**Nexus Between Monetary Policy and Commercial Lending Rates: Comprehensive Evidence from Czechia During Different Policy Stances**

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This paper investigates the interest rate pass-through in Czechia during different monetary policy stances from April 2005 to February 2020. The results suggest functioning pass-through in the initial stage of transmission, but responsiveness of the money market rate to the official rate differed during different monetary policy settings. The signalling role of the policy rate is important for loan pricing when policy is loosened, and the role of the money market is suppressed. Results also indicate a lowered responsiveness of PRIBOR to shocks in EURIBOR. When focusing on exchange-rate interventions effect, we cannot confirm any significant impact on loan pricing.

Keywords: commercial lending rates; exchange rate interventions; impulse response function; interest rate pass-through; money market rate; official policy rate; structural vector autoregressive model; variance decomposition

Subject classification codes: E43, E52, E58

# 1 Introduction

Understanding monetary transmission is a primary consideration for monetary authorities, analysts and academics in evaluating the effects of applied policies, with interest rate pass-through functioning representing an important tool used by central banks to achieve price stability. As De Bondt (2002) accurately stated, monetary transmission is more complete if a pass-through of official and market interest rates to retail bank rates is rapid and comprehensive. Developments in last decade in particular have brought many challenges for monetary authorities. Following the financial and consequent debt crises in Europe, empirical studies (e.g. Blot and Labordance, 2013; Paries et al., 2014; Holton and Rodriguez d’Arci, 2015; Avouyi-Dovi et al., 2017; Illes et al., 2019; Altavilla et al., 2020) have pointed to incomplete pass-throughs or the fact that the process of transmission has been slowed in euro-area (EA) countries.

The aim of this paper was to provide a comprehensive investigation of the interest rate pass-through, its changes and dynamics in the case of Czechia during the different monetary policy stances in operation from April 2005 to February 2020. Czechia is a small, open economy with an independent monetary policy and a commitment to adopt the euro currency at some point in the future.

The paper contributes to the existing body of knowledge in several ways, as explained below. In general, all such contributions help in making it possible to draw more informed conclusions and provide more relevant information concerning the behaviour of economic agents for economic policy-makers and economists, benefitting them in their decision-making processes.

First, the interest rate pass-through is examined in a complex way, from its beginnings, starting with a change in the official policy rate to the money market rate, and consequently from the money market rate to specific commercial lending rates for both corporations and households. Horvath and Podpiera (2012), Havranek et al. (2016) and Gregor and Melecky (2018) used simplified methodologies and did not examine the pass-through step by step. It is helpful to analyse, in more detail, the individual parts of the transmission of changes in monetary policy.

Second, since the above-mentioned works employed methods based on co-integration or error-correction frameworks, which suffer from several drawbacks (e.g. see Hamilton, 1994; Dahlhaus et al., 2018), we employed structural vector autoregressive (SVAR) models with imposed short-run restrictions. These models have been used recently for observing the effects of monetary policy (e.g. see Schenkelberg and Watzka, 2013; Can et al., 2020; Zabala and Prats, 2020) because they allow us to observe the economy as a whole system with identified relations and restrictions. Short-run restrictions were imposed because we focused on the short-run transmission of interest rates. Killian (2011) considered the SVAR model to be the workhorse of empirical research in the fields of finance and macroeconomics.

Third, reactions to shocks can be observed during different monetary policy settings, which helps us to demonstrate how such periods matter in terms of policy evaluation, as considered, for example, by Paries et al. (2014) and von Borstel et al. (2016). In total, four sub-periods, representing different monetary policy stances, were observed between April 2005 and February 2020. In addition, our dataset includes the last period of restrictive monetary policy, which has not been recorded in any previous studies on the Czech economy.

Fourth, in addition to shocks in the commonly observed variables (i.e. repo rate, money market rate, price development, exchange rate), and their role in the interest rate pass-through, we added three external shocks into the model––one in the EA’s money market rate, one representing spillovers in the EA and one in confidence. The shock in the EA’s money market rate, and its effect on the Czech money market rate, was analysed because Czechia should be undertaking steps towards future adoption of the euro. The spillovers coming from the EA were examined because they can significantly affect the development of a country, as posited by, for example, Keppel and Prettner (2015), Babecka Kucharcukova et al. (2016) and Hájek and Horvath (2016), who dealt with spillovers from the European Central Bank’s (ECB’s) monetary policy. The effects of shocks in business and consumer confidence were also observed because their importance is growing in studies focused on uncertainty, confidence and the behaviour of economic agents (e.g. see Federal Reserve Bank of Richmond, 2019; Zhang et al., 2019).

Our results suggest that the pass-through works well in the initial stages of a monetary policy, but the responsiveness of the money market rate (Prague Interbank Offered Rate, PRIBOR) to the official interest rate change differed for individual monetary policy stances. A significant disturbance was identified during the period of the financial crisis, which was maintained during the zero lower bound (ZLB) period, but during consequent monetary tightening, shocks in the repo rate began to contribute significantly to variance in the money market rate (by 84%, based on selected factors). We also found that shocks in confidence significantly contributed to the variance in rate changes on corporate loans of up to 30 million CZK when the monetary policy was tightened following the ZLB period. The results also suggest that the Czech money market has not responded to the EA money market since the ZLB period, even though Czechia has a commitment to one day adopt the euro currency. The outcomes of the estimations used did not highlight any effect of exchange-rate interventions on commercial loan pricing in Czechia.

This paper is structured as follows. Section 2 provides a literature review focused on the interest rate pass-through in the EA and Czechia. Section 3 contains a brief background to monetary policy in Czechia for readers who are not familiar with its specifics. Our dataset, its fundamental characteristics and the methods employed are presented in Section 4. Section 5 presents the results and discussion. Our conclusions appear in the final section.

# 2 Literature review

Because the functioning of the interest rate pass-through is crucial when pursuing monetary policy intentions, research on this topic is of great importance to central banks and economists. Its importance increases when new events or disturbances occur. With the establishment of the EA, empirical studies have attempted to investigate the possible benefits of this level of integration in terms of monetary policy transmission. For example, De Bondt (2002) examined the retail bank interest rate pass-through process in the EA, finding it to be faster since the introduction of the euro, whilst Sander and Kleimeier (2004) dealt with the convergence in retail banking in the EA, studying the role of the interest rate pass-through in monetary policy transmission, competition and integration.

Following the financial crisis, studies became focused on the issue of the possible impacts of the crisis and the anomalies that it may have potentially brought to the pricing of loans and deposits. Karagiannis et al. (2010) investigated the interest rate pass-through in Europe and the US, with a focus on post-financial-crisis monetary policy. Their results were somewhat mixed, indicating that the efficiency of the transmission of monetary policy in the US and Europe was disrupted, as reflected in a widening of the spreads between the central bank policy rates and the money market rates, as well as between the money market rates and the retail rates. Karagiannis et al. (2011) went on to deal with the symmetric or asymmetric interest rate adjustments in Greece, Bulgaria and Slovenia. Variations in the transmission processes of monetary policy were found, possibly due to different levels of competition, liberalisation, and the developmental level of the banking systems in the selected countries. Petrevski and Bogoev (2012) studied the interest rate pass-through in three economies in south-eastern Europe, concluding that the adjustment of interest rates in the short term was too low, and pointing to a fact that emerged that was in accordance with the theoretical expectations––the effectiveness of a monetary policy is limited when the fixed exchange-rate regime is applied in a country. The study also provided a well-arranged review of studies on the interest rate pass-through. Banerjee et al. (2013) examined how anticipated changes to short-term market rates influenced retail (both lending and deposit) interest rates in four major euro-area (EA) economies, at the aggregate and individual levels, for French banks. The important role of market rates in forecasting retail rates was confirmed.

The financial crisis revealed shortcomings in many economies, and was consequently followed by the European debt crisis, which resulted in a divergence between rates in the EA countries; for example, see Pareis et al. (2014), who observed the retail bank interest rate pass-through in the EA during the financial and sovereign debt crises. This divergence in bank lending rates was revealed to have occurred during the outbreak of the financial crisis in 2008 and the sovereign debt crisis in 2010. They also explored the very slow response of bank lending rates to the policy interest rate in certain economies, which may have been caused by asynchronous business cycles and differing perceptions of credit risk across countries.

This situation led to the lowering of official interest rates, to the point of zero or below, in order to overcome deflation and boost economic growth. The interest rate pass-through in these circumstances became a central research theme because this situation had not been commonly experienced in the European countries previously. The findings of the Deutsche Bundesbank (2019) pointed to the fact that the interest rate pass-through has been weaker in the EA since these crises. The observed indicators were: (a) a widening of the mark-up (rise); and (b) a weaker correlation between the rates. However, the Deutsche Bundesbank (2019) also stated that such an increase did not necessarily mean a change in interest rate pass-through. Many published studies on changes in the interest rate pass-through (e.g. Blot and Labordance, 2013; Paries et al., 2014; Holton and Rodriguez d’Arci, 2015) have confirmed an incomplete pass-through to retail bank rates in selected EA countries. Avouyi-Dovi et al. (2017) also provided evidence of a slowdown in the transmission process. Illes et al. (2019) concluded that policy rates, which were a reasonable proxy for funding costs before 2007, when liquidity risks and counterparty risks were low and stable, are no longer good proxies under the new conditions. They pointed out a divergence in bank lending rates from policy rates following the financial crisis, and showed strong evidence for a stable relationship between lending rates and a weighted average cost of liabilities measure than for policy rates. They summarised that funding costs, broadly defined, are most relevant to lending rates because there has been no divergence between these in the post-crisis period.

Because the possibilities for a standard monetary policy in the EA have been exhausted, the ECB also started to use non-standard policy tools, such as asset purchase programmes or targeted, longer-term refinancing operations, and so studies attempting to analyse the impact of these non-standard tools started to be released, such as that of Altavilla et al. (2020), who examined both standard and non-standard tools in their paper. They provided an analysis of the interest rate pass-through in the EA using bank-level data, and they also confirmed the results of studies that had showed a divergence in the rates. They found that the characteristics of banks are crucial when observing heterogeneity in the transmission, when focusing on conventional monetary policy tools, and that the heterogeneity is reduced when analysing the impact of non-standard measures. The effectiveness and transmission of the ECB’s unconventional monetary policy were investigated by Zabala and Prats (2020), using the SVAR model. They evaluated the impact on EA inflation and its growth rate. They confirmed the existence of transmission for a period when the non-standard measures were used. The SVAR methodology was also applied in a study by Afonso and Goncalves (2020), which focused on fiscal and monetary policy mix in the EA and the US. Regarding monetary policy, they confirmed the traditional relationship between interest rates and inflation in the US but, in the case of the EA, a price puzzle was confirmed. An extensive review devoted to the effects of non-standard policy tools on financial markets has been presented by Kampl (2021).

The recent monetary expansion and pass-through process have been supported by the adoption of the Basel III regulation and its interaction with the monetary policy framework of the central banks. This effect has been analysed by focusing on the determination of two ratio levels. Rubio and Carrasco-Gallego (2016) studied the interaction between the Basel I, II and III regulations and monetary policy. Focusing only on Basel III, the required total capital ratio increased by up to 10.5%, with up to an extra 2.5% of capital being added as a dynamic macroprudential element in the form of a countercyclical capital buffer. Investigating how monetary policy changes with different values of the capital requirement ratio, they found that monetary policy needed to be more aggressive with an increase in capital requirement ratio. Furthermore, Basel III leads to liquidity regulation changes and affects the demand for central-bank liquidity as funds obtained through open market operations or through lending facilities. In this way, Basel III raises the demand for longer maturities funds as part of the liquidity coverage ratio. This makes central-bank refinancing for longer maturities more attractive, such as through liquidity obtained via longer-term refinancing operations. Focusing on the situation in the Czech Republic, Bruna and Blahová (2018) directed their analysis towards the effect of Basel III and the constraints in credit supply in the country, suggesting the requirement for a capital buffer due to the Basel III requirements. Using data from 1999–2014, they confirmed an increasing demand for the debt financing of Czech firms and banks, motivated by providing credit, and resulting from the Czech National Bank’s (CNB’s) interventions. This growth in credit contributes to an increased demand for equity capital from the banks, based on the Basel III regulations.

In studies focused solely on Czechia and its economy, there have been only a few that have investigated the interest rate pass-through, including Bruna (2008), who examined the relationship between the market and the client interest rate during the period of the transformation of the banking system and inflation stabilisation in Czechia, from both the short- and long-term perspectives. They revealed different behaviours between the long- and short-term interest rates, and also confirmed the crucial impact of transforming the banking sector. Horvath and Podpiera (2012) investigated the heterogeneity in bank pricing policies from January 2004 to December 2008. Their results indicated that bank pricing in the short term was heterogeneous, but not in the long term. They also found that corporate rates and mortgage rates adjust to the money market changes, but often not fully in the long term. When focusing on consumer rates, the conclusion was that they were not co-integrated with the money market rates, even in the long term.

Havranek et al. (2016) focused on the interest rate pass-through of loan and deposit products between 2004 and 2013. They concluded that the pass-through significantly changed in the post-crisis period, which accorded with the findings of other studies conducted in the post-crisis period in other countries. They also focused on bank cost efficiency, confirming that cost-efficient banks smooth loan rates. Gregor and Melecky (2018) analysed the pass-through of monetary policy to lending rates from January 2004 to November 2017, and observed the roles of other macro-financial factors. With the use of an autoregressive distributed lag approach, they explored the long-term and stable pass-through for corporate lending rates and mortgages, determining that the pass-through was not confirmed for consumer lending rates.

In 2018 and 2019, publications tended towards dealing with particular problems, in detail, such as Bruna and Van Tran (2018), who reported inflation targeting and variability in money market rates under a ZLB, using a Bayesian vector autoregressive (VAR) model for the latter. They found that the financial crisis together with exchange-rate interventions represent the main shocks to interest rates. Kolcunova and Havranek (2018) estimated the effective lower bound of the CNB’s policy rate, whilst Filáček et al. (2018) suggested that deposit interest rates did not indicate a failure in transmission after the exit from the exchange-rate commitment, and that the pass-through of monetary policy rates to deposit rates has not worsened. Broz and Hlavacek (2019) focused on the drivers of the dynamics of interest rates on consumer loans in Czechia between 2014 and 2019. Their results suggested that a decreasing unemployment rate, benign development of credit risk and very slightly increasing market rates might have contributed to the distributional dynamics of the observed rates.

**3 Monetary policy regime in the Czech Republic and a brief economic overview**

The main aim of the monetary policy of the Czech Republic is to maintain price stability using open market operations to steer interest rates in the economy. Open market operations are mostly executed in the form of repo operations. Furthermore, foreign-exchange interventions have been applied by the CNB, aimed at restraining foreign-exchange market volatility or easing/tightening monetary policy (as happened in 2013). However, foreign-exchange interventions are not a regularly used instrument in the inflation-targeting regime. For the analysed period, the CNB used both tools––steering interest rates downward as well as an exchange-rate intervention. Since the exit from the exchange-rate commitment in April 2017, interest rates have again become the CNB’s main monetary policy instrument. The Czech Republic is a member of the V4 countries, having a similar economic and political development following its transition from a centrally planned economy. Although there are several similarities in monetary policy aims and tools among the V4 counties, there are also some differences. Excluding Slovakia, all V4 countries induct monetary independently; Slovakia joined the EA in January 2009 and, since then, the ECB has been its main monetary authority.

 The main differences in monetary policy during the quantitative easing period can be summed up as the following. The Polish central bank did not use the exchange-rate intervention as an alternative tool for the loose monetary policy in the analysed period. The last time the Polish central bank directly intervened in the exchange market was in 2010 and then not until December 2020 (Reuters, 2020). Furthermore, Hungary used to use foreign currency swap tenders in the long term, with the aim of providing local banks with foreign-exchange liquidity.

The economic situation in European Union countries in 2005 through 2007 was characterised by expansion at a robust pace. However, in 2007, the first signs of concerns about the outlook uncertainty were reflected. In 2008, all countries in the EA suffered from a strong slump in their economic activities. This situation was also reflected in the V4 countries, although with the Czech Republic and Slovakia being affected to a lesser degree Interest rate developments in the V4 countries and the EA are shown in Appendices 1 and 2, respectively. Following the implementation of anti-crisis measures, the decline in the first half of 2009 was replaced by a weak rise, although the economic situation in the EA was still poor. Among the V4 countries, only the Czech Republic and Slovakia showed an easing in the recession. However, in 2010, all the V4 countries experienced some recovery or at least a stabilisation. In 2011, economic activity varied among the EA countries, continuing to be weak and showing continued recession, and with the Czech Republic and Hungary showing significantly decreased output among the V4 countries (ECB Annual Report, 2011). In the case of the Czech Republic, this occurred because of fiscal tightening and limited external demand. Inflation measured using the Harmonised Index of Consumer Prices (HICP) for the period 2007–2012 was supported mostly by high energy and commodity prices (see Appendix 3). Despite unfavourable macroeconomic conditions in 2012, inflation was still high, again partly supported by high energy and commodity prices, but also partly because of indirect taxation in several European countries. In the period 2013–2016, a high pace in the growth of economic activity was observed in the EA, but this growth rate was still below the long-term average. In the V4 countries, the recovery was weaker due to low export growth, which was the case in the Czech Republic. Inflation slowed in the major non-EA countries, including the Czech Republic, in 2013, from 3% to 1.9% (ECB Annual Report, 2013), reflecting the easing of energy prices and fading out of the effect of indirect taxes.

In 2016, the growth rate in economic activity was moderate in the EA, but with an uncertain economic outlook. The growth rate in the Czech Republic and Hungary was declining. Inflation was low, mainly reflecting the influence of energy prices. In 2017–2018, the EA economy continued to recover, but the GDP was still lower than before the global financial crisis. Nevertheless, the V4 countries continued to experience a robust pace in growth. The end of 2019 was characterised by slow-activity growth, with the GDP indicator increasing slowly. The V4 countries, including the Czech Republic, lagged behind the EA average, the data showing weakening activity growth in the Czech Republic and Hungary. However, the robust performance of the real economy in 2017 did not match the development of inflation, which lacked any sign of an upward trend.

# 4 Data characteristics and methods

Aggregate banking and macroeconomic data on a monthly basis were obtained from the CNB’s ARAD database (which includes the monetary policy, money market, commercial and exchange rates), the ECB (the EA money market reference rate), the Czech Statistical Office (a harmonised index of consumer prices), the Organization for Economic Co-operation and Development (OECD) database (including business and consumer confidence indices) and Bloomberg (official interest rates for the EA and the V4 countries).

The CNB provides the rates of newly originated household and non-financial corporation loans denominated in CZK. To identify certain characteristics of the interest rate pass-through, we conducted separate analyses for households and non-financial corporations. Our sample started in April 2005 and ended in February 2020. To assess the role of monetary transmission during the different monetary policy stages, the entire sample period was divided into four sub-periods, with different monetary policy stances. This division allowed us to demonstrate that the period for policy evaluation was considered, as in, for example, Pareis et al. (2014) and von Borstel et al. (2016). We could therefore view the behaviour of the interest rate pass-through during different monetary policy settings, thereby providing beneficial information for policy-makers and other market participants. The following four periods were identified, based on the development of the official monetary policy repo rate, using data from the ARAD database:

* 1st period: April 2005–July 2008 (monetary restriction);
* 2nd period: August 2008–October 2012 (monetary expansion);
* 3rd period: November 2012–July 2017 (monetary expansion––ZLB); and
* 4th period: August 2017–February 2020 (monetary restriction).

The pass-through was investigated from its beginning, with the change in the official interest rate represented by a two-week repo rate, to the money market rate PRIBOR with a maturity of 1 year and, consequently, to the commercial loan rates. Several interest rates for households and non-financial corporate loans were chosen in order to investigate the interest rate pass-through in Czechia. Specifically, for household loans, we chose the rates for house purchases and consumer credit. For non-financial corporate loans, the rates for loans up to 30 million CZK and over 30 million CZK were chosen. The development of all the examined interest rates is presented in Appendix 4.

We also considered other macroeconomic variables in our estimation because they should not be omitted if we want to take into account other possible factors that can affect the economy and interact with each other. Because our data for all the interest rates were on a monthly basis, we included variables at the same frequency. The price level, CZK/EUR exchange rate, and the indicators of confidence were added to the dataset because they have important roles in the system. The role of confidence is important concerning monetary policy reactions (e.g. see Federal Reserve Bank of Richmond, 2019; Lien et al., 2019; Zhang et al., 2019; Funashima, 2021), and we believe that it must be included in any current research on the behaviour of agents in the economy. According to the OECD (2020a, b), the consumer confidence index represents the attitude of households to future developments in the economy and the tendency for saving. The business confidence index informs on future business performance. These are also all connected to the demand for credit. These indices represent the main economic indicators, according to the OECD (2021). Because Czechia is a small, open economy and a part of the European Union, we also included the EA money market reference rate (the Euro Interbank Offer Rate, EURIBOR) with a maturity of 12 months to our estimation in order to determine its possible effects in the defined SVAR system because spillovers can be expected, (e.g. see Keppel and Prettner, 2015; Hájek and Horvath, 2016; ter Ellen et al., 2020). All the time-series were transformed into differences to ensure their stationarity. The results of the descriptive statistics are presented in Appendix 5, while the results of the correlation analysis are included in Appendix 6.

Because monetary policy reacts to movements in other variables in the economy, its impact can be difficult to measure directly. Therefore, we decided to employ the SVAR model, which allowed us to treat our variables in one economic system in which they could interact with each other. In the SVAR model, the exogenous effects are identified in order to observe the dynamic effects (see Sims (1986))*.* Respecting that, the effects of the shocks on the variables can be predicted in the system. The effect of monetary policy using a SVAR model has been reported by Koluk and Mehrotra (2009) for East and South-East Asia, by Schenkelberg and Watzka (2013) for Japan, by Can et al. (2020) for Turkey, and by Zabala and Prats (2020) for the EA countries, for example.

Our final SVAR model included seven variables. Following the SVAR methodology (e.g. Killian, 2011), certain restrictions have to be imposed on the parameters of the model. The minimal number of restrictions has to be imposed as $n\left(n-1\right)/2$, where *n* is the number of variables, which means that we have to impose 21 restrictions, at a minimum, in matrix A. A restriction means that a selected coefficient equals 0 because a variable is not immediately affected by any other variable in the system. The coefficients that are estimated show the immediate reaction of a variable to a shock in any other variable in the system. The shock can be caused by each variable included in the system.

The final form of the SVAR model was as follows:

$\begin{matrix}xx&EA&MP&MM&c\\_rate&er&prices&conf\\EA&1&0&0&0&0&0&0\\MP&0&1&0&0&0&0&0\\MM&a\_{31}&a\_{32}&1&0&0&0&a\_{37}\\c\\_rate&0&0&a\_{43}&1&0&a\_{46}&a\_{47}\\er&a\_{51}&a\_{52}&a\_{53}&0&1&a\_{56}&a\_{57}\\prices&0&0&0&0&0&1&0\\conf&a\_{71}&0&0&0&0&0&1\end{matrix}\left[\begin{matrix}u\_{1t}\\u\_{2t}\\u\_{3t}\\u\_{4t}\\u\_{5t}\\u\_{6t}\\u\_{7t}\end{matrix}\right]=\left[\begin{matrix}b\_{11}&0&0&0&0&0&0\\0&b\_{22}&0&0&0&0&0\\0&0&b\_{33}&0&0&0&0\\0&0&0&b\_{44}&0&0&0\\0&0&0&0&b\_{55}&0&0\\0&0&0&0&0&b\_{66}&0\\0&0&0&0&0&0&b\_{77}\end{matrix}\right]\left[\begin{matrix}ε\_{1t}\\ε\_{2t}\\ε\_{3t}\\ε\_{4t}\\ε\_{5t}\\ε\_{6t}\\ε\_{7t}\end{matrix}\right]$ (1)

*Note: All variables are in differences*

Where *EA* represents the EA money market reference rate, EURIBOR, *MP* represents the monetary policy official interest rate in Czechia, *MM* is the Czech money market rate, PRIBOR, *c\_rate* is a corresponding loan rate for households or non-financial corporations, the exchange rate is presented by *er*, the price level by the variable *prices*, *conf* represents a business or consumer confidence index, *uit*are reduced-formed VAR residuals, *εit* are the structural shocks, and *ait* and *bit* are the coefficients to be estimated.

The definition of relationships between the variables in the SVAR system and the restrictions must be based on the economic theory of Sims (1986) or Killian (2011). Here, the principle of the creation of matrix A is briefly explained. In our SVAR model, the effect of interest rate development in the EU was determined using the EURIBOR. As can be seen in the first row of matrix A, the EURIBOR is not immediately affected by any other variable in the system, but it can affect other variables, as indicated in the first column of matrix A––the Czech money market rate (*a31*), as well as the exchange rate (*a51*) and confidence (*a71*). When focusing on the effects of Czech monetary policy, we can see that it does not react immediately to the change in any other variable in the system, because the *MP* responds to the development of inflation and the economic situation with a delay, not immediately. When considering the stages of the interest rate pass-through, changes in the official repo rate should be reflected in the PRIBOR (*a32*) money market rate. Consequently, the changes in the PRIBOR should be reflected in the commercial loan rates (*a43*). In the proposed SVAR system, commercial loan rates––the *c\_rate*––should be affected by the PRIBOR (*a43*) money market rate, price development (*a46*) and confidence (*a47*).

Because of the multivariate nature of the VAR and consequent SVAR models, impulse response functions (IRFs), using structural decomposition, are employed as standard for the interpretation of the results. We have also provided results on the structural variance decomposition (SVD), which allowed us to determine how each structural shock contributed to the total variance during different monetary policy stances for lags of one, three, six and nine months.

# 5 Empirical results and discussion

Prior to the estimation of the responsiveness of individual interest rates in the SVAR models, the results of tests for over-identifying restrictions were tabulated (Table 1). The null hypothesis that all restrictions are valid was tested. The likelihood ratio tests did not reject the over-identified models for most of the cases at the 5% level, showing that the imposed restrictions were valid. The null was rejected for all rates for the second period, which pointed to changes in the functioning of the pass-through. It was also rejected for rate on corporate loans over 30 million CZK in the fourth period, and rate on consumer loans in the first and fourth periods. Next, the sub-chapters bring more information on the pass-through to corporate and household loan rates.

Table 1. Results of the LR tests for over-identifying restrictions

The results of the IRFs and SVDs are provided to illustrate the effect of the EURIBOR on the PRIBOR first, and then for individual parts of the interest rate pass-through, based on the SVAR models employed. The IRF function allowed us to show which lag the contribution of selected factor was significant for. To obtain a deeper insight into the effects of different shocks on our SVAR models, we employed the SVDs so that we could determine how each structural shock contributed to the total variance.

## 5.1 Reaction of the Czech money market rate to the EA money market rate

The IRFs shown in Figure 1 reflect the positive statistically significant response of changes in the PRIBOR to a shock in the EURIBOR for the first and second periods. The results for the ZLB and fourth periods did not confirm a statistical significance for the responses in the Czech money market rate. During the first period, the immediate response was positive and almost twice as high as in the second period. The response also took one month when monetary policy was restrictive, compared to the second period when the positive response dropped gradually for three months in the case of monetary expansion. These findings are in accordance with studies that have demonstrated co-movements of rates in the EU countries and the interconnectedness of economies, such as Kadow et al. (2013) and Pungulescu (2013), who determined that the effects of EA monetary policy are transmitted into the Central and Eastern European money market rates. However, the interconnectedness between economies was lowered as a result of both economic crises, which caused disturbances in the transmission. These disturbances in the transmission and a possible divergence in the rates are in line with the findings of, for example, Chakraborty et al. (2017) and Hoffmann et al. (2020).

Figure 1. Responses of d\_pribor\_rate to a shock in d\_euribor rate

## 5.2 Pass-through from repo rate to money market rate

When focusing on the pass-through from the repo rate to the PRIBOR (see Figure 2 for the IRFs), we found that shocks in the repo rate affected the money market rate in all sub-periods except for the second, although the responses differed throughout the periods. The responses in the money market rates were higher in periods when the monetary policy was tightened compared to expansionary monetary policy periods, which is a consequence of the crises that brought new challenges not only for the monetary authorities.

The IRF representations indicate that, during the first period of restrictive monetary policy, a standard deviation shock to a change in the official policy rate caused a positive reaction in a change to the PRIBOR money market rate. The positive effect was statistically significant for a one-month lag. The representations of the SVDs in Appendix 7 show how shocks in individual variables contributed to the variance of changes in the PRIBOR. The contribution of a shock in the repo rate to variance in the PRIBOR was almost one-third that of the other observed variables. During the third (i.e. ZLB) period, the initial stage of pass-through was confirmed to be significant, with the reaction of the PRIBOR taking almost four months and being very low due to the almost exhausted possibilities for the monetary authorities to lower interest rates. The contribution of the repo rate to the variance in the PRIBOR was again almost one-third. When observing the last period, the response to the shock in the repo rate again took one month and contributed by 62%. The importance of the signalling role of changes in the official policy rate was again essential since the ZLB.

Figure 2. Reaction of d\_pribor\_rate to a standard deviation shock in d\_repo\_rate during different monetary policy stances

## 5.3 Pass-through from money market rate to corporate lending rates

The IRFs shown in Figure 3, representing the next stage in the pass-through from money market rate to corporate lending rates for loans of up to 30 million CZK, identified that the changes in the PRIBOR were significantly reflected in the lending rates during the first, second and fourth periods.

The IRFs were statistically significant for a one-month lag during the first and second periods. The contribution of a shock in the PRIBOR to the variance in the corporate lending rate for loans of up to 30 million CZK was very low (5% for the first and 3% for the second period; see Appendix 8 for more information) for this interest rate. During the ZLB period, the reaction was not statistically significant. This might point to disruptions and a slowdown in transmission, as posited by Holton and Rodriguez d’Arci (2015) and Illes et al. (2019), for example. It is also in line with Havranek et al. (2016), who mentioned possible complications in monetary transmission regarding the ZLB. The restrictive monetary policy of the CNB during the fourth period (as discussed in the previous sub-chapter) had an effect on the money market rate and, consequently, our estimates confirmed the effect of the shocks in the PRIBOR on the lending rate for loans of up to 30 million CZK. However, based on the SVD, the contribution of a shock in the PRIBOR to the total variance of the corporate rate was very low, being almost zero for a one-month lag.

Figure 3. Reaction of d\_corporate\_rate for loans of up to 30 million CZK to a shock in d\_pribor\_rate during different monetary policy stances

All the assumed shocks, instead of a shock in a variable itself, had a very low effect on variance in the corporate rates on loans of up to 30 million CZK during the financial crisis and, consequently, during the fourth period. The role of bank pricing policies and the funding costs seemed to have an increased importance during these periods. For example, Illes et al. (2019) found that unconventional monetary policies in the EA lowered bank retail lending and deposit rates. Nevertheless, the effects were found to be heterogeneous over the major EA countries. Similarly, Altavilla et al. (2020), using a bank-level dataset, found that the [monetary policy](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/monetary-policy) pass-through to lending rates was heterogeneous across European banks.

Our attention was also captured by an increased contribution of a shock in price development and business confidence. The shock in price development contributed 34% to the variance, the price effects confirming the economic theory expectations. The shock in business confidence contributed 38% to the variance in the fourth period.

The situation for rates on loans of over 30 million CZK was found to be different (see Figure 4 for the IRFs). The response to a shock in the PRIBOR was statistically significant only in one month during the financial crisis period, when the rates in this market segment were decreasing substantially. The results of the SVDs (Appendix 9) illustrate that a shock in the rate itself contributed to most of the variance in each period, which supports the results of Hainz et al. (2014) and Gregor and Melecky (2018), among others, who stated that bank-specific characteristics matter to this market segment.

The reactions in the other three periods were not statistically significant to the market segment. This may be explained by the fact that these large loans are for selected corporate clients; therefore, the rates did not incorporate changes in the monetary policy, as also supported by Hainz et al. (2014), who found that large corporate loans respond less to macroeconomic fundamentals.

Figure 4. Reaction of d\_corporate\_rate for loans of over 30 million CZK to a shock in d\_pribor\_rate during different monetary policy stances

## 5.4 Pass-through from money market rate to household lending rates

The IRFs shown in Figure 5 prove that there was no obvious significant reaction to the shocks in the money market rate during all the periods examined. The non-responsiveness of consumer rates to the policy or money market rate is in accordance with the findings of previous studies that observed the transmission to household loan rates. One explanation might be that consumer loans are considered by banks to be much riskier than other types of loans, as Horvath and Podpiera stated (2012), and that they are driven by other specific factors, as suggested by Havranek et al. (2016), who did not identify any financial market rate that would correlate with the rate for consumer loans.

Figure 5. Reaction of d\_consumer \_rate to a shock in d\_pribor\_rate during different monetary policy stances

This market segment has its own specifics in Czechia. The interest rates in this segment have decreased in the long-term, which is in line with the CNB (2018). As Hainz et al. (2014) already noted, consumer loans in Czechia are not affected by as many macroeconomic and bank-specific factors as small corporate loans or mortgage loans. The rates on consumer loans were significantly higher than the other rates (seeAppendix 4). We believe that this could be associated with the higher risk that is typical of this type of loan, and also with a high profit potential, or, as CNB (2018) claimed, the decrease in the rates in the last two periods may have been caused by both structural and cyclical factors. The structural factors were previously noted by Broz and Hlavacek (2019), who found that factors such as decreasing unemployment and the non-threatening development of credit risk might have contributed to the development in interest rates of consumer loans between 2014 and 2019. They also mentioned a decreasing market concentration, which we believe could be a crucial factor because, during these two periods, several new banks entered the market and the competition in this market segment increased significantly, contributing to an overall decrease in consumer loan rates, even though monetary policy was tightened. Research into the factors affecting consumer loan rate pricing mechanisms is still important, but also questionable, with such studies mostly failing because the factors seem to be very specific. We believe that, for example, studies on the effect of inequality on the transmission of monetary policy, as provided by Voinea et al. (2018) and Colciago et al. (2019), can provide deeper insights into this issue.

Figure 6. Reaction of d\_mortgage\_rate to a shock in d\_pribor\_rate during different monetary policy stances

Finally, the effect of a shock in the money market rate on the change in mortgage rates was analysed. The responses were not confirmed to be statistically significant in any of the observed periods (see Figure 6). These results contrast with those published by Horvath and Podpiera (2012), who demonstrated that the adjustment of mortgage rates to the money market rate was quick in the short term, or Hainz et al. (2014), who confirmed the important role of macroeconomic factors for mortgages. By contrast, our results support those of Havranek et al. (2016), who came to the conclusion that the market rate is insignificant in mortgage pricing in the short term. Because this market segment is rather complex, it deserves special attention as a separate research topic, if one wanted to deal with all aspects of this market more in detail.

## 5.5 Effect of exchange-rate interventions on corporate lending rates

We also observed the effect of exchange-rate interventions, which started in November 2013 and ended in April 2017. Using the exchange rate in our SVAR model, the significance of this factor was not confirmed in any case. We also applied a dummy variable for the period of the exchange-rate interventions; however, we found no significant effect on the corporate lending rates. Exchange-rate interventions can be used a tool in a small, open economy with its own currency (however, this was not the task of this paper; for more information, see, e.g., Hajkova, 2017) if the economy wants to prevent deflation through the effect on exports and, consequently, on aggregate demand and price level. However, the effect of interest rate interventions on interest rate pass-through has still not been explained in detail. The use of foreign-exchange reserves instead of the exchange rate or a dummy for the intervention period has still not been confirmed as being significant (see Gregor and Melecky, 2018). Our estimations in the defined SVAR model revealed that the period of exchange-rate interventions affected business confidence, which is a channel that could, consequently, affect the export side of the economy, thereby deflecting the threat of deflation in the economy.

# 6 Concluding remarks

The interest rate pass-through from the official policy rate to the money market rate and, consequently, to commercial lending rates in Czechia was estimated using SVAR models for different periods of monetary policy stances. The results on the pass-through from the official policy rate to the money market provided evidence that the money market rate responded to shocks in the repo rate during different monetary policy stances in three out of four periods. A very low response was identified during the crisis period, confirming disturbances identified in the literature. However, the signalling role of changes in the official rate was found to be important for transmission in the consequent ZLB period.

Estimates for the pass-through from the money market rate to commercial lending rates provided evidence that rates on corporate loans of up to 30 million CZK were the most responsive to shocks in the money market rates when the monetary policy was tightened in the fourth period. We also detected that, during this period, the responsiveness to shocks in business confidence increased significantly compared to the previous periods. The reaction to shocks in prices was detected particularly during the fourth period, during which inflation started to increase significantly in Czechia. During the financial crisis and the ZLB period, the responses to macroeconomic factors were very low for this loan category. The responsiveness of rates on corporate loans of over 30 million CZK to shocks in the money market was very limited, and only confirmed for the crisis period. This loan category might be affected by bank-specific factors (see Hainz et al., 2014; Gregor and Melecky, 2018) and client-specific factors.

Rates on consumer loans were found to be non-responsive to the shocks in the money market rate during all the observed periods. However, this market segment had its own specifics, being very rigid to the changes in rates during the first two periods, with low competition in this segment contributing to that situation. Currently, the market is the subject of a long-term interest rate decrease, caused particularly by changes in market competition, as well as other structural and cyclical factors (see Broz and Hlavacek, 2019, for more information on these factors). Mortgage rates were also not responsive to shocks in the money market rate. The shocks in the EURIBOR were found to be important for this loan segment from the ZLB period, which might point to a spillover significance for long-term yields (see ter Ellen et al., 2020).

The effect of shocks in the EA money market was also determined, with Czechia, as a small, open economy, being undoubtedly affected by external shocks. We found that the responsiveness of the Czech money market rate to shocks in the EURIBOR was no longer the case, even though Czechia will likely adopt the euro in the future. The effect of exchange-rate interventions on commercial lending rates has not been confirmed, but the significance of interventions on business confidence was revealed.

Generally, a low-interest rate policy is expected to dominate in the EA. Nevertheless, based on the recent macroeconomic situation, the setting of monetary policy in the Czech Republic diverges from the official ECB monetary policy regime. The ECB is going to continue with a low level for key interest rates, with a further decrease not being ruled out. The EBC has pointed out that interest rates will remain at their present or lower levels until it has seen the inflation outlook robustly converge on a level close to 2%. Furthermore, the future determination of key rates depends not only on the level of inflation in the EA, but also on its dynamics. The ECB has also confirmed that it will continue in its supporting programmes (ECB monetary policy decisions, 2021). However, the CNB expected a rise in main rates in the middle of 2021, when the previous need for an easy monetary policy was based on necessary responses to pandemic and government epidemic restrictions. Nevertheless, in August 2021, the CNB’s Bank Board increased the two-week repo rate to 0.75%, expecting the growth in the official rate to cause inflation to fall close to the official target over the period to the end of 2022. This decision was based on a new macroeconomic forecast that expected inflation to rise well above the upper boundary of the tolerance band, driven by stronger inflation pressures from the domestic and foreign economies (Monetary Policy Report, 2021). Based on our findings, we might expect a reaction in the money market rate because our findings suggest greater responses in periods of monetary policy tightening.

The COVID-19 pandemic has caused a sharp decline in economic activity. The partial improvement at the end of 2020 was caused by a contribution from the previous large-scale monetary and fiscal easing. Economic activity in the V4 countries did not reach pre-COVID-19 levels in 2020. Inflation in the Czech Republic was 3.3%, significantly above the inflation target in 2020, mostly because of a very high level of heading inflation (CNB Inflation Report IV/2020, 2020). The COVID-19 pandemic brought economic challenges, including a challenge to monetary authorities in the future.

Future research should be directed towards the factors that were not usual prior to both economic crises, such as business confidence, which was found to be of increased importance for the market segment involving loans of up to 30 million CZK. It may have important implications for future monetary policy frameworks because the role of this segment is crucial in the economy. Additionally, confidence seems to be an important feature, and we believe that it should be a focus of study because it could shed some light on pass-through functioning in a challenging environment.

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# Declaration of Interest Statement

No potential competing interest was reported by the authors.

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