weighted averages of respective interest rates). Loans to assets ratio (LAR) is measured as a ratio of total loans in the total assets of banks. Finally, the Herfindahl-Hirschman Index (HHI), capturing a concentration in lending of commercial banks, is broken down into the 6 categories (e.g. exposures to corporate, housing, consumer lending, etc.). Thus the average value for these 6 categories was calculated and then the function of natural logarithm was used to obtain values in percentage points.

The development of selected aggregate banking determinants of NPLR is captured in the Fig. 1. As can be seen from the figure, the most volatile time series is the credit growth. At the beginning of selected time period credit growth reached negative values (approximately -15%). This was associated with adverse effects of banking crisis, which hit the Czech banking system around the millennium. After the year 2003 credit started to growth gradually, and in the years 2005 to 2007 credit dynamics was the highest (the values peaked above 20%). After that there was a strong decrease caused by the economic slowdown associated with the adverse effects of last financial crisis. In the last five years credit dynamics was relatively stable and reached values about 5%. The ratio of FX lending in total loans showed the slight upward trend in the period from 2002 to 2015. More specifically, the ratio increase from approximately 15% in 2002 to 18% in 2015. Thus the indebtedness of economic agents in foreign currencies did not rise so significantly as in other countries for example from V4 region and the level of FX lending can be considered as sustainable. The loans to assets ratio showed slight upward trend in period 2002 to 2008 so in this period the volume of loans in banks' balance sheets was rising. Since the year 2008 this ratio has reached stable values around 50%. Both interest rate margin and HHI index showed very weak downward trend in the selected time period. The interest rate margin decreased approximately about one percentage (from 4.7 to 3.6%). The decrease of natural logarithm of the HHI index was about the half of percentage point.

Figure 1: Development of Selected Banking Determinants of NPLR



Source: CNB (2015), author´s elaboration

4. Methodology

The effects of banking determinants on non-performing loans ratio (while controlling for macroeconomic development) are estimated helped by autoregressive distributed lag (ARDL) model, see e.g. Melecký (2014). This approach enable us to identify the structure of time lags with which the selected banking determinants affect the assets quality in the Czech banking system. These empirically motivated lags are identified based on their statistical significance, Bayesian information criteria (with the focus on the Schwarz information criterion which is more suitable for small samples), and the overall model performance (goodness of fit; F statistic and its statistical significance).

The method of ordinary least squares (OLS) is used for the estimation. As this method requires time series to be stationary, all selected variables were tested for the presence of unit root (or whether they are stationary – in the case of KPSS test). As was assumed, most of selected time series is not stationary at the level (a lot of variables show trends or contain structural breaks, etc.). Thus the data are transformed by the first differencing method. All transformed time series are again tested and all of them are perceived as stationary.

We use dynamic form of model specification, i.e. the lagged value of dependent variable is present on the right-hand side of model equation. Thus non-performing loans are modeled as a dynamic process as they show some persistence.[1] Keele and Kelly (2006) reported that in the model with dynamic process, it is appropriate to include a lagged value of dependent variable to the right-hand side of model equation (stationarity of dependent variable is required) even in the presence of weak autocorrelation in residuals. The authors reported (based on the results of econometric exercise) that the presence of weak autocorrelation (with autoregressive parameter reaching values of 0.1 or 0.2) might bias marginal effect of independent variable on a dependent variable in a range of 2-7%. On the other hand, if a relevant explanatory variable is not included in model specification, the error in model specification arises (model is underspecified), and the OLS estimator is biased, see omitted variable bias, e.g. Wooldridge (2009).

As was mentioned before, quality of assets, approximated by NPLR, was regressed against the two groups of macroeconomic and banking determinants. The investigated relation can be written in the formal representation of equation 2:

$$NPLR_t = \alpha + \beta NPLR_{t-x} + \gamma X_{t-x} + \delta Y_{t-x} + u_t, \qquad (2)$$

[1] The static versions of model specification were also considered but they showed high first order autocorrelation of residuals what might implicate a bad model specification (caused by non-considering an autoregressive process in NPLR variable).

where $NPLR_t$ represents the non-performing loans ratio in the time *t* and $NPLR_{t-x}$ is a lagged value of dependent variable in the time *t-x*. X_{t-x} is the vector of macroeconomic variables (REG, INFL, LR, UNP and NER) in the time *t-x*. Y_{t-x} is the vector which contains lagged aggregate banking determinants (CG, FX, LAR, IRM and HHI). Finally, α is a constant, β, γ, δ capture regression coefficients and u_t is the error term.

The final model specification, with identified structure of time lags, was tested to ensure that the *i.d.d.* requirement on residuals holds.[2] The normal distribution of residuals was confirmed helped by the graphical representation of histogram with the provided values of kurtosis and skewness, and the Jarque-Bera statistic. This statistic was not significant at the 5% level of significance (i.e. *p-value* reached higher values than 0.05) what indicates that the null hypothesis of normal distribution of residuals could not be declined. Residuals were also tested for the presence of heteroskedasticity (i.e. a non-constant variation in residuals). The Breusch-Pagan-Godfrey test confirmed required homoskedastic residuals (the test statistic – R2**Obs*. – was not statistically significant so the null hypothesis of constant variation in residuals could not be declined). Finally, the graphical representation of Correlogram and the Breusch-Godfrey Serial Correlation LM test were used to control for the presence of serial correlation in residuals. According to graphical representation, there is no serial correlation in residuals. The results of LM test are not so straightforward. The test statistic – R2**Obs*. – was statistically significant at the 5% level of significance what indicates that the null hypothesis of no presence of serial correlation could be declined. On the other hand, the value of provided F-statistic, which is more suitable for small samples, was statistically insignificant. Overall, the results are mixed, and we cannot clearly accept or decline the null hypothesis of no serial correlation in residuals. In the presence of serial correlation, the ordinary least square estimator is still unbiased as well as consistent and asymptotically normally distributed, but it is no longer efficient, meaning that standard errors are estimated in the incorrect way and, therefore, usual confidence intervals and hypotheses tests are unreliable. Therefore, the estimated parameters were obtained with the usage of HAC matrix estimation with more robust standard errors (in the presence of heteroscedasticity or serial correlation in residuals).

5. Discussion of Results

Empirical results of ARDL model, describing the length of time lags of banking and macroeconomic determinants affecting non-performing loans ratio in Czech Republic, are presented in Table 1 in Appendix. Overall, the model performance is satisfying. The goodness of fit is high - value of adjusted coefficient of determination is 91%. According to this result, 91% of variability in dependent variable (NPLR) is caused by changes in independent variables (i.e. macroeconomic and banking determinants, and persistence in NPLs). The probability of F statistic is 0.00 what indicates that model as a whole is statistically significant.

Firstly, we will discuss results of macroeconomic determinants of non-performing loans as the model controls for macroeconomic development. The real economic growth (REG) is affecting NPLR after 8 and 10 quarters (the estimated parameters are -0.12 and -0.18, respectively). This result is in line with economic theory when higher growth of output increases revenues of economic agents, and enables them to better pay their debts off.

In the case of inflation, the estimated coefficient has value of 0.05 (it is significant on the 10% level of statistical significance) and inflation seems to affect NPLR approximately after 5 quarters. This result can be interpreted in the following way: a 1% increase in inflation rises NPLR by 0.05%. Thus rising inflation seems to increase non-performing loans in the Czech Republic in the selected time period, but this effect is very weak. Some economic postulates claim that rising inflation causes macroeconomic outlook to be less transparent what makes decision-making process to be more difficult. Also rising inflation, usually unanticipated, and/or connected to general economic instability might cause the rise of non-performing loans.

[2] Due to limited length of this paper results associated with testing of residuals are available upon request.

In the case of lending rates, statistically significant values of estimated parameters were identified with the lag of 2, 3, 8 and 10 quarters. The effect of rising lending rate on NPLR after two quarters is counterintuitive (negative value -0.87). Other three coefficients reach positive values (1.07, 3.36 and 0.88) whereby the biggest effect was identified after 8 quarters. This result might be interpreted as following: 1% rise in lending rate causes 3.36% rise in NPLR after approximately two years. Nevertheless, we should not forget on other significant coefficients, which reach positive values and imply adverse effects of rising LR on NPLR. So the overall effect of rising lending rate could be higher as the debt burden increases with rising debt-servicing costs.

According to empirical results, also rising unemployment seems to have adverse effects on non-performing loans. Increase in unemployment influences NPLR after approximately 2 years (more precisely, after 8 and 9 quarters). Both estimated coefficients are significant at 1% level and reach values of 0.68 and 0.26. In real economy rising unemployment adversely affects revenues of households, potentially decreasing aggregate demand, and indicating a future decline in companies` revenues. Both declining revenues of households and companies worsen an ability of economic agents to pay their debts off.

Changes in exchange rate were approximated by changes in the nominal exchange rate of the Czech koruna to euro (NER). Estimated coefficient of rising NER on NPLR is 0.36 at 1% level of significance, and the identified time lag is 6 quarters. This indicates that depreciation of domestic currency seems to cause rise in non-performing loans ratio after year and a half. However, it need to be pointed out that this study does not model the two opposite effects of exchange rate (income and balance-sheet effect; see e.g. Melecký et al., 2015 or Jakubík and Reininger, 2013) what can be considered as a drawback of this study. According to obtained results, 1% depreciation in domestic currency rises NPLR by 0.36% confirming the adverse effect of depreciation on unsecured positions (debts) denominated in foreign currencies.

In the case of interest rate margin, the estimated coefficients reach quite high values (-2.31 and -2.21), and the estimated time lag after which changes in IRM influence NPLR is either 5 or 9 quarters. These results confirmed assumptions from economic theory that changes in interest rate margin are very important determinant of banks´ profitability. So the rising IRM causes non-performing loans to decline in significant extend. The economic rationale behind this result is following: rising profitability should prevent banks from excessive risk taking (e.g. in the form of granting loans to less creditworthy clients), and thus help to decrease volume of non-performing loans.

The results for credit growth are mixed. Firstly, there is a contemporaneous effect with negative estimated coefficient (-0.10). Then after 6 or 9 quarters there is a lagged effect of rising credit dynamics when the coefficients are following: -0.07 and 0.14, respectively. When assessing the impact of credit growth on non-performing loans, economic theory pays attention to the fact from which side of market (either demand or supply) the rising credit growth comes. Keeton (1999) argues that when loan growth is driven by banks' willingness to lend (i.e. supply side), lending increases either through the reduction in lending rates or lowering credit requirements for new loans. This would increase a likelihood that borrowers may default on their loans, and affect the quality of bank loans. However, if the growth is from the demand side, the pull factors will drive loan rates upwards and lead to tightening of credit standards, ensuring greater scrutiny of loan applicants to reduce the possibility of adverse selection, and hence lower the probability of future loan defaults. In this case, a negative relationship between credit growth and asset quality is assumed.

As was mentioned before, increasing indebtedness in FX currencies poses indirect credit risk. The results obtained from the ARDL model confirm this assumption. More specifically, rising value of loans denominated in foreign currencies seems to adversely affect aggregate NPLR approximately after two years (estimated coefficients are 0.25 and 0.28 for 8^{th} and 10^{th} time lag, respectively). Indirect credit risk is associated with the balance-sheet effect of changing exchange rate. Aforementioned depreciation of domestic currency rises value of unsecured FX debts. Thus when there is a rising FX lending and indebtedness in an economy, a potential adverse effect of depreciation is connected to higher problem loans and loan losses.

For the needs of this analysis, the Herfindahl-Hirschman Index was used as the indicator of the lending concentration of commercial banks operating in the Czech Republic. The estimated result suggests positive relationship between rising concentration and non-performing loans ratio, whereby this effect appears after 5 quarters. However, we need to be cautious when interpreting the value of

estimated coefficient because the variable was transformed with natural logarithm. In a Level-log model the parameter of variable in logarithm need to be divided by the value of 100 (see e.g. Wooldridge, 2009, p. 46). After this adjustment the value of estimated coefficient is 0.06. This can be interpreted as following: 1% rise in lending concentration leads to the 0.06% rise in NPLR after 5 quarters. Finally, the loans to assets ratio affects NPLR after 8 quarters. The estimated coefficient is -0.10 at the 5% level of statistical significance so this effect is again rather weak. This result does not confirm economic postulate that rising volume of loans in total assets imposes higher credit risk for the future.

6. Conclusion

The aim of the paper was to identify the structure of time lags with which selected banking determinants affect assets quality in the Czech banking sector in the period 2002Q1-2015Q1. This aim was fulfilled with the usage of ARDL model with empirically motivated lags.

While estimating the influence of selected aggregate banking determinants on non-performing loans ratio, the paper also controls for macroeconomic development. Based on the empirical results, non-performing loans react to the changes in inflation and in nominal exchange rate of the Czech koruna to euro at first. The approximate time lag is 5 and 6 quarters, respectively. After the longer period of about two years changes in real economic growth and unemployment rate seem to act on non-performing loans. When accessing the magnitude of estimated effects, the strongest effect was identified with lending rate, comparatively smaller effects were captured with real economic growth, unemployment and change in CZK/EUR exchange rate. Finally, the estimated effect of inflation on NPLR is weak and close to zero.

From the group of banking determinants the shortest reaction of non-performing loans ratio was identified in the case of Herfindahl-Hirschman index measuring the lending concentration (the particular lag length was 5 quarters). Also the effect of interest rate margin appears after 5 and then 9 quarters. The results associated with the credit growth are rather mixed, contemporaneous and also lagged (after 6 and 9 quarters) effect was identified. Changes in loans to assets ratio seem to influence NPLR after 8 quarters but the estimated effect is counterintuitive. Finally, similar lag length of about two years was captured when investigating time period after which changes in FX lending affect assets quality (the identified time lags were 8 and 10 quarters). The highest values of coefficients were estimated with interest rate margin, comparatively smaller with FX lending. The effect of the rest of selected banking determinants is rather small.

According to empirical results, variables affecting profitability of banks, i.e. lending rate further influencing interest rate margin, seem to play the most important role when researching non-performing loans in the relation to selected groups of determinants. Thus respective authorities should carefully watch development of lending rates as it appears to be very important both for profitability and assets quality of banks.

In the future research these results might be supplemented (and verified) by results obtained with the usage of more advanced methods. For example, the usage of Bayesian methods might help to overcome limitations connected to the limited (short) time series. Moreover, it is also possible to enlarge data sample helped by microeconomic (bank-level) data.

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Appendix

Table 1: Results of ARDL estimation

Variable	Coefficient	Prob.
C	0.09	0.0015
NPLR(4)	0.24	0.0017
INFL(5)	0.05	0.0988
LR(2)	-0.87	0.0002
LR(3)	1.07	0.0004
LR(8)	3.36	0.0000
LR(10)	0.88	0.0061
LN_HHI(5)	5.67	0.006
REG(8)	-0.12	0.0001
REG(10)	-0.17	0.0000
IRM(5)	-2.31	0.0000
IRM(9)	-2.28	0.0002
NER(6)	0.36	0.0000
CG	-0.1	0.0000
CG(6)	-0.07	0.0001
CG(9)	0.14	0.0000
UNP(8)	0.68	0.0000
UNP(9)	0.26	0.0028
FX(8)	0.25	0.0001
FX(10)	0.28	0.0000
LAR(8)	-0.1	0.0445
R-squared	0.96	
Adjusted R-squared	0.91	
Akaike criterion	-0.63	
Schwarz criterion	0.23	
Hannan-Quinn criter.	-0.32	
F-statistic	22.4	
Prob (F-statistic)	0.0000	
No. of obs. (after adj.)	42	

Note: Numbers is brackets listed after the explanatory variables denote the identified time lags.

Source: author`s calculations