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The Pass-Through of Monetary Policy Rate to Lending Rates: *The Role of Macro-financial Factors*[*]

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Abstract

This paper assesses how changes in the monetary policy rate transmit to the lending rates for the consumer, mortgage, SME, and corporate loans in the Czech Republic. It further examines whether this interest rate pass-through is stable or could vary at different levels of bank competition, leverage, non-performing loans, and foreign exchange (FX) interventions. Using the ARDL modelling approach, we find a significant and complete pass-through for SME lending rates. Significant structural shifts are estimated in the pass-through for mortgage and corporate rates. These shifts can be entirely or largely explained by bank deleveraging. We do not find any stable pass through for consumer lending rates. A greater spread between government bond and monetary policy rates increases the markup for all lending rates but corporate rates. FX interventions affected most the markups for corporate and SME rates; however, in a puzzling direction.

Keywords: Monetary Policy Rate, Bank Lending Rates, Interest Rate Pass-Through, Foreign Exchange Interventions, Time Series Analysis, Czech Republic.

JEL Classification: E4, E5.

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1. Introduction

The interest rate channel of monetary policy is one important channel through which the changes in the monetary policy rate affect the cost and volume of lending to the real economy, and thus the credit cycle, business cycle, and inflation. How effective this channel can be in each economy is an empirical question that is of great interest to central bankers (Peter Praet, 2016; Minouche Shafik, 2016, William C. Dudley, 2017).

This paper assesses how the monetary policy rate affects the lending rates for the consumer, mortgage, small and medium enterprises (SME), and corporate loans in the Czech Republic. It further examines the stability of this interest rate pass-through, and whether it can vary at different levels of bank competition, bank leverage, borrower credit risk, and foreign exchange interventions. We also examine whether factors such as bank credit risk, bank competition, or foreign exchange interventions significantly influence the markup for lending rates over and above the monetary policy rate. Another possible determinant of the markup that we consider is the spread between the government bond yield and the monetary policy rate as a proxy for changes in the term premium and sovereign risk. We are not interested in modeling the term structure of interest rates and the term premium in a greater detail as in Mallick et al. (2017), Brand et al. (2010), or Piazzesi (2002), among others. We are simply interested in estimating a reduced form model describing how the monetary policy rate transmits to lending rates in different market segments, while controlling for macrofinancial variables that could determine the lending rate markup and the strength of the pass-through itself. The spread between the government bond yield and the monetary policy rate, which controls for the effects of the term premium and sovereign risk, is one such macrofinancial variables.

In 2008, the Czech Republic joined the club of high-income OECD countries.[1] It is an open economy with exports amounting to 83 percent of GDP and one of the most industrialized countries in the EU.[2,3] The country is not part of the Eurozone yet and maintains its own currency, the Czech koruna. The Czech National Bank (CNB) uses inflation targeting as the operational monetary policy regime, and the main monetary policy tool is the two-week repurchase rate (repo rate). The Czech financial sector is dominated by banks, largely foreign-owned subsidiaries of Western European banking groups. In 2017, the Czech banking system comprised 47 banks. The 4 largest banks accounted for 62 percent of total banking sector assets (about US$ 350 billion). By ownership, there were 9 domestic and 38 foreign banks, including the 4 biggest ones. Although the global financial crisis (GFC) hit several EU countries, the Czech Republic was affected by the GFC only indirectly and did not experience a systemic border-line or full-blown banking crisis (Laeven and Valencia, 2012). The GFC's indirect effect worked mainly through reduced export demand, and through the adjustment of Western European banking groups to the post GFC environment. Faced with the challenging low interest rate environment, the CNB complemented its traditional monetary policy by foreign exchange (FX) interventions as of 2013.[4] Namely, the CNB announced a public commitment to intervene in the FX market against appreciation of the Czech koruna as necessary to keep the Czech koruna above 27 CZK for one euro. This one-sided exchange rate commitment helped the CNB in achieving its stated inflation target. The CNB abandoned the exchange rate commitment in April 2017.

Using the autoregressive distributed lag modelling approach and a baseline linear model, we find that, over 2004-17, the pass-through from the monetary policy rate to mortgage, SME, and corporate lending rates appeared overall significant and complete. We cannot confirm long-term relationship (cointegration) between consumer lending rates and the monetary policy rate. Banks in the Czech Republic may thus set

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[1] OECD - Country Classification for aid and repayment terms.
http://www.oecd.org/tad/xcred/country-classification.htm

[2] World Bank statistics (2015) - Exports of goods and services.
http://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=CZ

[3] According to OECD industrial production index (2015), the Czech Republic is 7th most industrialized EU country.
https://data.oecd.org/industry/industrial-production.htm

[4] Czech National Bank - The exchange rate as a monetary policy instrument – FAQs.
https://www.cnb.cz/en/faq/the_exchange_rate_as_monetary_policy_instrument.html

their consumer lending rates considering factors other than the monetary policy rate. Testing the stability of the baseline model specification reveals structural shifts in the estimated relationship for mortgage and corporate rates. For the mortgage rate, these structural shifts recede when we allow for a non-linearity in the monetary policy rate at different levels of the bank capital to asset ratio (an interaction term)—the pass-through to mortgage rate can thus change with the degree of bank leverage. For corporate rates, allowing for a similar nonlinearity helps lower the importance of the identified structural shifts (in 2007 and 2011) but they do not recede completely and stay significant. Nevertheless, the two structural shifts end up affecting only the markup over the monetary policy rate not the pass-through of the monetary policy rate to the corporate lending rate. Specifically, the average markup for corporate lending rates shifted up about 54 basis points with the onset of the GFC, and then down about 57 basis points in early 2011—around the time when the new Capital Requirement Directive (CRD III) for the European Union was adopted and helped decrease the uncertainty about future bank capital requirements.[5]

As for the macro-financial determinants of the lending rate markups, the spread between the government bond yield and the monetary policy rate is the most prominent. The spread increases most the mortgage and consumer rates—for instance, a one percentage point increase in the spread increases mortgage rates by about 70 basis points depending on the model specification. The SME and corporate markups respond also positively to the growth in CNB's deposits at foreign banks (a proxy for FX interventions). However, this result is puzzling. It may suggest that funds that would normally be invested in the Czech economy were invested in the Czech korunas in the international markets shortening the supply of funds flowing into the Czech economy. This puzzling result needs to be confirmed and further examined by future research.[6] In addition, as banks were deleveraging they were systematically increasing the markup for SME lending rates.

[5] https://web.archive.org/web/20130627202127/http://ec.europa.eu/internal_market/bank/regcapital/legislation_in_force_en.htm#maincontentSec5

[6] Using percentage or log-log growth rates or normalizing the CNB deposits by prices did not change the result.

Our paper contributes to the interest rate pass-through literature in three ways: (i) To our knowledge we are the first, who test the efficiency of the pass-through in the Czech Republic during the zero lower bound period. (ii) We test the effect of unconventional monetary policy in the form of FX interventions on the pass-through. (iii) We examine how stable the pass-through is considering possible structural shifts, as well as a possible variation in the pass-through with the changing macrofinancial environment.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 presents the theoretical underpinning for the interest rate pass-through. Section 4 describes the data and basic statistics. Section 5 describes the employed co-integration model and estimation method. Section 6 discusses the baseline estimation results. Section 7 tests for possible multiple structural breaks. Section 8 examines non-linear dependence of the estimated pass-through on varying macrofinancial conditions. Section 9 performs additional tests of stability. Section 10 concludes.

2. Literature Review

The empirical literature estimating the interest rate pass-through typically uses either the cost of funds approach (Bondt, 2005; Hofmann, 2006; Bernhofer and van Treeck, 2013; Havránek et al., 2016) or the monetary policy approach (Mojon, 2000; Espinosa-Vega and Rebucci, 2004; Becker et al. (2012); Blot and Labondance, 2013; Holton and d'Acri, 2015). The choice of the reference rate differentiates both methods. The cost of fund approach follows the term structure of interest rates assigning each lending rate a market rate with comparable maturity. In contrast, the monetary policy approach uses the main monetary policy rate (sometimes approximated by the short-term money market rate) as the reference rate for the pass-through to all lending rates. In this paper, we follow the monetary policy approach because we are interested in how both the short- and long-term lending rates respond to changes in the monetary policy rate.

Rousseas (1985) proposed a simple theoretical model for interest rate pass-through based on the marginal cost theory. Assuming perfect competitive markets, bank lending rates would change one-to-one with the monetary policy rate (the cost of funding) and one would speak about a complete pass-through.

However, this assumption is often violated in practice because the banking and financial market structures show rather monopolistically competitive or even oligopolistic behaviors. Therefore, an incomplete pass-through could be expected. Considering the modelling approach, numerous papers examine interest rate pass-through using just a reference rate as an explanatory variable (Jobst and Kwapil, 2008; Holmes et al., 2015; Bernhofer and van Treeck, 2013). In contrast, numerous other papers acknowledge that the lending rate markup and interest rate pass-through depend on various market conditions and not just on the monetary policy stance. Hence, they include more control variables (Gambacorta et al., 2015; Sander and Kleimeier, 2006; Eller and Reininger, 2016).

The most commonly used co-determinant of interest rate pass-through is probably bank competition. For instance, van Leuvensteijn et al. (2013) and Mojon (2000) find, using different measures of bank competition, that the pass-through is faster and more complete at higher levels of bank competition. In addition, Cottarelli and Kourelis (1994), Mester and Saunders (1995), Mojon (2000), Bondt (2005) point also to other market factors distorting the pass-through such as the non-elastic loan demand, as well as the existence of asymmetric information, menu costs, and switching costs.

Other co-determinants of the pass-through involve bank characteristics such as bank assets, the leverage ratio, capital buffer, and the liquidity ratio, among others (Horváth and Podpiera, 2012; Holton and d'Acri, 2015; Havránek et al., 2016; Kapuściński and Stanislawska, 2018). In the last decade, pass-through studies have emphasized the role of bank credit risk as a result of the GFC. For instance, Paries et al. (2014) test whether supply- and demand-side risks affect household and corporate rates. They find growing influence of borrower credit risk on corporate loan rates, particularly in Spain, Italy, and Ireland. Similarly, Holton and d'Acri (2015) focusing on the euro area banks report a significant effect of credit risk on the interest rate pass-through.

Some papers also examine the impact of fiscal policy on the pass-through. Commercial banks use government bonds as an alternative investment asset to loans. Therefore, movements in the government bond market could affect the pass-through of the monetary policy rate to bank lending rates. Focusing on

EU countries, Eller and Reininger (2016) report that long-term bond yields significantly affect the long-term lending rates in most Eurozone countries, but not the Central and Eastern European countries. In addition, Zoli (2013) examines the role of sovereign bond spreads in Italy's pass-through and finds a significant effect on business lending rates. Paries et al. (2014) concurs with Zoli's finding estimating a significant effect of the sovereign spread on the consumer and corporate rates in Italy, Spain, and Portugal.

Overall, the empirical evidence on interest rate pass-through varies. Some studies find complete, other studies incomplete pass-through in different country contexts (Wang and Lee, 2009; Haughton and Iglesias, 2012). The evidence varies also for the EU countries and their different types of loans (Hofmann, 2006; Sorensen and Werner, 2006; Égert et al., 2007; van Leuvensteijn et al., 2013; Belke et al., 2013; Holton and d'Acri, 2015). For instance, while Rocha (2012) finds a strong pass-through from money market rates to general lending rates in Portugal, Hofmann (2006) finds such pass-through to be weak in Germany. For different types of loans in the Eurozone, Sorensen and Werner (2006) detect a higher interest rate pass-through for mortgage rates and a lower one for consumer loan rates. In contrast, Belke et al. (2013) and Mojon (2000) find that, for Eurozone countries, short-term lending rates could show a stronger pass-through than mortgage rates.

The onset of the global financial crisis and the resulting policy and market adjustments are generally seen to have weaken the interest rate pass-through. Gambacorta et al. (2015) use a cointegration model to examine the long-run relationship between money market rates and bank lending rates in Italy, Spain, the UK, and the US. They find a weakening pass-through in the post GFC period that could be associated with the heightened uncertainty and perception of risk. Hristov et al. (2014) analyze the interest rate pass-through in the Eurozone countries using panel VAR and DSGE models. They find that weaker pass-through in the aftermath of GFC is caused by higher distress of the banking sector. Aristei and Gallo (2014) show a weakened degree of the pass-through during the crisis period using a Markov-switching VAR model. In contrast, Borstel et al. (2016) use factor-augmented (FA)VAR framework and conclude that the GFC has changed only the composition of the interest rate pass-through but not the magnitude of the pass-through.

The post GFC period has challenged monetary policy implementation in many countries because of the generally low interest rate environment. Several countries thus used foreign exchange interventions as an unconventional monetary policy. Lízal and Schwarz (2013) pointed out that FX interventions are highly effective for small open economies such as the Czech Republic when the use of traditional operational tools (such as the repo rate) is no longer an option. They explain that the exchange rate pass-through to inflation might be even larger in binding conditions (ZLB on interest rates) because the import price channel and the real interest rate channel work in the same directions. Therefore, for the Czech Republic, the use of FX interventions is a reasonable choice considering the "unlimited" capability of the CNB to buy foreign assets. Franta et al. (2014) reviews the use of FX interventions in the Czech Republic as a form of quantitative easing. Switzerland has also used FX interventions to implement monetary policy at the zero lower bound (ZLB); however, less efficiently. For instance, Amador et al. (2017) show that FX interventions are costly for the Swiss central bank—because of their negative impact on balance sheet—and for the economy. The challenges with monetary policy implementation at the ZLB using FX interventions include the well-known example of Japan starting in the 1990s. In Japan, similarly as in Switzerland, the use of FX interventions was effective only to a limited extent (Iwata and Wu, 2012). In particular, the impact of the FX interventions on the pass-through to retail lending rates in a low interest rate environment has not been examined by the empirical literature. This paper helps fill this gap.

For the Czech Republic, to our knowledge, only two papers estimate the interest rate pass-through. Horváth and Podpiera (2012) detect fast and almost complete pass-through for the mortgages and firm lending rates using the pooled mean group estimation approach. They emphasize that factors such as bank asset size, capital, amount of deposits, and credit risk affect the pass-through. The study, however, does not cover much of the post GFC period.[7] Havránek et al. (2016) analyze the interest rate pass-through in the Czech Republic during 2004-13. They find a weaker interest rate pass-through for corporate lending rates

[7] Babecká-Kucharčuková et al. (2013) update the results by Horváth and Podpiera (2012) using the same approach with the sample period extended to December 2009. Their results show only minor changes. In general, they confirm mostly weaker interest rate pass-through in compare to the original research.

and stronger for mortgage lending rates after the onset of the GFC. Nevertheless, the interest rate pass-through and its effectiveness in the Czech Republic remain under-researched and this paper helps close this gap.

Our paper differs from the one by Havránek et al. (2016) in several ways. First, we study the pass-through from the monetary policy rate to lending rates and do not assume a perfect correlation between the money market rate (or the CZEONIA rate) and the two-week repo rate (the monetary policy instrument). We contribute to Havránek et al. and the literature by estimating a richer model for the pass-through controlling for bank lending concentration, the bank leverage, the non-performing loans ratio, FX interventions, and the spread between the government bond yield and the monetary policy rate—a join control for changing term premium and sovereign risk. Furthermore, we consider and test for possible multiple structural breaks—for instance, due to the onset of the GFC in 2007, the emergence of the European debt crisis, the monetary policy rate reaching the zero lower bound (ZLB), the CNB announcing systematic foreign exchange interventions, and the changing banking conditions in response to the GFC.[8] In addition, we test for possible non-linear dependence of the pass through on varying macroeconomic conditions.

Andries and Billon (2016) provide a useful survey of the interest rate pass through literature and the challenges it faces. The study discusses, among others, the issues of non-linear pass-through in particular issues with an asymmetric pass-through. Wang and Lee (2009) and Haughton and Iglesias (2012) are example studies that use threshold autoregressive (TAR) models and models of conditional heteroscedasticity to estimate possible asymmetry in the interest rate pass-through. Asymmetric adjustments are a type of non-linearity that the interest rate pass-through can exhibit and policy maker may need to account for. Other types of non-linearities dependent on the state of the economy—for instance, business or credit cycle, bank competition, bank leverage—are equally interesting and important to policy makers. In addition to the models used by Wang and Lee (2009) and Haughton and Iglesias (2012), other

[8] This includes global deleveraging and de-risking, and changes in regulation and supervision in the EU.

statistical approaches could be considered to examine asymmetries, including regimes shifts within, for instance, Markov-switching models (Aristei and Gallo, 2014). Along these advance statistical approaches to examine possible non-linearities in the pass through, a more structural approaches could be applied to provide complementary empirical insights that can be equally important to policymakers. To our knowledge, the structural approach to assessing non-linearity in the pass-through has not been explored much in the existing research. Our paper takes this avenue to help fill the possible gap and inform policy makers about changing pass-through at different levels of macrofinancial determinants using interactive regression terms.

3. Theoretical Motivation

Rousseas (1985) defines a simple markup equation for commercial banks to describe the interest rate pass-through process:

$$lr = k(u), \tag{1}$$

where *lr* is the bank lending rate, *k* is a markup function reflecting the degree of monopoly or market power exercised by individual bank or, in aggregate, by the banking industry as a whole. And *u* is the unit prime or variable costs incurred by banks, basically the interest paid on deposits and borrowed funds. Growing market power or growing prime costs of the bank lead to an increase in bank lending rates. Since the banking market structure is not perfectly competitive, one can assume a permanent markup over the bank costs of funds for lending rates. Assuming a constant mark-up, equation (1) could be written in a linear form as:

$$lr = \alpha + \beta u. \tag{2}$$

where α is the markup over the bank cost of funds and β is a degree of the pass-through from the bank cost of funds to its lending rate. Rousseas (1985) suggests approximating the cost of funds with the monetary policy rate.[9] Hence, changes in the main monetary policy rate can determine bank lending rates. Moreover,

[9] For instance, Grigoli and Mota (2017) follow this suggestion.

note that the spread α can comprise both constant and time-varying components. The latter component considers the possibility that the bank market structure, bank conditions, and other macrofinancial conditions, which determine the markup, could vary over-time:

$$lr_t = (\alpha_1 + \alpha_{2,t}) + \beta mpr_t. \qquad (3)$$

Failing to account for the possible time-varying component of the spread, $\alpha_{2,t}$, could bias the β estimate. Synthesizing the existing literature, $\alpha_{2,t}$ is determined by vector X_t including macro-financial factors such as bank competition[10], credit risk premium[11], and the alternative return from investing in government bonds[12,13]:

$$\alpha_{2,t} = \gamma X_t + \varepsilon_t. \qquad (4)$$

We discussed the effect of bank competition on the pass-through earlier as part of the Rousseas (1985) model. Therefore, we proceed with discussing the effect of credit risk. The credit risk arises on both the borrower side and the bank side. On the bank side, credit risk could be measured as capital to assets ratio—the bank leverage (Chileshe and Akanbi, 2016).

On the borrower side, the credit risk is mostly related to the problem of asymmetrical information. Since commercial banks cannot easily distinguish between creditworthy borrowers and risky borrowers, they must assume default of some loans. The probability of loan default may rise when the lending rate increases. Stiglitz and Weiss (1981) differentiate two effects connected to imperfect information: (i) the adverse selection effect, and (ii) the incentive (moral hazard) effect. The adverse selection effect describes the situation when growing interest rates push out safer but less profitable loans, and, in contrast, attract riskier projects with higher expected returns. Therefore, with growing interest rates commercial banks face a challenging situation when they must decide which borrower is more likely to repay its debt. The incentive

[10] van Leuvensteijn et al. (2013), Leroy and Luccote (2015), Chileshe and Akanbi (2016).
[11] Gambacorta et al. (2015), Bondt (2005), Mihaylov (2016), Grigoli and Mota (2017), Chileshe and Akanbi (2016).
[12] Holton and d'Acri (2015), Cifarelli and Paladino (2016).
[13] For instance, this paper includes in vector X_t foreign exchange interventions as an unconventional monetary policy tool.

(moral hazard) effect concerns the borrower investment decision. Higher lending rates force the borrower to invest in riskier projects to obtain higher returns. Therefore, safer projects are pushed out by more profitable but riskier projects.

These two effects can make banks unwilling to further increase the lending rate after reaching its optimal level because of the increasing probability of default (credit rationing). This situation leads to upward stickiness of lending rates. However, as Bondt (2005) pointed out, banks do not have to ration credit. Instead, they can increase the risk premium on loans. This bank strategy could result in overestimating of the retail rate pass-through ($\beta > 1$). To avoid this possible bias, we control for the borrower credit risk by adding the non-performing loans ratio in vector X_t.

Further, when the interest rates are at zero lower bound (ZLB), the credit risk could play a different role. In the post-crisis environment, banks usually tighten their lending standards and even though the monetary policy is eased, the supply of loans is restricted (Altavilla et al., 2015; Bijsterbosch and Falagiarda, 2014; and Plašil et al., 2012). Moreover, right after the crisis banks typically evaluate new loans with a greater risk premium. This, in turn, leads to a downward stickiness in the lending rates.

Using government bonds as an alternative asset to loans may shift bank decision from commercial lending to governments lending, especially in the post GFC period. The alternative return from investing in government bonds is reflected by the spread between the government bond yield and the repo rate. It captures the impact of fiscal policy and time varying sovereign risk, as well as the expectations about the future path of short-term rates and the term premium, which further affect the setting of long-term lending rates (Hofmann and Mizen, 2004).[14]

Lastly, after 2008, the monetary conditions in the Czech Republic eased markedly, with the repo rate hitting the ZLB. The CNB started using foreign exchange interventions as an alternative monetary policy

[14] There can also be a feedback effect as these long rates may be influenced by the expectations of fiscal actions. For modelling of the strategic monetary-fiscal interactions see Libich et al. (2015)

tool as of November 2013 to manage the business cycle and inflation.[15] In this situation, the monetary policy may experience less effective transmission mechanism, especially during economic recovery (Borio and Hofmann, 2017). Therefore, we further examine whether the pass-through environment changed significantly with the greater use of FX interventions.

4. Data

We use monthly data from January 2004 to November 2017 from the CNB's ARAD database.[16] Data series and their sources are in the appendix (table A1). We examine the pass-through to four different lending rates: The consumer loan rate (*LRCONS*), mortgage loan rate (*LRMORT*), small corporate loan rate (*LRSME*), and large corporate loan rate (*LRCORP*). Small corporate loan rates are defined as lending rates on loans up to 30 million CZK granted to non-financial corporations, while large corporate loan rates are lending rates on loans over 30 million CZK granted to non-financial corporations. For the monetary policy reference rate, we use the two-week repo rate (*MPR*).

Figure 1 shows that lending rates appear to co-move together, except for the consumer loan rate, which does not exhibit a visible relationship with the repo rate. Therefore, consumer loan rates could have been influenced by other factors than the remaining lending rates. The corporate loan rate appears to co-move with the repo rate most closely, especially before 2009. Mortgage and SME loan rates seem to have reacted much less to the sharp decrease of the repo rate over 2008-9. Nevertheless, both rates still follow a decreasing trend of the repo rate until the end of our sample period. In 2012, the CNB has further lowered the main monetary policy rate to its ZLB level. While the corporate loan rates promptly reacted to this move, other rates responded less and with a delay.

[Figure 1 about here]

[15] The use of FX interventions as an alternative monetary policy tool was officially ended in April 2017. https://www.cnb.cz/en/monetary_policy/exit_exchange_rate_commit/index.html

[16] The Czech National Bank's Aggregated Time Series Database (ARAD) calculate the interest rate series as weighted average rates on loans granted to clients. For more detail see http://www.cnb.cz/docs/ARADY/MET_LIST/mir_en.pdf

To test whether changes in bank competition affect the pass-through environment in the Czech Republic, we use the Herfindahl-Hirschman index (*HHI*) of bank lending. Although the literature prefers more direct measures of bank competition such as the Lerner or Boon indicators (van Leuvensteijn et al. 2013; Leroy and Lucotte, 2015), we use the HHI because of data availability in monthly frequency and data coverage of our sample period. The Lerner index and Boone indicator are published only in annual frequency and until 2014. Although the HHI measures banking sector concentration, in the case of the Czech Republic, the HHI for lending to non-financial corporations correlates well with the annual Lerner index showing correlation coefficient of 0.94 (see figure 2, left panel). Therefore, using the HHI as a proxy measure for bank competition in the Czech Republic seems practical. Figure 2 (right panel) plots the HHI along the repo rate.

[Figure 2 about here]

Figure 3 and 4 shows the remaining explanatory variables included in vector X_t. The ratio of non-performing loans to total loans (NPLR) measures the borrower credit risk (figure 3, left panel). We use the respective NPLR for consumers (*NPLRCONS*), mortgages (*NPLRMORT*), and non-financial companies (*NPLRNFC*). Over 2004-8, the three ratios were trending down, rapidly increasing over 2008-10, and returning to their pre-crisis levels at the end of the sample period. The NPLR for consumers remained stable at 12 percent until the end of 2015 when it has started declining. For mortgages, the NPLR exhibits a similar trend as the NPLR for consumer loans but at much lower levels. Mortgages seem to be the least risky credit for banks compared with other consumer and business loans. For corporate loans, the NPLR trended down as of 2011 converging to pre-2008 levels by 2017.[17]

The Czech banking system does not show any significant evidence of systemic insolvency pressures during the sample period. The ratio of bank capital to assets (*CAPTOASSETS*) shows relatively modest variation between 9-12 percent with only a mild decrease in 2008 and 2017 below 10 percent (figure 3,

[17] For the analysis of macroeconomic drivers of non-performing loans ratio in the Czech Republic see Melecky et al. (2015).

right panel). Numerous studies emphasize the influence of bank leverage on commercial lending (Bernanke and Gertler, 1995; Kishan and Opiela, 2000; Ciccarelli et al., 2015). Therefore, we control for the possible effect of bank capitalization on bank lending rates as well.

[Figure 3 about here]

The spread between the government bond yield and the repo rate (*SPREAD_GBYREPO*), which we use to control for the term premium, sovereign risk, and the alternative cost of investing in government bonds rather than lending to the private sector, is shown in figure 4 (left panel). Before 2008, the repo rate and the spread seem to show a negative correlation, whereas after 2009, the spread follows the decreasing trend of the repo rate.

Lastly, we plot the FX interventions against the repo rate (figure 4, right panel). Figure 4 indicates a rapid grow of FX interventions starting in November 2013 and peaking in 2017.

[Figure 4 about here]

The summary statistics (table A2) show that, on average, banks charge the highest rates on consumer loans and the lowest rates on corporate loans. Correspondingly, the average NPLR (the borrower credit risk) is also the highest for consumer loans. The least risky loans seem to be the mortgage loans, followed by the corporate loans.

We perform a cross correlation test between variables in first differences (table A3). The results show almost a zero correlation coefficient between the repo rate and the consumer lending rate. Other lending rates are positively correlated with the repo rate. The highest correlation coefficient of about 0.36 is found between the repo rate and the corporate loan rate.

We test the degree of integration for the employed time series using three different unit root tests (table A4). First, we perform the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, where the null hypothesis confirms the existence of a unit root. For robustness, we use the Kwiatkowski-Phillips-Schmidt-

Shin (KPSS) test, which has an opposite null hypothesis (the time series is stationary). The results of ADF and PP tests show that the mortgage lending rate could be stationary in levels. However, we could not confirm this result with the KPSS test. All other time series are integrated to order one, I(1). Therefore, we treat all variables, including the mortgage rate as integrated to order one for the purpose of our analysis.

In addition, we report the results of unit root tests with a possible structural break (table A5 in the appendix). Although the tests identify breaks in the individual time series, we are more interested in whether the structural break(s) occurred in the studied multivariate relationship among the considered variables. Therefore, section 7 performs multi-variate tests of stability for the estimated relationships.

5. Estimation Methodology

We employ the Autoregressive Distributed Lag (ARDL) model by Pesaran and Shin (1999) and Pesaran et al. (2001) to estimate the assumed cointegration relationship and the associated short-run dynamics. The advantage of the model is that it allows us to use stationary time series I(0) as well as first order integrated time series I(1). Moreover, we can distinguish between short-run and long-run reaction of bank lending rates to changes in the monetary policy rate, and determine the speed of adjustment toward the long-run equilibrium.

First, we define the long-run co-integration relationship based on equations (1) and (2) as:

$$lr_t = \alpha_1 + \beta mpr_t + \gamma X_t + \varepsilon_t, \quad (5)$$

where lr_t is the bank lending rate, α_1 is the estimated constant, which represents the long term markup between the repo rate and the bank lending rate, β is the coefficient of long-run pass-through, mpr_t is the repo rate, γ is the estimated vector of coefficients on the control variables X_t, and ε_t is the error term. Estimated β equaling to one would indicate a complete pass-through. In contrast, estimated β smaller than one would indicate incomplete pass-through, and β higher than one would indicate an overshooting of the lending rate. The vector of control variables, X_t, includes, the risk premium component comprising the

$nplr_t$, the ratio of non-performing loans to total loans for the respective loan segment, and $captoassets_t$, the ratio of bank capital to total bank assets. The vector further contains, $spread\_gbyrepo_t$, the spread between the government bond yield and the repo rate, $grHHI_t$, the log-log difference of Herfindahl-Hirschman index of bank lending concentration, and $grcbdep_t$, the log-log difference of CNB's deposits in foreign banks measuring the size of FX interventions. In addition, we control for a possible time trend in the estimation.

To simplify the exposition of the ARDL estimation method, let us assume the ARDL (1,0,0)[18]:

$$lr_t = \delta_1 + \psi mpr_t + \theta X_t + \mu lr_{t-1} + \epsilon_t. \quad (6)$$

Hence, the error correction model (ECM) can be written as follow:[19]

$$\Delta lr_t = \underbrace{\psi \Delta mpr_t + \theta \Delta X_t}_{\textit{short run dynamics}} + \underbrace{\lambda(lr_{t-1} - \alpha_1 - \beta mpr_{t-1} - \gamma X_{t-1})}_{\textit{long run relationship}} + \epsilon_t, \quad (7)$$

where

$$\lambda = -(1-\mu), \alpha_1 = \frac{\delta_1}{1-\mu}, \beta = \frac{\psi}{1-\mu}, \gamma = \frac{\theta}{1-\mu}.$$

The ECM equation (equation 7) displays the short run dynamics (terms with delta symbol) as well as long run relationship (terms in parenthesis). The coefficient λ represents the speed of adjustment toward the long-run equilibrium. Since we assume return of lending rates to their equilibrium level, the coefficient is expected to be negative and significant. In general, higher λ (in absolute terms) means a faster adjustment of lending rates, and thus more efficient pricing of the rates.

To confirm the existing cointegration relationship between variables, we use the Bound test proposed by Pesaran et al. (2001). It allows us to compare the estimated F-statistic value with border critical values

[18] Numbers in parentheses show lag length structure. In our estimation, we use the Schwarz criterion (SC) to select an appropriate lag structure of endogenous variables in each ARDL model.
[19] Similar specifications with a set of conditioning variables were used, for instance, by Leroy and Luccote (2015), Gambacorta et al. (2015), Grigoli and Mota (2017), Chileshe and Akanbi (2016), Holton and d'Acri (2015).

for I(0) and I(1) time series. If the estimated value of the F-statistic is higher than the upper bound value provided by Pesaran et al. (2001), then we can confirm the cointegration relationship.

6. Estimation Results for Baseline Specification

We estimate the pass-through and its determinants for four different types of lending rates: The consumer loan rate, mortgage loan rate, small corporate (SME) loan rate, and large corporate loan rate. The estimation results are reported in table 1. We show both the long-run relationship and the short-run dynamics of the estimated relationship for lending rates.

The results suggest that according to the ARDL Bounds test we cannot confirm a long-run relationship for consumer lending rates. Nevertheless, mortgage, SME, and corporate rates co-move with the repo rate, suggesting a complete pass-through in the long run. In the short run, the mortgage rate showed the weakest pass-through and speed of adjustment to the equilibrium. The short-run pass-through to SME and corporate rates is much stronger. Namely, using equation 7, the estimates suggest that banks transmit 45 and 34 percent of the change in the repo rate into their SME and corporate rates in the following period (month).

The borrower credit risk (*NPLR*) significantly increases the lending rate premiums over the repo rate only for the consumer rate. In contrast, the bank credit risk measured by the capital to assets ratio affects only the SME rate. Less leveraged banks extended riskier SME loans with proportionately higher rates than did the more leveraged banks. Interestingly, bank credit risk did not have significant impact on the mortgage rate and corporate rate. For the mortgage rate, it is perhaps due to low risk perception of the real estate market and the dominant collateralizing with primary residence. For the corporate rate, it may be due to a reduced supply of loans in the post-2008 period together with a crowding out effect of government bonds, which pushed riskier corporate loans from the market.

The spread between the government bond yield and the repo rate has a significant effect on all lending rates. The effect is stronger for loans to households than loans to enterprises. This result could suggest that the term premium and/or sovereign risk could affect households more than enterprises. While the spread affects all lending rates, bank lending concentration, our control proxy for bank competition, does not affect any of our lending rates when controlling for other macro-financial determinants.

The FX interventions, measured by the log-log difference of central bank deposits in foreign banks (*grCBDEP*), significantly influence the SME and corporate lending rates. However, the results are counterintuitive. Lower growth rate of FX interventions helps decrease the interest rates. Perhaps funds that would, at existing interest rate spread and risk premium, flow to the Czech economy stayed abroad and were used to buy the Czech korunas offshore. Hence, the supply of capital to the Czech economy might have decreased, helping to increase the lending rate. Nevertheless, this would render the FX interventions ineffective through the interest rate channel and leave their effectiveness dependent only on other channels such as the exchange rate channel. Future research could investigate this hypothesis in detail.

Loan rates for mortgages and corporations show significant trends over time on top of the one followed by the monetary policy rate and all other variables covered in vector X_t. The time trend has mildly positive slope for both rates. One explanation of the mild trends could be a possible shift in the respective interest rate spreads (gradual repricing of risk) and the underlying relationships after the GFC that indirectly affected also the financial sector behavior in the Czech Republic.

[Table 1 about here]

7. Testing for Possible Structural Shifts (Breaks)

The last decade in the Czech Republic and whole Europe has been characterized by lower stability or instability, respectively. Hence, we perform several tests of multiple breakpoints to identify any possible structural breaks in our estimated baseline model. We consider four different tests for multiple unknown breakpoints. Two of them use the global optimization procedure and other two use the sequential procedure Perron (2006). The results of all tests are shown in table 2.

[Table 2 about here]

The estimated models for consumer and SME lending rates seem to be stable and we could not confirm any structural breaks. For mortgage and corporate lending rates, however, the tests detect mostly two breakpoints. We choose the Bai-Perron (1998) test with globally determined breaks as our preferred test because, according to Perron (2006), it performs better than sequential tests in determining multiple structural shifts. In line with the results of our preferred test, we set the break dates for the mortgage lending rate to September 2010 and February 2014. The dates may represent a delay reaction of the mortgage market to the onset of GFC, and the monetary policy rate hitting the zero lower bound in December 2012. For corporate lending rates, the break dates are set to August 2007 and January 2011. In contrast to the mortgage market, the non-financial sector may be more efficient and respond largely in expectation. Therefore, the first break may reflect the response to the onset of GFC in the US, while the second break may be connected to adoption of new regulation framework for the EU banks.

To control for structural changes, we extend our baseline model by shift dummies according to the Bai and Perron multiple break test (table 2, test 1):

$$lr_t = \alpha_1 + \beta mpr_t + \gamma X_t + \rho_1 dummy\_1_t^S + \rho_2 dummy\_2_t^S + \rho_3 (dummy\_1_t^S \cdot mpr_t) + \rho_4 (dummy\_2_t^S \cdot mpr_t) + \varepsilon_t, \quad (8)$$

where the $dummy\_1_t^S$ and $dummy\_2_t^S$ are specified for each lending rate as shown in table 3.

[Table 3 about here]

We re-estimate the model using the ARDL approach.

[Table 4 about here]

The results show, that the pass-through to mortgage rates dropped significantly after 2014 and turned out to be negative. Thus, in response to the MPR reaching the zero lower bound, the pass-through to mortgage rates fell practically to zero. In contrast, the pass-through to corporate lending rates is not showing any structural shifts. Specifically, while the 2014 dummy variable significantly affects the size of the pass-through for mortgage rates—the respective interactive term is statistically significant at the 1 percent level—the dummy variables in model for corporate rates are insignificant in interaction with the MPR. However, the two dummies affect the conditional mean of the corporate lending rate, indicating structural shifts in the markup function. In the first case, August 2007, the expectations about a possible global financial crisis led to an increase of the corporate lending rate (its markup) by 1 percentage point. In the second case, January 2011, the situation was reversed and the average markup dropped down by 0.8 percentage point around the time when the new Capital Requirement Directive (CRD III) for the European Union was adopted and helped decrease the uncertainty about future bank capital requirements.

In the short-run, estimates support the long-run results for corporate rates. They confirm stable pass-through and significant effect of both dummy variables on corporate lending rates (markups). For mortgages, the 2014 dummy variable no longer affects the size of the pass-through, but directly the lending rate markup.

Turning to the control variables, we register only mild differences in estimation results compared with our baseline model estimates. First, with the inclusion of the shift dummy variables, the effect of the spread between the government bond yield and the repo rate becomes insignificant for corporate lending rates. In contrast, the effect of NPLR turns out to be significant—indicating that banks could increase the markup (charge a higher risk premium) on corporate loans to cover increasing expected loses when NPLR for corporations rises.

Interestingly, with the inclusion of the shift dummies, the speeds of adjustment (pricing efficiency) increased for all lending rates. While the speed of adjustment for the mortgage rates increased only modestly, the one for corporate rates doubled.

8. Non-linear Effects

To test whether the individual variables in our vector X_t affect both the average markup and the pass-through from monetary policy rate, we specify the model to include the following interaction terms:

$$lr_t = \alpha_1 + \beta mpr_t + \gamma X_t + \varphi(mpr_t \cdot X_t) + \varepsilon_t. \quad (9)$$

where $mpr_t \cdot X_t$ represents the interactions of all variables in vector X_t with the monetary policy rate. We test the significance of the interaction terms one by one. If the interaction term is jointly significant with the corresponding explanatory variable, we include the term into the final model specification. The final estimated models are shown in table 5.

[Table 5 about here]

According to the results, we cannot confirm any non-linear effect for consumer and SME lending rates. For these two rates, we return back to the baseline specification for our final model estimation. For the other two rates on mortgages and corporate loans, we find significant negative effects of an interaction between the monetary policy rate (*MPR*) and capital to assets ratio (*CAPTOASSETS*) on the respective lending rates. The total size of the interest rate pass-through may by calculated according to the following equation:

$$\textit{Pass-through} = \beta + \varphi_2 \cdot \textit{average captoassets}, \quad (10)$$

where β shows the mean pass-through (*MPR* coefficient), φ_2 represents the coefficient of the interaction term ($MPR \cdot CAPTOASSETS_t$), and *average captoassets* is the unconditional sample mean of the capital to assets ratio (see the Summary statistics in table A4).

According to equation 10, we calculate the pass-through for mortgage rates to equal 0.56, and for corporate rates to equal 0.5, when the pass through is allowed to vary with the degree of bank leverage. The results demonstrate a significant decline of the pass-through compared with the baseline estimation for periods when bank leverage fell to or below its sample mean value. Therefore, deleveraging of the banking sector has significantly reduced the strength of the pass-through from the monetary policy rate to mortgage and corporate lending rates. Presumably, higher capital requirements imposed by the incoming BASEL III regulatory framework have pushed banks to enforce tighter lending standards, which have interacted with the efficiency of the monetary transmission mechanism. Specifically, banks at higher lending standards might have been forced to reduce their lending activity to maintain an adequate capital ratio, which decreased the sensitivity of their lending rates to changes in the monetary policy rate.

Considering the significance of other variables included in vector X_t, the estimates of the non-linear model are similar to those of the model with structural shift dummies. The results show a significant positive effect of the spread between government bond yield and the repo rate (*SPREAD_GBYREPO*) on the mortgage lending rate, and a significant positive effect of the non-performing loans ratio (*NPLR*) and FX interventions (*CBDEP*) on the corporate lending rate.

An interesting hypothesis to test next is whether the interaction between the capital to assets ratio and the monetary policy rate could explain the structural breaks estimated earlier using the shift dummies. Hence, we again test for possible multiple breaks for the estimated models specified in equation 9.

[Table 6 about here]

The multiple breakpoint tests do not reveal any structural changes for the mortgage lending rate. This result suggests that the process of deleveraging caused the break in the pass-through for the mortgage lending rate. For the corporate lending rate, we mostly confirm zero breaks as well. However, when using a different statistic than F-test, two breakpoints are indicated by the Bai-Perron test. Therefore, we estimate yet another model for the corporate lending rate including both dummy variables together with the interaction term for the monetary policy rate and the capital to assets ratio. The equation is specified as follows:

$$lr_t = \alpha_1 + \beta mpr_t + \gamma X_t + \varphi_2(mpr_t \cdot captoassets_t) + \rho_1 dummy\_1_t^S + \rho_2 dummy\_2_t^S + \varepsilon_t. \quad (11)$$

Table 7 shows the estimation results. The interactive term and both dummies turn out to be significant. However, the size of the coefficients for both dummy variables decreased almost by half. This result suggests that the capital to assets ratio partly, but not fully, explains the structural shifts in the pass through for the corporate loans. Using equation 10, we determine the size of the interest rate pass-through to be

0.57, which is similar to the results of the model with interaction terms only. Therefore, increasing capital ratios (deleveraging) is mostly responsible for the reduced pass-through to corporate lending rates.

Lastly, we confirm the significant effect of the NPL ratio and FX interventions—measured as central bank deposits in foreign banks. Both results are robust, holding throughout all extended specifications.

[Table 7 about here]

9. Further Tests of Stability

We further test the stability of the best-fitting models using rolling regressions to gain insights into the sample dynamics of the estimated pass-through. We roll through the sample (January 2004 – November 2017) using a fixed window of 75 observations and the step size set to one. Doing this, we get 92 estimated time-varying coefficients of the interest rate pass-through. We plot their dynamics over time and compare it to the estimated mean and confidence intervals for the entire sample. Figure 5 plots the estimated rolling pass-through for each market segment.

[Figure 5 about here]

The rolling pass-through for the consumer lending rate shows two major drops into the negative territory (figure 5, top left panel). Recall that we could not confirm any cointegration relationship between the repo rate and consumer loans rate. The rolling estimates could thus simply reflect the overall instability of the pass-through for consumer rates. For the mortgage lending rates, the rolling pass-through shows a small drop followed by a sharp increase in 2011. As of 2012, the rolling coefficient gradually declines reaching a zero pass-through by 2016 (figure 5, top right panel).

The SME rolling pass-through exhibits the highest stability over time (figure 5, bottom left panel). The moderate decline in 2012-14 is promptly reversed. By the end of 2015 and at the beginning of 2016, the SME rolling coefficient falls rapidly, reducing the pass-through efficiency by half. The rolling coefficient for corporate loans follows a similar trend as the rolling coefficient for mortgages (figure 5, bottom right panel). In this case, the plot shows a continuous decline of the pass-through starting at the end of 2011 followed by a deep sudden fall to zero at the beginning of 2015. By the end of the estimation period, the rolling pass-through partly recovers and returns into the wider confidence band.

Overall, the rolling pass-through for mortgage and corporate lending rates indicate that, after 2012-13, the interest rate channel of monetary policy becomes unstable. According to our previous estimations, the instability could be partly related to the deleveraging of the Czech banking sector. To gain further insight, figure 6 plots the rolling pass-through against the rolling mean of the capital to assets ratio. The figure illustrates the opposite trends in the rolling pass-through and average capital to asset ratio for mortgage and corporate rates corroborating our estimation results with interaction terms. An increasing capital to assets ratio has, on average, restrained the strength of the pass-through.

[Figure 6 about here]

In addition, we estimate the rolling coefficients for the spread between the government bond rate and the monetary policy rate. This spread could capture the effects of a changing term premium and sovereign risk on the markup for different lending rates. We have previously estimated that this spread significantly influences the markups for all rates—perhaps apart from the corporate lending rates when considering the model specification with interactive terms. For SME and corporate rates, the respective rolling coefficients are estimated to be more stable than for consumer and mortgage rates (figure A1 in the appendix).

We also perform the CUSUM test for our best-fitting models: The baseline model for consumer and SME lending rates, the model with interaction terms for mortgages, and the model with interaction terms and breakpoint dummies for the corporate lending rates. The CUSUM tests and the CUSUM of squares tests are plotted in figures A2 and A3 in the appendix. Both tests confirm that our models are overall stable in their parameters, except the consumer lending rate model. Recall that, for consumer lending rates, we could not confirm any long-run cointegration relationship.

10. Conclusion

This paper examined how changes in the monetary policy rate affected the lending rates for consumer, mortgage, SME, and corporate loans in the Czech Republic from January 2004 to November 2017. To this end, we controlled for changing macro-financial factors that could affect the lending rate markup and possibly the pass-through as well. Moreover, we tested whether the interest rate pass-through is stable or depends on the level of bank competition, bank leverage, borrower credit risk, and the use of FX interventions.

Using the ARDL modelling approach, we found a stable long-run interest rate pass-through for mortgages, SME, and corporate lending rates. With no model specification could we confirm a stable pass-through from the monetary policy rate to consumer lending rates. The most important determinant of the markup across all considered lending rates is the spread between the government bond rate and the monetary policy rate, which captures the influence of a changing term premium and sovereign risk. The increasing spread raises the lending rate markup more for the mortgage and consumer rates than for the SME and corporate rates. The markup for SME and corporate rates is also significantly influenced by the level of CNB foreign currency deposits abroad—our proxy of FX interventions—however, in a puzzling direction. One explanation could be that rising CNB deposits abroad and the foreign currency investments in Czech korunas might not have increased the supply of funds in the Czech economy if these koruna investments stayed abroad. Moreover, the funds that would otherwise flow into the Czech economy stayed invested (in the korunas) abroad. In addition, the SME markup increases when the capital to assets ratio rises and banks deleverage.

Testing the stability of the estimated models, we found significant structural shifts in the models of interest rate pass-through for the mortgage and corporate lending rates. For the mortgage rate, these structural shifts can be fully explained and the model stabilized by allowing the pass-through to vary with different levels of bank leverage. For the corporate rates, allowing a similar interaction can explain much of the structural shifts but not all of them. Namely, the markup for corporate rates experienced two structural shifts in 2007—an increasing markup after the onset of the global financial crisis—and in 2011—a declining markup around the adoption to new CRD III for the EU. For both the mortgage and corporate rates, we found that when banks, in their deleveraging, reached the sample mean of the capital to assets ratio, the pass-through fell to about 0.5, indicating much smaller influence of monetary policy over the pricing of mortgages and corporate loans.

To gain further insights into the stability of the estimated pass through, we estimated the rolling pass-through for each lending market segment. These rolling pass-through coefficients indicated a greater stability of the pass-through to SME rates than to corporate and mortgage rates. The most volatile rolling pass-through estimated for the consumer rates reflects the overall instability and lacking cointegration for these rates. While all rolling pass-through coefficients decline at the end of the sample period, the declines are more pronounced for mortgage and corporate rates than for the SME rate. They reflect the role of declining leverage and increasing ratios of capital to assets.

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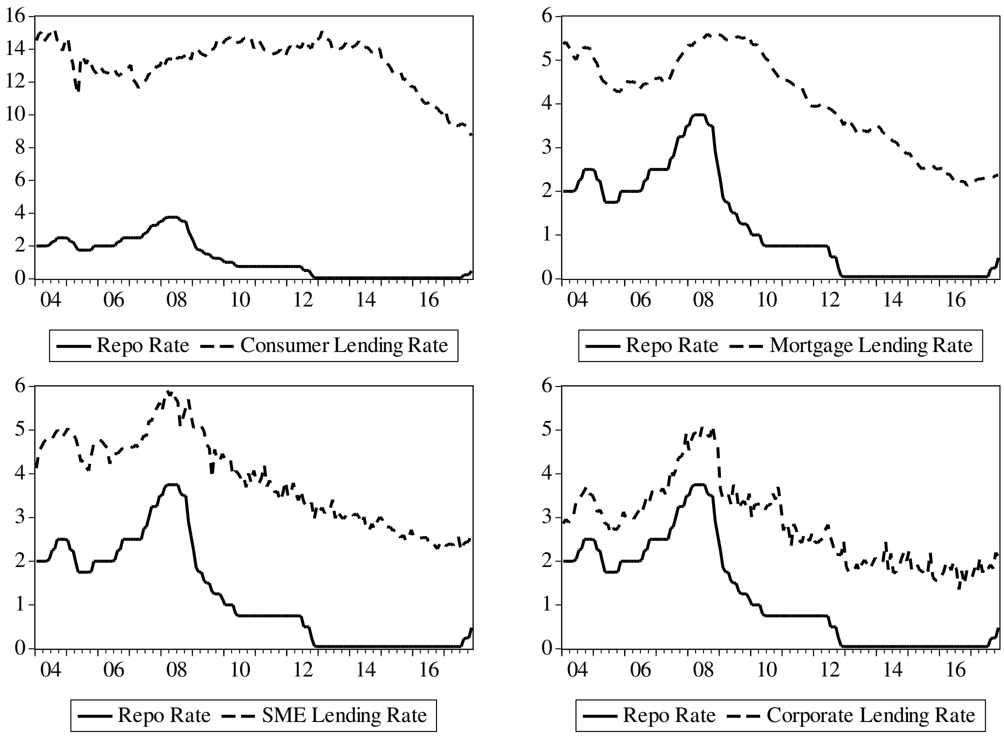
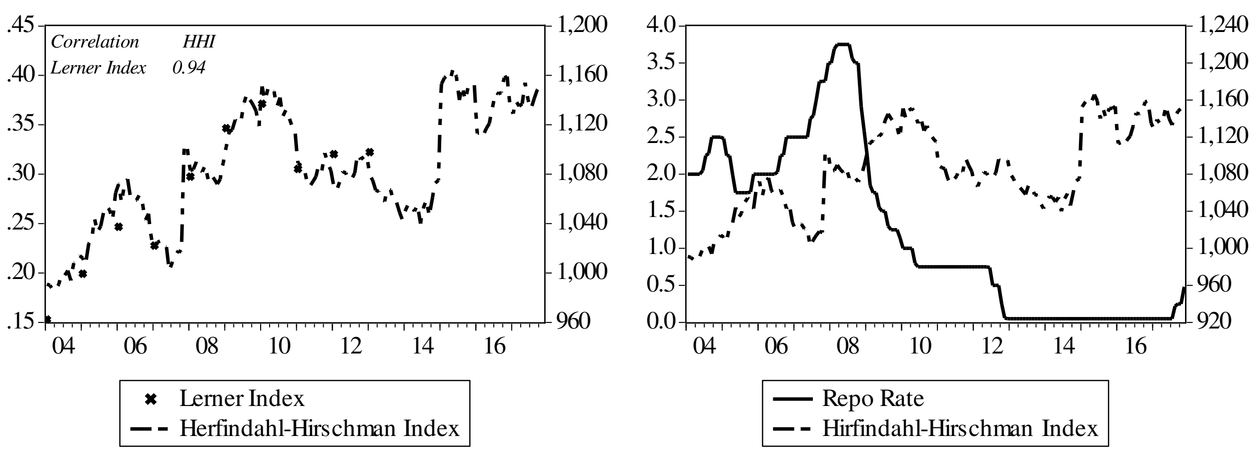
Figures and Tables in the Main Text

Figure 1 - Individual Lending Rates and the Repo Rate



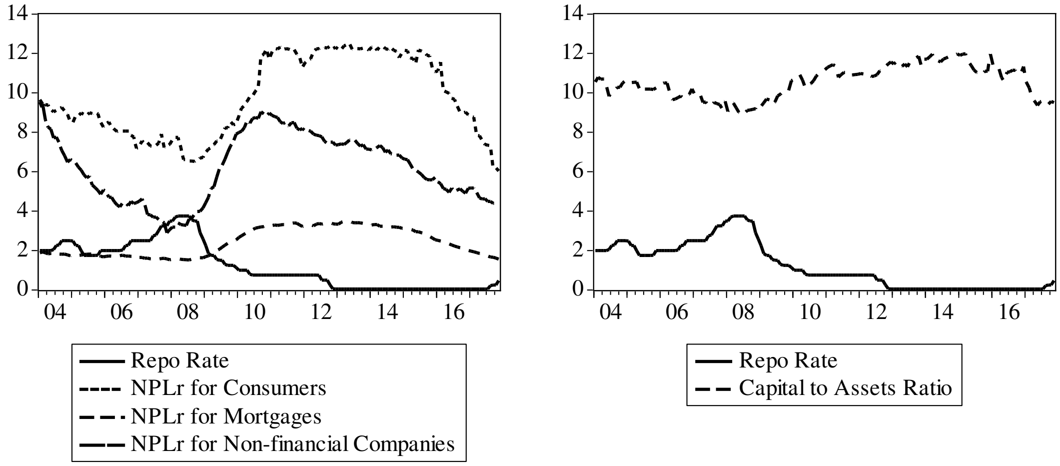
Source: CNB's ARAD database (2017)

Figure 2 - Herfindahl-Hirschman Index as a Proxy for Lerner Index and Bank Competition



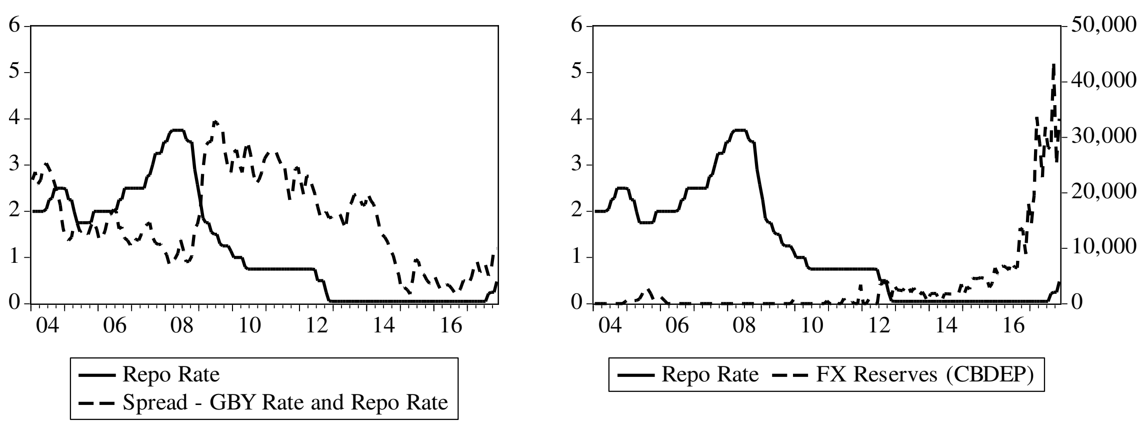
Source: CNB's ARAD database (2017)

Figure 3 - Non-Performing Loans and Capital to Assets Ratio against the Repo Rate



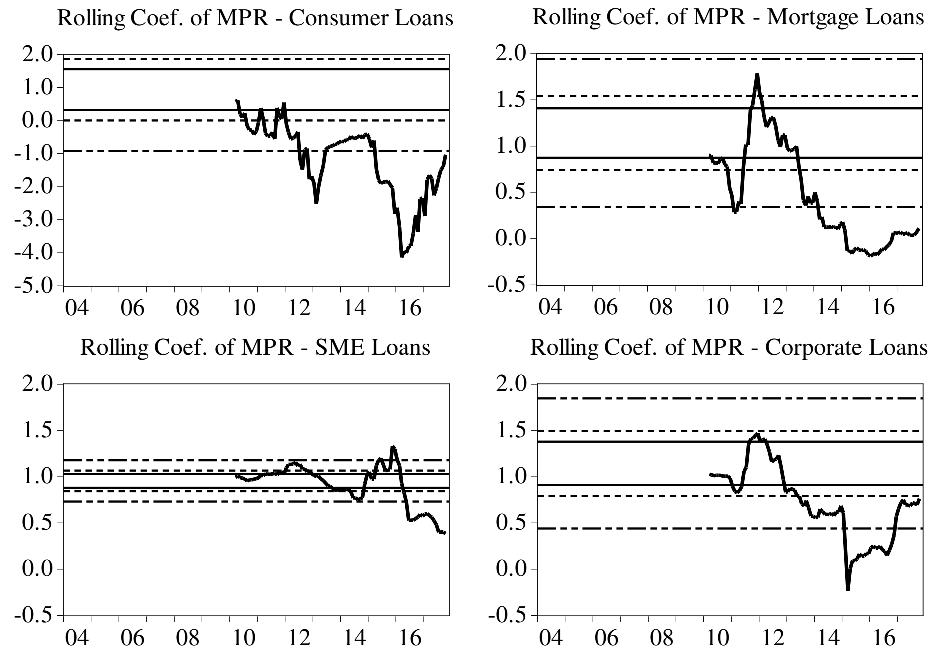
Source: CNB's ARAD database (2017)

Figure 4 – Spread between GBY and Repo Rate and FX Reserves (CBDEP) against the Repo Rate



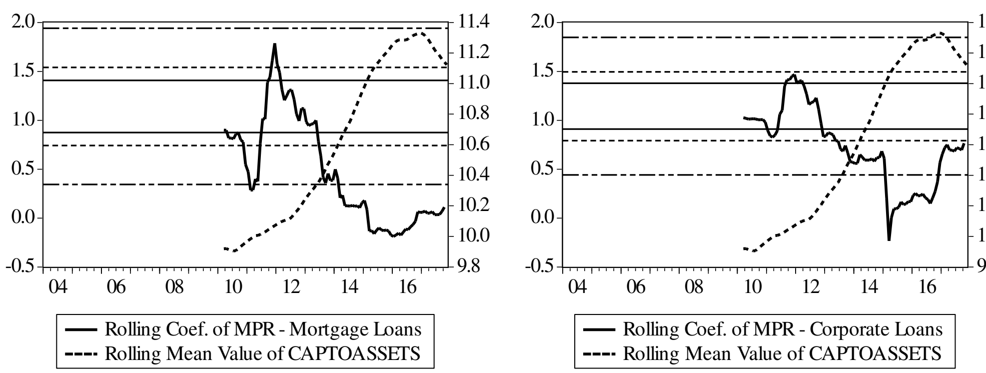
Source: CNB's ARAD database (2017)

Figure 5 - Rolling Coefficient of the Monetary Policy Rate (Baseline Model)



Notes: Rolling regression with fixed window (window size: 75, step size: 1, number of subsamples: 92). Horizontal lines represent confidence intervals of two, three and six standard deviations.

Figure 6 - Rolling Coefficient of the Monetary Policy Rate vs Rolling Mean Value of Capital to Assets Ratio



Notes: Rolling regression with fixed window (window size: 75, step size: 1, number of subsamples: 92). Horizontal lines represent confidence intervals of two, three and six standard deviations (MPR).

Table 1 – Results of Baseline Model

	(1) Consumer Loans	(2) Mortgage Loans	(3) SME Loans	(4) Corporate Loans
Long-run Cointegration Relationship				
MPR	**0.9323***** **(0.3094)**	**1.1413***** **(0.1331)**	**0.9546***** **(0.0371)**	**1.1437***** **(0.1171)**
NPLR	**0.5464**** **(0.2314)**	-0.1857 (0.1952)	-0.0132 (0.0390)	0.1004 (0.0679)
CAPTOASSETS	-0.3722 (0.8138)	0.1240 (0.1419)	**0.2421***** **(0.0628)**	-0.0612 (0.1159)
SPREAD_GBYREPO	**1.2999***** **(0.3182)**	**0.7720***** **(0.0906)**	**0.2713***** **(0.0524)**	**0.2152**** **(0.0931)**
grHHI	-22.0085 (28.950)	-2.0717 (1.5301)	0.7905 (2.0504)	2.7938 (3.7008)
grCBDEP	-0.1946 (0.2894)	0.0088 (0.0369)	**0.0555**** **(0.0228)**	**0.0914**** **(0.0425)**
C	7.8616 (6.9069)			
SPEED OF ADJ.	**-0.0943**** **(0.0422)**	**-0.0987***** **(0.0161)**	**-0.4544***** **(0.0524)**	**-0.3370***** **(0.0665)**
Short-run Dynamics				
ΔMPR	0.0879 (0.0571)	**0.1127***** **(0.0169)**	**0.4338***** **(0.0481)**	**0.3854***** **(0.0853)**
ΔNPLR	0.0515 (0.0360)	-0.0183 (0.0175)	-0.0060 (0.0177)	0.0338 (0.0241)
ΔCAPTOASSETS	-0.0351 (0.0920)	0.0122 (0.0150)	**0.1100***** **(0.0290)**	-0.0206 (0.0389)
ΔSPREAD_GBYREPO	**0.1226***** **(0.0452)**	**0.0762***** **(0.0127)**	**0.1233***** **(0.0288)**	**0.0725**** **(0.0338)**
ΔgrHHI	-2.0754 (2.6888)	-0.2046 (0.2028)	0.3592 (0.9394)	0.9415 (1.2413)
ΔgrCBDEP	-0.0184 (0.0226)	0.0009 (0.0039)	**0.0252**** **(0.0097)**	**0.0308**** **(0.0128)**
C	0.7414 (0.6972)	-0.0457 (0.1686)	-0.1174 (0.2685)	0.0916 (0.4301)
Trend		**0.0009***** **(0.0003)**		**0.0033***** **(0.0010)**
Lag Length Structure	1,0,0,0,1,0,0	1,0,0,0,1,0,0	2,0,0,0,1,0,0	2,1,0,0,0,0,0
Num. Of obs.	166	166	165	165
Adj. R-squared	0.9497	0.9972	0.9807	0.9591
ARDL Bounds Test	2.0710 [2.43 - 3.52]	12.4831 [3.077 - 4.284]	13.858 [2.627 - 3.864]	4.8989 [3.077 - 4.284]
Covariance Matrix	HAC	WHITE		

Notes: ***, **, * - shows statistical significance at the 1%, 5%, and 10%. The sample covers period from January 2004 to November 2017. The lag length structure is chosen according to the Schwarz Criterion (SC) while the maximum lag length is set at twelve lags. We include the linear trend into the equation only if it is statistically significant. Terms in parentheses show standard errors and values in brackets are critical values for the ARDL Bound test. Term *WHITE (HAC)* means that we used the White (the Newey-West HAC) covariance matrix to deal with an observed heteroscedasticity (autocorrelation and heteroscedasticity) in the residuals for the estimated model.

Table 2 – Multiple Breakpoint Tests for Baseline Model

	Consumer Lending Rate	**Mortgage Lending Rate**		**SME Lending Rate**	**Corporate Lending Rate**	
	No. of breaks	No. of breaks	Estimated Break Dates	No. of breaks	No. of breaks	Estimated Break Dates
1. Bai-Perron tests of 1 to M globally determined breaks						
Sequential F-statistic determined breaks:	0	2	**2010M09** **2014M02**	0	2	**2007M08** **2011M01**
Significant F-statistic largest breaks:	0	2	**2010M09** **2014M02**	0	2	**2007M08** **2011M01**
UDmax determined breaks:	0	1	**2007M07**	0	1	**2011M01**
WDmax determined breaks:	0	2	**2010M09** **2014M02**	0	1	**2011M01**
2. Compare information criteria for 0 to M globally determined breaks						
Schwarz criterion selected breaks:	0	0		0	1	**2011M01**
LWZ criterion selected breaks:	0	0		0	0	
3. Bai-Perron tests of L+1 vs. L sequentially determined breaks						
Sequential F-statistic determined breaks:	0	2	**2007M06** **2010M05**	0	2	**2009M01** **2011M01**
4. Bai tests of breaks in all recursively determined partitions						
Sequential F-statistic determined breaks:	0	2	**2007M06** **2010M05**	0	2	**2009M01** **2011M01**

Table 3 – Specification of Structural Dummies

	dummy_1	***dummy_2***
Consumer Loans	**-**	**-**
Mortgage Loans	Value of 0 before **2010M09** and 1 thereafter.	Value of 0 before **2014M02** and 1 thereafter.
SME Loans	-	-
Corporate Loans	Value of 0 before **2007M08** and 1 thereafter.	Value of 0 before **2011M01** and 1 thereafter.

Table 4 – Results of the Model with Dummy Variables Based on Bai-Perron Breakpoint Test

	(5) Mortgage Loans	(6) Corporate Loans
Long-run Cointegration Relationship		
MPR	**0.9795***** **(0.0929)**	**1.1567***** **(0.1268)**
NPLR	-0.0500 (0.1610)	**0.0731**** **(0.0318)**
CAPTOASSETS	0.1498 (0.1089)	0.0586 (0.0617)
SPREAD_GBYREPO	**0.6797***** **(0.0747)**	0.0882 (0.0555)
grHHI	-1.7671 (1.0844)	0.6238 (1.5525)
grCBDEP	0.0124 (0.0235)	**0.0318*** **(0.0162)**
DUMMY_1	-0.4494 (0.3188)	**1.0315**** **(0.4985)**
DUMMY_2	-0.3215 (0.1995)	**-0.8012***** **(0.1463)**
MPR*DUMMY_1	-0.3857 (0.2988)	-0.2832 (0.1748)
MPR*DUMMY_2	**-1.3548***** **(0.5099)**	0.1693 (0.1532)
SPEED OF ADJ.	**-0.1383***** **(0.0195)**	**-0.7490***** **(0.0654)**
Short-run Dynamics		
ΔMPR	**0.1354***** **(0.0175)**	**0.8664***** **(0.1210)**
ΔNPLR	-0.0069 (0.0225)	**0.0548**** **(0.0239)**
ΔCAPTOASSETS	0.0207 (0.0161)	0.0439 (0.0460)
ΔSPREAD_GBYREPO	**0.0940***** **(0.0131)**	0.0661 (0.0409)
ΔgrHHI	-0.2443 (0.1916)	0.4672 (1.1636)
ΔgrCBDEP	0.0017 (0.0037)	**0.0238**** **(0.0118)**
ΔDUMMY_1	-0.0621 (0.0462)	**0.7726*** **(0.3918)**
ΔDUMMY_2	**-0.0444*** **(0.0249)**	**-0.6001***** **(0.1227)**
ΔMPR*DUMMY_1	-0.0533 (0.0358)	-0.2121 (0.1349)
ΔMPR*DUMMY_2	-0.1873 (0.1222)	0.1268 (0.1165)
C	-0.0644 (0.1658)	-0.4498 (0.5544)
Trend	**0.0016***** **(0.0004)**	**0.0054**** **(0.0025)**
Lag Structure:	1,0,0,0,1,0,0,0,0,0,0	1,0,0,0,0,0,0,0,0,0,0
Num. Of obs.	166	166
Adj. R-squared	0.9975	0.9647

ARDL Bounds Test	11.2147 [2.33 - 3.46]	13.4994 [2.33 – 3.46]
Covariance Matrix	WHITE	

Notes: ***, **, * - shows statistical significance at the 1%, 5%, and 10%. The sample covers period from January 2004 to November 2017. The lag length structure is chosen according to the Schwarz Criterion (SC) while the maximum lag length is set at three lags. We include the linear trend into the equation only if it is statistically significant. Terms in parentheses show standard errors and values in brackets are critical values for the ARDL Bound test. Term *WHITE* means that we used the White covariance matrix to deal with an observed heteroscedasticity in the model.

Table 5 – Results of the Model with Interaction Terms

	(7) Consumer Loans	(8) Mortgage Loans	(9) SME Loans	(10) Corporate Loans
Long-run Cointegration Relationship				
MPR	**6.0214**** **(3.0506)**	**3.9728****** **(0.9946)**	0.4183 (0.4133)	**3.4095****** **(0.6645)**
NPLR	**0.4793***** **(0.1904)**	-0.1347 (0.2779)	-0.0340 (0.0487)	**0.1606***** **(0.0753)**
CAPTOASSETS	0.4545 (0.4145)	0.0481 (0.1861)	**0.2256****** **(0.0598)**	-0.1841 (0.1200)
SPREAD_GBYREPO	**1.5342****** **(0.2854)**	**0.7350****** **(0.1436)**	**0.3032****** **(0.0666)**	0.0917 (0.0954)
grHHI	-15.636 (17.017)	-2.1188 (1.9382)	0.5800 (2.1699)	2.9652 (3.9274)
grCBDEP	-0.1075 (0.1698)	0.0067 (0.0374)	0.0581 (0.0376)	**0.0978***** **(0.0440)**
MPR*NPLR	-0.3569 (0.2443)	-0.1154 (0.2266)		
MPR*CAPTOASSETS	-0.2372 (0.4141)	**-0.3233****** **(0.1158)**	0.0577 (0.0440)	**-0.2756****** **(0.0674)**
MPR*SPREAD_GBYREPO		0.0580 (0.0889)	-0.0231 (0.0436)	
MPR*GRCBDEP			0.0145 (0.0340)	
SPEED OF ADJ.	**-0.1483****** **(0.0452)**	**-0.0979****** **(0.0192)**	**-0.4049****** **(0.0529)**	**-0.3141****** **(0.0560)**
Short-run Dynamics				
ΔMPR	**0.8928**** **(0.4763)**	**0.3889****** **(0.0780)**	0.1694 (0.1764)	**1.0708****** **(0.2607)**
ΔNPLR	0.0711 (0.0497)	-0.0132 (0.0269)	-0.0137 (0.0182)	**0.0505***** **(0.0250)**
ΔCAPTOASSETS	0.0674 (0.1143)	0.0047 (0.0184)	**0.0914****** **(0.0300)**	-0.0578 (0.0378)
ΔSPREAD_GBYREPO	**0.2275****** **(0.0546)**	**0.0719****** **(0.0166)**	**0.1228****** **(0.0330)**	0.0288 (0.0304)
ΔgrHHI	-2.3184 (2.6197)	-0.2074 (0.1901)	0.2349 (0.9415)	0.9313 (1.2304)
ΔgrCBDEP	-0.0159 (0.0220)	0.0007 (0.0037)	0.0235 (0.0190)	**0.0307***** **(0.0126)**
ΔMPR*NPLR	-0.0529 (0.0428)	-0.0113 (0.0217)		
ΔMPR*CAPTOASSETS	-0.0352 (0.0751)	**-0.0317****** **(0.0099)**	0.0234 (0.0174)	**-0.0866****** **(0.0242)**
ΔMPR*SPREAD_GBYREPO		0.0057 (0.0087)	-0.0094 (0.0184)	
ΔMPR*GRCBDEP			0.0059 (0.0201)	
C	-0.0269 (0.8438)	0.1601 (0.1486)	-0.0016 (0.2767)	**0.8854***** **(0.3745)**
Lag Structure	1,0,0,0,1,0,0,0,0	1,1,0,0,1,0,0,0,2,0	2,0,0,0,0,0,0,0,1,0	2,0,0,0,0,0,0,1
Num. Of obs.	166	165	165	165
Adj. R-squared	0.9524	0.9976	0.9810	0.9597
ARDL Bounds Test	2.9222	9.3839	9.0615	5.1358

	[2.22 - 3.39]	[2.14 - 3.3]	[2.14 - 3.3]	[2.48 - 3.75]
Covariance Matrix	HAC		WHITE	

Notes: ***, **, * - shows statistical significance at the 1%, 5%, and 10%. The sample covers period from January 2004 to November 2017. The lag length structure is chosen according to the Schwarz Criterion (SC) while the maximum lag length is set at three lags. We include the linear trend into the equation only if it is statistically significant. Terms in parentheses show standard errors and values in brackets are critical values for the ARDL Bound test. Term *WHITE (HAC)* means that we used the White (the Newey-West HAC) covariance matrix to deal with an observed heteroscedasticity (autocorrelation and heteroscedasticity) in the estimated model residuals.

Table 6 - Multiple Breakpoint Tests for Model with Interaction Terms

	Mortgage Lending Rate	Corporate Lending Rate	
	No. of breaks	No. of breaks	Estimated Break Dates
1. Bai-Perron tests of 1 to M globally determined breaks			
Sequential F-statistic determined breaks:	-	0	
Significant F-statistic largest breaks:	-	2	**2007M08** **2011M01**
UDmax determined breaks:	-	2	**2007M08** **2011M01**
WDmax determined breaks:	-	2	**2007M08** **2011M01**
2. Compare information criteria for 0 to M globally determined breaks			
Schwarz criterion selected breaks:	-	2	**2007M08** **2011M01**
LWZ criterion selected breaks:	-	0	
3. Bai-Perron tests of L+1 vs. L sequentially determined breaks			
Sequential F-statistic determined breaks:	0	0	
4. Bai tests of breaks in all recursively determined partitions			
Sequential F-statistic determined breaks:	0	0	

Table 7 – Results of the Model with an Interaction term and Dummy Variables

	(11) **Corporate Loans**
Long-run Cointegration Relationship	
MPR	**1.8278***** **(0.5341)**
NPLR	**0.1101**** **(0.0432)**
CAPTOASSETS	-0.0668 (0.0664)
SPREAD_GBYREPO	0.0179 (0.0537)
grHHI	0.7113 (2.1485)
grCBDEP	**0.0504**** **(0.0233)**
MPR*CAPTOASSETS	**-0.1187**** **(0.0567)**
DUMMY_1	**0.5363***** **(0.1096)**
DUMMY_2	**-0.5710***** **(0.1148)**
SPEED OF ADJ.	**-0.5449***** **(0.0751)**
Short-run Dynamics	
MPR	**0.9960***** **(0.2854**
NPLR	**0.0600**** **(0.0241)**
CAPTOASSETS	-0.0364 (0.0360)
SPREAD_GBYREPO	0.0098 (0.0293)
grHHI	0.3876 (1.1670)
grCBDEP	**0.0274**** **(0.0119)**
MPR*CAPTOASSETS	-0.0163 (0.0309)
DUMMY_1	**0.2923***** **(0.0795)**
DUMMY_2	**-0.3111***** **(0.0724)**
C	1.0555 (0.6317)
Lag Structure	**2,0,0,0,0,0,0,1,0,0**
Num. Of obs.	165
Adj. R-squared	0.9643
ARDL Bounds Test	6.2915 [2.14 - 3.3]

Notes: ***, **, * - shows statistical significance at the 1%, 5%, and 10%. The sample covers period from January 2004 to November 2017. The lag length structure is chosen according to the Schwarz Criterion (SC) while the maximum lag length is set at three lags. We include the linear trend into the equation only if it is statistically significant. Terms in parentheses show standard errors and values in brackets are critical values for the ARDL Bound test.

Appendix

Table A1 - Data series and their sources

	Variable	Data source
Dependent Variables		
Consumer lending rate	*LRCONS*	CNB - ARAD DATABASE
Mortgage lending rate	*LRMORT*	CNB - ARAD DATABASE
Small corporate loans lending rate	*LRSME*	CNB - ARAD DATABASE
Large corporate loans lending rate	*LRCORP*	CNB - ARAD DATABASE
Explanatory Variables		
2-week Repurchase rate	*MPR*	CNB - ARAD DATABASE
Non-performing loans ratio for consumer loans	*NPLRCONS*	CNB - ARAD DATABASE
Non-performing loans ratio for mortgages	*NPLRMORT*	CNB - ARAD DATABASE
Non-performing loans ratio for non-financial corporations	*NPLRCORP*	CNB - ARAD DATABASE
Ratio of banks capital to total banks assets	*CAPTOASSETS*	CNB - ARAD DATABASE
Spread between government bond yield and repo rate	*SPREAD_GBYREPO*	CNB - ARAD DATABASE
Herfindahl-Hirschman index	*HHI*	CNB - ARAD DATABASE
CNB's deposits in foreign banks	*CBDEP*	CNB - ARAD DATABASE
Dummy Variables		
Dummy based on Bai and Perron multiple break test	*DUMMY_1*	Constructed by the Authors
Dummy based on Bai and Perron multiple break test	*DUMMY_2*	Constructed by the Authors

Table A2 - Summary statistics of used variables

Variable	*Observations*	*Mean*	*Median*	*Maximum*	*Minimum*	*Std. Dev.*
LRCONS	167	13.170	13.7	15.23	8.73	1.503
LRMORT	167	4.087	4.41	5.6	2.13	1.108
LRSME	167	3.861	3.9	5.91	2.25	1.018
LRCORP	167	2.828	2.77	5.11	1.35	0.932
MPR	167	1.198	0.75	3.75	0.05	1.153
NPLRCONS	167	9.744	9.21	12.52	6.04	2.056
NPLRMORT	167	2.424	2.23	3.48	1.52	0.724
NPLRNFC	167	6.197	6.24	9.66	2.91	1.724
CAPTOASSETS	167	10.561	10.63	11.996	8.874	0.837
SPRD_GBYREPO	167	1.809	1.71	3.95	0.2	0.962
HHI	167	1084	1080	1166	986	47.86
CBDEP	167	3336	484	43687	25.24	7360.81

Source: CNB's ARAD database (2017)

Table A3 - Cross correlation between variables

Correlation in First Diff.	*MPR*	*NPLR CONS*	*NPLR MORT*	*NPLR NFC*	*CAPTO ASSETS*	*SPREAD GBYREPO*	*HHI*	*CB DEP*
LRCONS	0.015	0.085	0.190	0.111	-0.026	-0.162	-0.092	-0.063
LRMORT	0.269	-0.022	-0.033	0.107	0.030	-0.088	-0.001	-0.4E-04
LRSME	0.276	-0.227	-0.183	-0.083	0.172	0.118	-0.085	0.111
LRCORP	0.361	-0.023	-0.148	-0.059	0.019	-0.093	-0.037	-0.024
MPR	1	-0.119	-0.295	-0.195	0.024	-0.357	-0.115	0.048
NPLRCONS		1	0.433	0.166	0.068	-0.052	0.057	-0.271
NPLRMORT			1	0.377	0.066	0.027	-0.009	-0.064
NPLRNFC				1	0.320	0.011	-0.079	0.045
CAPTOASSETS					1	-0.109	0.030	0.010
SPRD_GBYREPO						1	-0.001	-0.037
HHI							1	-0.079
CBDEP								1

Source: CNB's ARAD database (2017)

Table A4 - Stationarity tests

Null Hypothesis:	**TIME SERIE has a unit root**				**TIME SERIE is stationary**	
	Level		*First Difference*		*Level*	*First Difference*
	ADF test stat.	***PP test stat.***	***ADF test stat.***	***PP test stat.***	***KPSS test stat.***	***KPSS test stat.***
LRCONS	-1.007	-1.100	-12.98***	-12.99***	0.209	0.213
LRMORT	-2.172**	-2.033**	-8.209***	-8.422***	0.299***	0.125*
LRSME	-2.352	-2.936	-16.80***	-16.82***	0.224***	0.248
LRCORP	-2.104	-2.332	-15.84***	-15.86***	0.226***	0.152
MPR	-2.925	-1.175	-3.443***	-8.476***	0.144*	0.110
NPLRCONS	-0.302	-0.310	-11.81***	-11.91***	0.177**	0.320
NPLRMORT	-0.278	0.037	-2.982***	-7.385***	0.205**	0.278***
NPLRNFC	-2.957**	-2.231	-4.088***	-9.402***	0.173**	0.282
CAPTOASSETS	0.110	0.234	-13.01***	-13.41***	0.211**	0.170
SPREAD_GBYREPO	-1.184	-1.283	-8.741***	-8.575***	0.237***	0.112
HHI	-1.939	-1.963	-12.96***	-12.94***	0.140*	0.067
CBDEP	2.447	-0.034	-10.81***	-14.15***	0.297***	0.468**

Notes: ***, **, * - shows statistical significance at the 1%, 5%, and 10%.

Source: CNB's ARAD database (2017)

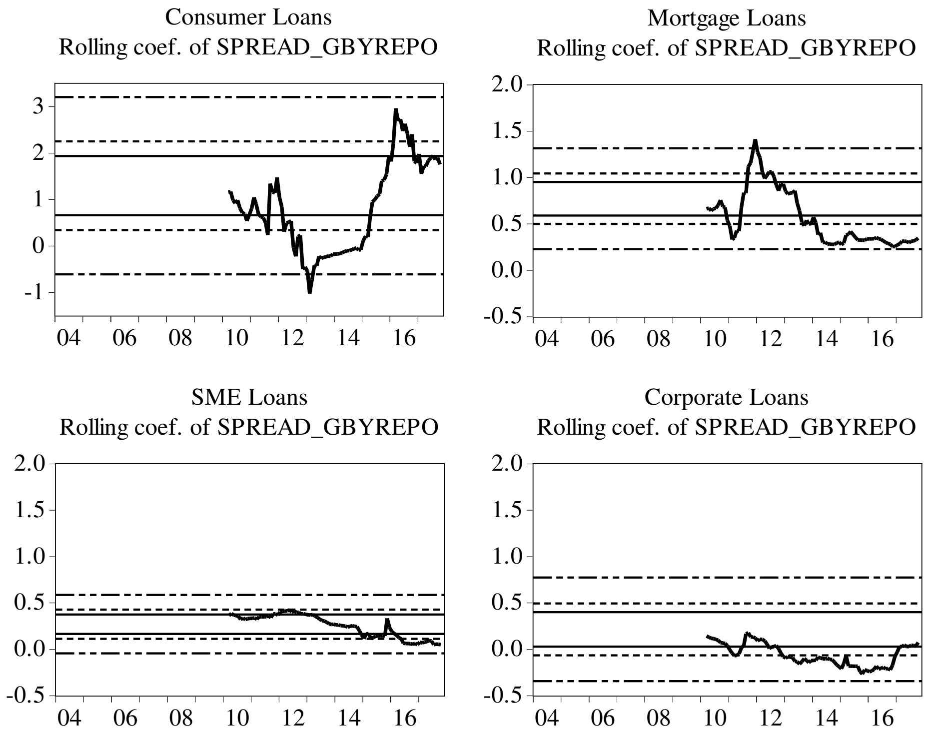
Table A5 – Unit root test with a structural break

	Level				*First Difference*	
	ADF test statistic	**Break Date:**	**Zivot-Andrews test statistic**	**Break Date:**	**ADF test statistic**	**Break Date:**
LRCONS	-2.93	2014M12	-3.37	2014M12	-14.69***	2005M06
LRMORT	-1.97	2010M03	-4.62*	2007M06	-8.73***	2009M12
LRSME	-2.91	2008M11	-3.68	2007M05	-17.92***	2008M08
LRCORP	-3.02	2010M11	-3.37	2006M08	-17.25***	2009M01
MPR	-4.80**	2008M10	-4.35	2008M11	-4.48**	2008M11
NPLRCONS	-2.98	2009M06	-3.23	2010M01	-13.69***	2010M09
NPLRMORT	-2.76	2008M12	-3.51	2009M03	-3.94	2013M03
NPLRNFC	-3.65	2007M04	-4.92*	2009M01	-4.51**	2007M11
CAPTOASSETS	-3.71	2009M05	-3.32	2009M07	-13.75***	2015M12
SPREAD_GBYREPO	-2.56	2014M01	-5.53***	2008M11	-9.68***	2009M02
HHI	-3.29	2014M09	-3.74***	2011M01	-15.34***	2007M11
CBDEP	-0.86	2005M03	1.53**	2015M11	-21.76***	2005M03

Notes: ***, **, * - shows statistical significance at the 1%, 5%, and 10%.

Source: CNB's ARAD database (2017)

Figure A1 - Rolling Coefficient of the Spread between GBY and the Repo Rate (Baseline Model)



Notes: Rolling regression with fixed window (window size: 75, step size: 1, number of subsamples: 92). Horizontal lines represent confidence intervals of two, three and six standard deviations.

Figure A2 - CUSUM for Best Fit Models

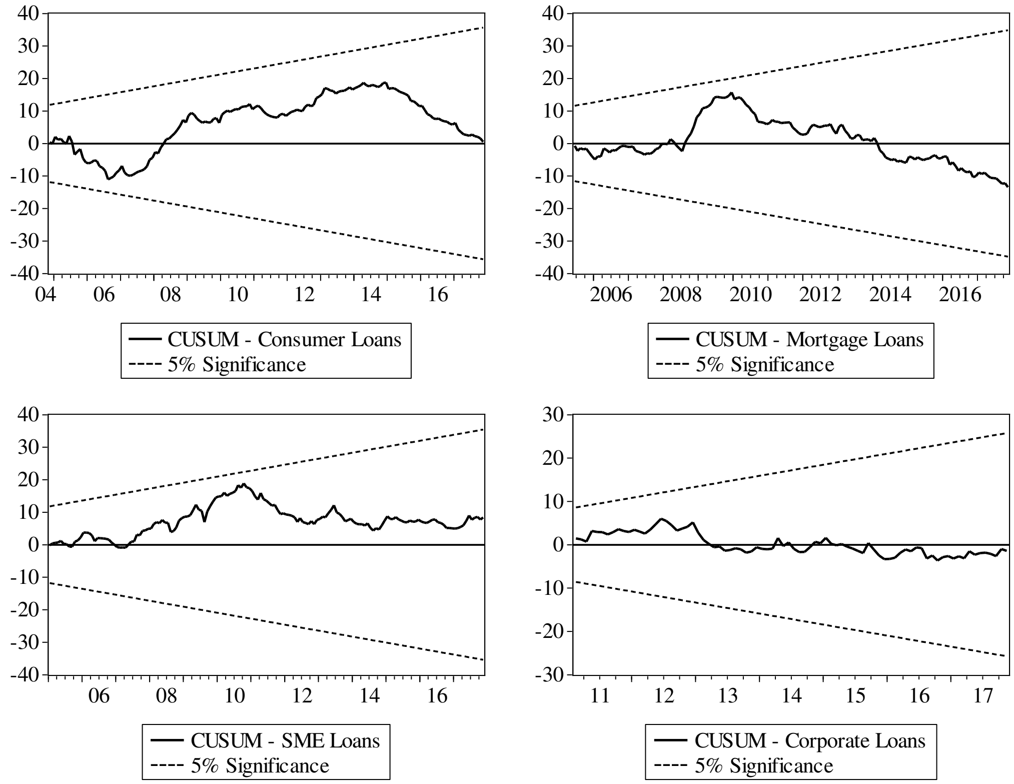


Figure A3 - CUSUM of Squares for Best Fit Models