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Analysis of the Repricing Practice of Newly Disbursed Housing Loans*

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In the Hungarian banking system, newly disbursed, fixed-rate housing loans are typically repriced with a lag of several months after a change in the interbank rates, which can be viewed as the cost of funds for institutions. This paper examines the number of months it takes for a change in the interbank rates to pass through to the interest rates of newly disbursed housing loans with an initial interest rate period of over one year. The two-step analysis looks at the repricing practices observed for Certified Consumer-Friendly Housing Loans (CCFHLs) employing a descriptive approach, and then a vector autoregressive model is used to estimate the speed at which interbank rates pass through to aggregate housing loan rates. Based on the authors' estimate drawing on aggregate interest rate statistics, the changes in interbank rates are incorporated into the mortgage rates applied by Hungarian banks in approximately four months; however, according to the interest rate condition data of institutions' CCFHL announcements, banks' repricing practices vary, leading to differences in the speed and extent of the interest rate changes following a shift in the cost of funds.

Journal of Economic Literature (JEL) codes: C10, G20, G21

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1. Motivation

This study analyses an important part of the interest rate channel of monetary policy transmission: the relationship between interbank rates and client interest rates.[1] This is because it is important to understand how quickly changes in interbank rates, which are directly linked to the interest rate policy of the central bank, appear in the price of the loans disbursed by commercial banks, as the pace of interest

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[1] The study looks at the transmission between average interbank rates and the average annual percentage rate (APR); for the sake of simplicity, the latter is often referred to as the interest rate.

rate pass-through is pivotal in the lag experienced by households (or businesses) after central bank measures are introduced. The paper focuses on housing loans: Hungarian households prefer owner-occupied housing to renting (*Magyar Nemzeti Bank*[2] (*MNB*) *2016*), and purchasing homes on credit has accounted for an increasing share of housing transactions (*MNB 2021*); therefore, it is particularly important to examine the features of how these loans are repriced.

According to the marginal cost pricing model, banks – like all profit-oriented firms – price their products based on their marginal costs.[3] If the interbank rate is taken to be the marginal cost of financing, this relationship can be expressed as follows:

$$i = \alpha + \beta r \tag{1}$$

where *i* is the interest rate, *α* is a markup constant, *r* is the interbank rate representing marginal cost, and β denotes a sensitivity coefficient (*Rousseas 1985*; *De Bondt 2005*; *Varga 2021*). It follows from Equation (1) that any rise in the marginal costs of financing raises the marginal yield expected from banks' additional lending, as otherwise, ceteris paribus, banks' profitability would decline. In other words, the change in interbank rates influences the pricing of new loans, albeit with some lag. Accordingly, the starting point of the analysis is the assumption that the banks operating in Hungary price housing loans based on the *Budapest Interest Rate Swap* (*BIRS*) rate, as the reference rate, with the maturity corresponding to the given type of loan interest fixation period.[4] In practice, of course, banks' pricing behaviour is influenced not only by the change in interbank rates, but also other factors, such as changes in the intensity of competition within the sector or the credit riskiness of clients, and therefore the size of the markup may change over time.[5] Central banks and other regulatory institutions have several instruments to influence longer-term lending rates, including the base rate, which has an indirect effect, along with macroprudential, resolution and credit market regulations as well as unconventional quantitative tools (*Ábel et al. 2018*). The impact of these measures can be reflected in the change in reference rates and spreads.

In practice, banks' lending rates are determined based on the costs of borrowing, in addition to the factors mentioned above. It can be seen that the interbank rates used in the analysis give a good approximation of this, because in the case of loans with interest rate fixed for the long term, banks can either directly borrow

[2] The Central Bank of Hungary

[3] In practice, if the sector is characterised by an abundance of liquidity, the price of loans is influenced not only by the marginal cost of the cost of funds, but also by the opportunity cost of lending.

[4] This method is often used in the international literature on the repricing of interest rates, see for example *Sorensen – Werner* (*2006*); *De Bondt* (*2005*); *Sander – Kleimeier* (*2004*). The BIRS also plays an important role in determining the interest rate and its changes with respect to Hungarian housing loans, because these interest rates also serve as the basis for several "fair bank" indicators used for repricing.

[5] For a detailed summary of the main institutional and banking factors shaping interest rates, see *Aczél et al.* (*2016*).

the fixed-rate funds or produce them through interest rate swaps (exchanging the interbank market cost of funds for an interest rate fixing with the same maturity as the interest rate period of the loan). In the latter case, the fixed leg of the interest rate swap has a significant impact on banks' cost of funds. However, it is important to note that interest rates are also influenced by the cost of other funds of banks, such as deposit rates, and therefore the BIRS does not fully capture banks' cost of funds. Ideally, banks' cost of funds should be the weighted average of their classic cost of borrowing (deposits) and market-based borrowing (interbank market, bond issuance), but this is disregarded due to the unavailability of data. Nevertheless, besides using BIRS time series, adjusted cost of funds, time series were also produced, taking into account the cost of deposit-type borrowing:

$$Adjusted\ cost\ of\ funds = BIRS - \frac{Deposits}{Loans} * (BUBOR - Weighted\ average\ deposit\ rate) \tag{2}$$

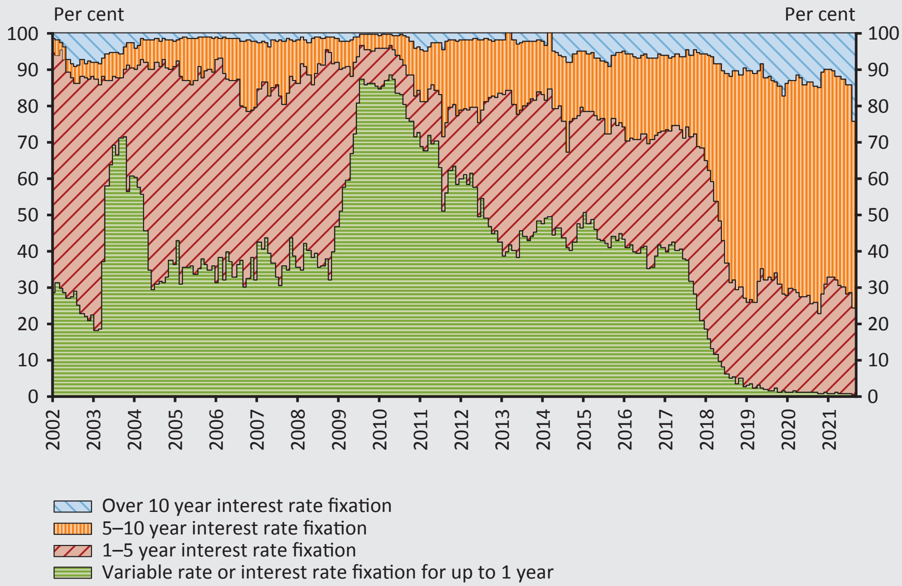
where *BIRS* denotes the fixed leg of the interest rate swap transaction with the same maturity as the loan's interest rate period, *Deposits/Loans* is the credit institution sector's aggregate deposit-to-loan ratio, *BUBOR* is the six-month interbank lending rate, and the *weighted average deposit rate* stands for the weighted average interest rate on new, HUF-denominated time deposits and demand deposits placed by households and companies. The logic behind the creation of the adjusted cost of funds is the following: if banks raise funds through deposits at a price that is different from the interbank market cost of funds (6-month BUBOR), the difference is incorporated into the pricing of loans to the extent that it reflects banks' overall financing position.[6] The time series created by this method were used in the empirical analysis (see *Section 4*) to examine whether the models estimated by taking into account both deposit-type borrowing and interest rate swaps differ from the dynamics of the baseline model, in which only interest rate swaps are considered in measuring interest rate pass-through.

The central focus of the analysis is warranted by the fact that, based on data from recent years, the aggregate interest rates of newly disbursed housing loans in the Hungarian banking system are repriced only with a lag of several months after a change in BIRS rates, used as the reference rate in the present analysis. This also means that for a limited time there may be an inverse relationship between the change in the reference rate and the interest rate spread (the difference between the interest rate and the reference rate). This causes a distortion in spreads mainly when BIRS yields change in the same direction for several months, creating a trend, or when loan disbursement almost exclusively comprises loans fixed for the longer

[6] During the calculation, the deposit-to-loan ratio was capped at 1 (100 per cent) on the grounds that banks implement the difference between the cost of funds on deposit-type borrowing and interbank market borrowing up to the extent that is in line with the volume of outstanding loans.

term, such as in the recent period (*Figure 1*). In the case of such loans, banks may incorporate the cost of funds into lending rates only with a lag of several months.[7]

Figure 1
Distribution of HUF-denominated housing loans in the Hungarian banking system based on initial interest rate period



Source: MNB

This paper examines the number of months it takes for any change in interbank rates, or the adjusted cost of funds, to pass through to the aggregate interest rates of newly disbursed housing loans with an initial interest rate period of over one year (hereinafter: fixed-rate loans). The research question is answered using two different approaches.

1) Employing a descriptive method and using interest rate condition data collected from the websites of the seven largest banks operating in Hungary based on balance sheet total, banks' practices regarding the repricing of fixed-rate CCFHLs are analysed.

[7] In the case of variable-rate housing loans with up to one year initial interest rate fixation, according to banks' lists of conditions, the interest rate on new loans typically depends on the BUBOR prevailing at the end of the previous month, and the spread – which is also given in the list of conditions – must be added to this. By contrast, in the case of loans with interest rates fixed for a longer period, typically there are exact interest rate values which are not updated by banks every month.

2) On a model basis, interest rate statistics downloaded from the website of the MNB are used to estimate the amount of time it takes for repricing to take hold. The estimation is performed using a vector autoregression (VAR) model, in which the interest rate of fixed-rate housing loans is explained by the past evolution of the cost of funds (BIRS and adjusted cost of funds) and the dependent variable itself.

The study is structured as follows: *Section 2* presents an overview of the results of the theoretical and empirical studies on slow and partial repricing (stickiness). *Section 3* provides a descriptive summary of the development of the aggregate time series on which this paper focuses, as well as the repricing practices observed based on the interest rate conditions of individual banks. *Section 4* then presents the time series analysis methodology and the results of modelling. Finally, the main findings are summarised.

2. Factors influencing the stickiness of interest rates

Assuming perfect competition, perfect information and zero transaction costs, the derivative of price with respect to marginal cost equals one (*Lowe – Rohling 1992*; *Horváth et al. 2005*). In the context of this paper, the above means that if the conditions listed are satisfied, the change in banks' cost of funds is fully incorporated into lending rates. If the above-mentioned conditions are not met though, the price will adjust to the marginal cost imperfectly. In other words, the pass-through of the cost of funds into lending rates will not necessarily be complete or it will slow down. The stickiness of the customer rates used by banks is a well-known phenomenon in the international financial literature, as confirmed by several empirical studies (for a detailed summary, see, for example, *Lowe – Rohling 1992*; *Nabar et al. 1993*). "*Interest rate stickiness*" is used for two related but nevertheless different phenomena: the relative inelasticity of lending rates to credit demand on the one hand, and the incomplete or slow adjustment of lending rates to money market yields on the other hand (*Cottarelli – Kourelis 1994*). Below, the explanations related to the reasons behind the latter identified on a theoretical or model basis are reviewed.

One of the best-known explanations for the stickiness of interest rates is the one based on the asymmetry of information between banks and borrowers (*Stiglitz – Weiss 1981*), in essence stating that raising interest rates leads to adverse selection of potential borrowers, which dents banks' expected profits through the rising credit risk of the loan portfolio. The reason behind the adverse selection is that the borrowers which are more willing to pay the higher rates are also more likely to have a greater probability of default. Moreover, higher rates may encourage borrowers to implement riskier projects (*moral hazard*). There is, then, an optimal level of interest rates, where banks' expected profits are maximised. The main conclusion of the theory is that higher interest rates may lift the credit risk and probability of default in the loan portfolio to such an extent that it can begin to erode banks' expected profits. In such a situation, it is rational for banks to raise interest rates less than the rise in the cost of funds and set them lower than the equilibrium rate, which ultimately distorts the interest rate transmission mechanism.

Mester and Saunders (*1995*) attribute the inelasticity of interest rate pricing to the cost of repricing triggered by the change in the cost of funds (*menu costs*). According to the theory, it is only rational for banks to change the interest rate level when the equilibrium interest rate is higher than the current rate by at least an amount where the income induced by the higher rate exceeds the administrative costs of repricing. In their empirical studies, the authors also point out the asymmetrical repricing practices of profit-maximising banks, where banks incorporate a drop in the cost of funds into lending rates less elastically than a rise in the cost of funds.

In the theory of *Fried and Howitt* (*1980*) based on sharing risks, interest rate stickiness is rooted in the risk-aversion of customers. If borrowers are risk-averse, preferring steady, predictable interest rates, banks set lending rates so that they change less than their cost of funds. Overall, banks set a higher interest rate than for a hypothetical risk-free customer, thereby compensating banks' owners for taking greater risk. Thus, the theory runs that banks smooth interest rates over time, and therefore customers can sometimes borrow cheaper than the equilibrium rate, and sometimes they need to pay more than that. According to those behind the theory, due the costs of changing the interest rates (*menu costs for the banks, and shoe-leather costs for customers*), risk-sharing is favourable to both parties. In this context, *Hodgman* (*1963*) found that banks adjust their rates less frequently than warranted by the changes in the cost of funds because they consider customer relations.

In recent decades, in addition to the theoretical considerations detailed above, several studies have examined the factors in the financial systems of certain economic areas and country groups that best explain the differences in the efficiency of the interest rate transmission mechanism. These studies typically used different econometric approaches, but there were many similarities with respect to the variables taken into account and the findings. Most relevant studies have found that the efficiency of transmission is mostly attributable to the structural characteristics of the financial system. Furthermore, the international literature agrees that strong or increasing competition among banks boosts the efficiency of the interest rate transmission mechanism (*Gigineishvili 2011*). Nonetheless, the impact of competition may be exerted asymmetrically within the banking system, depending on the change in the direction of the yield environment: it entails a quicker adjustment for new loans (on the assets side) in a falling yield environment, and slower adjustment in a rising yield environment.

Cottarelli and Kourelis (*1994*) were the first to use models to identify the factors that determine the repricing of interest rates. The authors looked at data from 31 advanced and emerging economies and found that the efficiency of the interest rate transmission mechanism is mainly attributable to the maturity of financial markets, the barriers to the free flow of capital, the intensity of competition within the banking system and between banks and financial intermediaries, as well as the volatility of money market yields. They showed that the stickiness of lending rates and the features listed here are related in terms of the following factors, which also depend considerably on the structure of the given country's financial system:

1) *The costs of repricing interest rates and the price elasticity of loan demand.* Banks change lending rates if the cost of repricing is lower than the revenue loss arising from deviating from the equilibrium rate. The role played by the cost of repricing in the interest rate transmission mechanism also depends on the price elasticity of loan demand.

2) *The costs of repricing interest rates and the uncertainty surrounding the future change in the cost of funds.* If banks deem the change in money market yields to be temporary, they do not necessarily reprice their products due to menu costs, which constrains the interest rate transmission mechanism.

3) *Non-profit-maximising banking system.* The considerations related to the repricing of interest rates are based on the assumption that banks are profit-maximisers. If the banking system is non-profit-maximising, for example because a large portion of it is state-owned, lending rates may become sticky upwards, meaning that a rise in money market yields is not necessarily reflected in loan prices, or only slowly.

4) *Oligopolistic banking system.* In an oligopolistic banking system, banks' behaviour – and thus also the speed and extent of interest rate repricing – may be influenced by the uncertainty related to competitors' pricing.

Several analyses of the topic have appeared since *Cottarelli and Kourelis* (*1994*). For example, *Sorensen and Werner* (*2006*) examined the banking systems in the euro area and found that pace of repricing was influenced negatively by the concentration of the market, banks' excess liquidity and excess capital, a stable deposit structure and interest rate risk (the maturity mismatch between the assets and liabilities side), and positively by the diversity of banks' portfolio (high share of non-interest income) and the riskiness of the loan portfolio. *Mojon* (*2000*) also looked at the banking systems of the euro area, finding that the volatility of money market yields and high operating costs (personnel costs) had a negative impact on the interest rate transmission mechanism, while competition among banks and that generated by players offering alternative sources of finance had a positive impact. *Sander and Kleimeier* (*2004*) analysed the interest rate transmission mechanism in the banking systems of Central and Eastern European countries and pointed out that interest rate pass-through was more efficient in banking systems with a low share of non-performing loans and a strong presence of foreign banks. *Gigineishvili* (*2011*) analysed the reasons behind the heterogeneity of interest rate repricing on a sample of 70 economies, taking into account not only the features of the financial system but also other macroeconomic variables. According to his results, the macroeconomic variables of high GDP per capita and inflation had a positive impact on repricing, while the volatility of money market rates had a negative effect.

In addition to exploring the factors that determine the repricing of interest rates, a large portion of the literature cited above also addressed the quantification of the extent and speed of repricing. *Cottarelli and Kourelis* (*1994*) found that the parameter of interest rates' long-term adjustment takes a value of 0.75–1.25 on average in the sample under review; in other words, changes in money market yields are typically fully reflected in lending rates in the long run. As regards the speed of the pass-through, they showed that three and six months after the change in the market yields, only two thirds or three quarters of that was incorporated into lending rates on average, with significant heterogeneity across the countries under review. Many papers have demonstrated that interest rates respond differently to the rise and fall in yields: lending rates are stickier downwards, while deposit rates are stickier upwards. *Mojon* (*2000*) observed such an asymmetry for European countries, whereas *Mester and Saunders* (*1995*) did so for the United States.

The Hungarian literature, which is even more relevant for the present analysis, also features papers on this topic. *Világi – Vincze* (*1996*), *Árvai* (*1998*), *Horváth et al.* (*2005*) and *Varga* (*2021*) all attempted to provide an econometric model for interest rate pass-through in the banking system. *Világi and Vincze* (*1996*) used ADL (autoregressive distributed lag) models for 1991–1995, finding that the adjustment of banks' interest rates was slow on both the deposit and the lending side, and in the case of loans adjustment it was not complete even in the long term. *Árvai* (*1998*) employed a vector error correction model in her analysis to show that the transmission between market interest rates and lending rates was relatively efficient in 1995–1998, but the results should be used with some reservations due to the short time series. *Horváth et al.* (*2005*) also used an error correction model: based on their linear model, adjustment can be considered complete and quick in the short-term corporate loan market over the long run, while the other submarkets are characterised by partial and/or slow repricing. *Varga* (*2021*) examined the features of interest rate pass-through using a weighted average cost of funds produced by the author, based on which a long-run equilibrium relationship with housing loan rates was established.

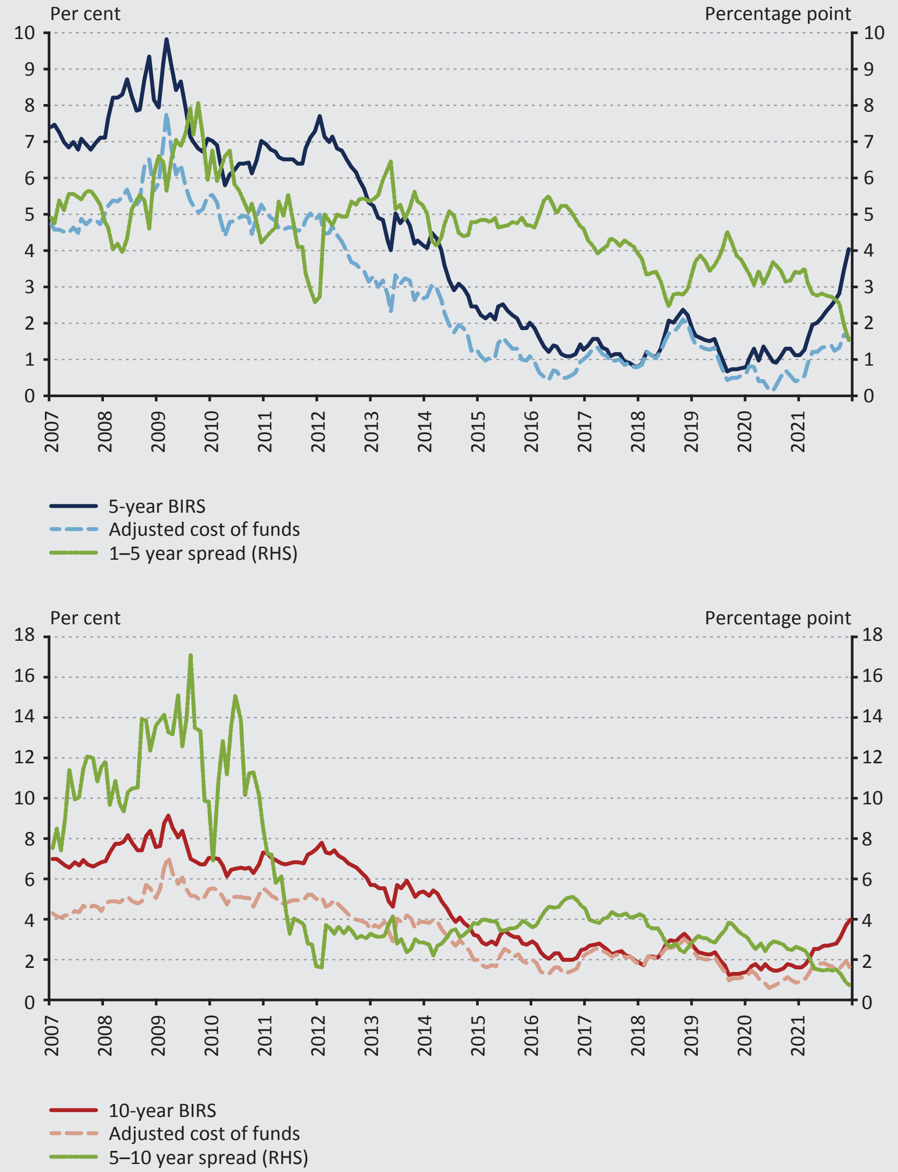
3. Assessment of the change in interest rates based on descriptive statistics

The descriptive analysis uses monthly interest rate statistics and the interest rate condition data from the announcements available on banks' websites. The analysis of the aggregate data covers the period from January 2007 to December 2021, while the analysis of interest rate conditions covers January 2018–December 2021. The examination considers housing loans that have an initial interest rate period of over one year and up to 5 years (hereinafter: 1–5-year loans), and those with an initial interest rate period of over 5 years and up to 10 years (here: 5–10-year loans), as these products have represented a growing share of new housing loans in recent years, while variable-rate loans with an initial interest rate period of up to one year only account for half a per cent of disbursements in the current banking practices.

3.1. Aggregate interest rate statistics

As briefly mentioned in *Section 1*, the examination of the average mortgage rates on new loans in the Hungarian banking system clearly shows that the interest rate spread between lending rates and interbank rates changes when interbank rates shift (*Figure 2*). This also means that there is an inverse relationship between the change in interbank rates and the change in the interest rate spread. That suggests that banks' customer rates do not perfectly adjust to market yields in the short run. This can be clearly observed in several periods characterised by interest rate declines and increases. For example, the latest period when interest rates on the interbank market sank for a longer time was between October 2018 and August 2019, when 5-year and 10-year BIRS yields declined by 171 and 205 basis points, respectively, while the spreads of the loans with corresponding interest rate periods rose by 173 and 150 basis points, respectively. The interest rate increase that began in 2021 is a good example for the inverse relationship between reference rates and spreads as well: between January and December 2021 5-year and 10-year BIRS yields rose by 334 and 255 basis points, respectively, while the spreads of the loans with corresponding interest rate periods narrowed by 194 and 199 basis points, respectively.

Figure 2
5-year and 10-year BIRS and adjusted cost of funds, and the average APR of housing loans with an initial interest rate period of 1–5 years and 5–10 years



Note: Spreads are relative to the 5-year and 10-year BIRS.

Source: MNB

The inverse relationship between the interbank rate and the interest rate spread is typical of not only the Hungarian banking system, as international data suggest a similar picture. *Table 1* contains the correlation coefficients between the changes of the mortgage rate spread and the interbank rate (IRS) for the maturity corresponding to the interest fixation period in 18 European countries, which all take a negative value. It is important to understand that the examination of the simultaneous correlations between differential time series does not yield an accurate picture of the stickiness of lending rates, because we do not control for factors whose change over time may influence the speed of repricing, such as the change in the intensity of competition; moreover, the time it takes for repricing to take hold is not taken into account. With respect to the latter, it is rational to assume that banks do not reprice their loans within the month, and therefore the fact that market yields are not immediately incorporated into the pricing of housing loans can be considered a given. In this context, if the spread is calculated based on the interest rate for the given month and a reference rate from 1, 2 or 3 months earlier, the negative relationship is weaker in all countries, and in some instances it turns into a positive correlation between the changes in time series.

Table 1
Correlation coefficient between the mortgage rate spread and the interbank rate for the maturity corresponding to the interest fixation period in international comparison

Country	Correlation coefficient (simultaneous spread)	Correlation coefficient (spread with 1-month lag)	Correlation coefficient (spread with 2-month lag)	Correlation coefficient (spread with 3-month lag)	Period
Croatia	–0.99	–0.26	–0.02	–0.12	Oct 2006 – Nov 2021
Denmark	–0.95	–0.26	0.03	–0.03	Jan 2000 – Nov 2021
France	–0.91	–0.26	0.06	0.00	Feb 2013 – Nov 2021
Belgium	–0.90	–0.25	0.08	0.02	Jan 2000 – Nov 2021
Czechia	–0.87	–0.23	0.20	0.13	Jan 2000 – Nov 2021
Netherlands	–0.85	–0.16	0.13	0.10	Jan 2003 – Nov 2021
Ireland	–0.82	–0.18	0.15	0.11	Oct 2007 – Nov 2021
Germany	–0.80	0.00	0.27	0.23	Apr 2009 – Nov 2021
Italy	–0.80	–0.12	0.07	0.16	Jan 2009 – Nov 2021
Slovenia	–0.63	–0.23	–0.05	0.05	Mar 2002 – Nov 2021
Lithuania	–0.56	–0.21	–0.20	–0.23	Dec 2011 – Nov 2021
Austria	–0.56	–0.09	0.08	0.06	Jul 2017 – Nov 2021
Luxembourg	–0.55	–0.04	0.17	0.19	Jan 2000 – Nov 2021
Spain	–0.46	–0.12	–0.01	0.01	Jan 2000 – Nov 2021
Portugal	–0.42	–0.15	–0.14	–0.21	Jan 2000 – Nov 2021
Slovakia	–0.40	–0.10	0.08	0.09	Jan 2003 – Nov 2021
Latvia	–0.27	–0.10	–0.03	–0.03	Dec 2018 – Nov 2021
Finland	–0.24	0.19	0.35	0.33	Jan 2001 – Nov 2021

Note: The lagged spreads are the differences between the given month's interest rates and the reference rates from 1, 2 or 3 months earlier.

Source: ECB

In connection with the aggregate interest rate statistics of the Hungarian banking system, it is important to underline that they contain the average interest rates of the mortgage loans signed by the banks in the given month. When examining repricing, this may cause a distortion, as according to the current practices of Hungarian banks a considerable amount of time can elapse between acceptance of the loan application and actual signing of the contract.

In the case of the CCFHLs, which have accounted for over 60 per cent of newly disbursed housing loans since 2018, the distortion is due to the fact that based on the information provided by the applicant, the lending bank gives an offer, irrevocable for 90 days, to the effect that it will sign a contract with the borrower under the credit terms prevailing at the time of the acceptance, or under better conditions from the perspective of the borrower.[8] This means that the aggregate data of signed loan contracts may not necessarily be based on the credit terms applicable in the given month, but on those applicable at the time of acceptance, and a considerable amount of time may elapse between the two dates. Based on the reporting on CCFHLs, on average about two months pass between the acceptance of the loan application and the signing of the contract, so the interest rate transmission estimated on aggregate data should indeed be distinguished from the actual adjustment time of individual banks, which can be determined based on banks' announcements of condition changes and which is the adjustment time perceived by costumers as well.

In the case of non-CCFHL, market-based loans, no information is available as to the time of the acceptance of the loan application, but since there is no major difference between the two types of products when it comes to the period until the next step in the process, the credit assessment and the signing of the contract (approximately one month), it can be reasonably assumed that the time requirement for the two administrative processes is similar. Nonetheless, one difference in connection with repricing may be that in the case of market-based loans, institutions are not bound by the regulation on the provision of an irrevocable offer upon acceptance, as applicants only get the loan offer after the credit assessment, and therefore the interest rate in the offer may differ from the contract terms applied by the bank at the time of acceptance.

It should also be noted that changes in reference rates may appear even in the conditions for CCFHLs with a considerable lag, if banks offer the maximum interest rates allowed by the CCFHL regulation prevailing at the time, or one close to that. This is because according to this regulation, the initial value of the starting interest rate may not be higher than the reference rate applicable on the 15th day preceding the last working day of the month prior to acceptance[9] plus 3.5 percentage points.

[8] For the detailed regulations pertaining to CCFHLs, see the tender for Certified Consumer-Friendly Housing Loans (https://www.minositetthitel.hu/letoltes/minositett-fogyasztobarat-lakashitel-palyazati-kiiras-20190723.pdf).

[9] The Government Debt Management Agency's reference yield for the Hungarian government bonds with a nominal maturity corresponding to the interest rate period or the BIRS with the same maturity.

A similar regulation applies to another popular loan product that also appears in aggregate interest rate statistics, namely the Home Purchase Subsidy for Families interest rate-subsidised loan, where the starting interest rate may not be higher than 3 percentage points plus 130 per cent of the arithmetic mean of the yields of the government bonds with a nominal maturity of 5 years, as published monthly by the Hungarian Government Debt Management Agency based on the auctions in the three months preceding the publication date, weighted by the amounts accepted at the given auctions.[10]

3.2. Interest rate conditions

Actual adjustment to the interbank rate can be best captured through the changes in the interest rate conditions of banks' terms and conditions: thus, in order to obtain a comprehensive picture of banks' response time, capturing any heterogeneous repricing by individual banks, the practice of changing interest rate conditions was also examined. The analysis looked at the interest rates offered by banks without discounts. It must be noted here that banks may also implement the change in their cost of funds by tweaking the discounts, so even though the terms and conditions do not immediately reflect the change in interest rates, customers may perceive it earlier through the change in discounts. However, based on the compilation for this study, the discounts changed only rarely and moderately in the period under review, to varying extents or even in different directions across the individual loan amount categories. Therefore, considering the change in discounts does not yield significant additional information, and accordingly it was decided that their change over time would be disregarded.

With respect to the change in interest rate conditions, it is important to distinguish between variable-rate and fixed-rate loans. The interest rate conditions of variable-rate loans are determined by banks as the sum of the previous month-end BUBOR, mostly a 3-month or 6-month figure, and a given spread. Thus, in this case the change in the reference rate in the given month automatically, uniformly and completely appears in the next month's interest rate conditions, the transmission mechanism is homogeneous, and any difference between the interest rates charged by banks can only be caused by the change in interest rate spreads. By contrast, in the case of fixed-rate loans, the reference rate may not necessarily be automatically incorporated into the conditions, and thus banks may reprice interest rates with a lag of several months.

If banks fail to incorporate the change in the reference rate into their interest rates immediately in the next month, it does not mean that they are adjusting their spreads to the same extent as the change, but with the opposite sign. It merely means that they are interested in delaying the repricing for some reason,

[10] Government Decree No 17/2016. (II. 10.) on the Home Purchase Subsidy for Families for the purchase and extension of used homes. https://net.jogtar.hu/jogszabaly?docid=A1600017.KOR

for example because they wish to acquire market share. On the other hand, if banks do not modify their interest rates by the same amount as the change in the reference rate for a long time, that may not necessarily signal a temporary delay in repricing, but instead a permanent change in spreads. With respect to the speed of interest rate transmission for fixed-rate loans, one cannot rely solely on examining the change in conditions, and this is the reason behind the present econometric analysis. Nevertheless, these are the conditions that are relevant for households.

The practice of adjusting interest rate conditions was examined using the monthly changes in the CCFHL credit conditions[11] at the seven largest credit institutions operating in Hungary, and the shifts in the month-end interbank rates for the corresponding interest rate period, starting from January 2018. Three longer repricing periods were identified where interbank rates steadily rose or declined for months in the beginning. These periods were as follows:

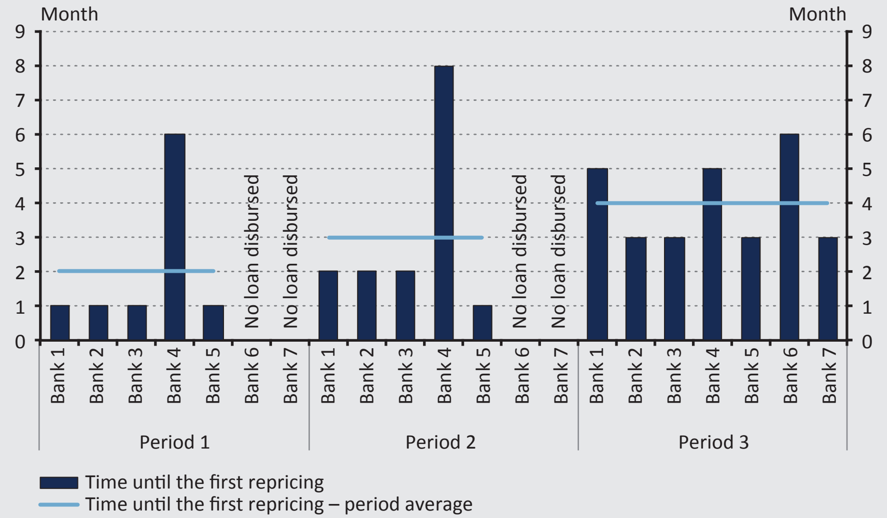
- Period 1: BIRS rising between May and October 2018;
- Period 2: BIRS falling between November 2018 and August 2019;
- Period 3: the portion of the rise in BIRS since January 2021 lasting until the end of December 2021.

These periods were examined to see the extent of the cumulative change in the interest rate conditions of the banks under review in the individual months, relative to the cumulative BIRS change that occurred until the end of the previous month. Repricing within the month is very rare, therefore, and because of the overlap between the repricing periods, the cumulation of banks' interest rate repricing was started from a month later than that of BIRS changes.

The authors found varying practices among banks regarding repricing. Banks typically changed their conditions with a lag of 1–3 months after the first month of the persistent and significant rise/fall in the BIRS, while some institutions waited for 5–8 months in the beginning (*Figure 3*). The different repricing periods were characterised by different bank response times: with the exception of the bank that usually conducted the repricing at the slowest pace, banks first changed their conditions after one month in the first identified period, whereas the most typical lag was two months in the second period, and in the period of yield increase that began in January 2021 the most typical delay was three months or even longer, which suggests an intensification in competition among banks and a motivation to acquire market share.

[11] The conditions of the market-priced housing loans without CCFHL certification were also analysed. In the case of most banks, these conditions were the same as the CCFHL conditions in all months during the period under review, however, certain large banks offered the non-CCFHL loans under stricter interest rate conditions, and the interest rates were changed much less frequently. Therefore, the paper examines the CCFHL conditions, which better capture the repricing of the banks under review.

Figure 3
Time needed for the first interest rate repricing following the change in the 5-year BIRS among banks disbursing CCFHLs with an initial interest rate fixation of 5 years



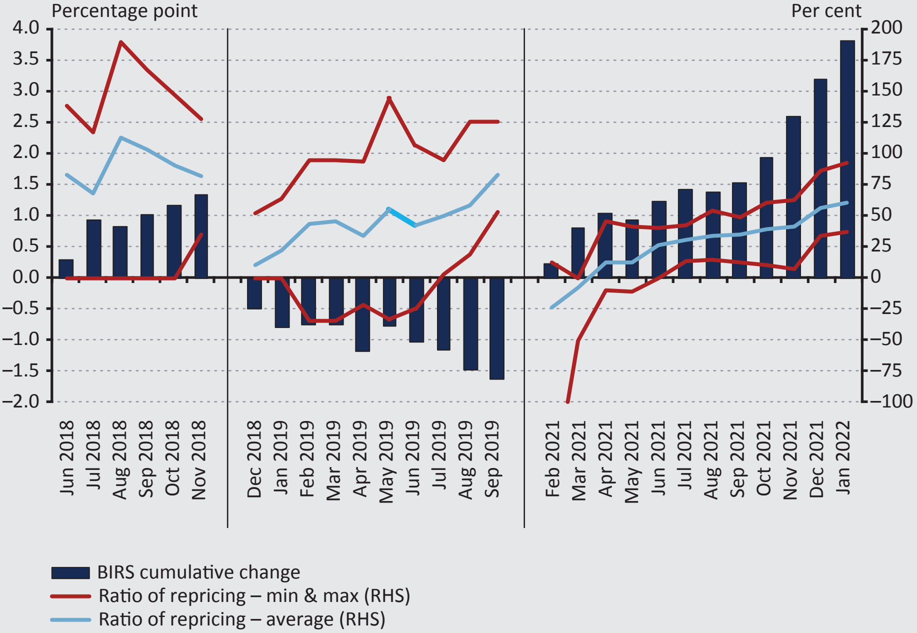
Note: The comparison only covers the seven largest credit institutions operating in Hungary that offer CCFHLs.

Source: Based on bank website data

Another important lesson learnt from the comparative analysis was that the extent of banks' change in interest rates usually, and often significantly, fell short of the cumulative change in the BIRS observed until the end of the previous month in the given repricing period, so they were regularly followed by one or two changes in the same direction. An exception to this was the period of steeply rising interbank rates triggered by the tightening cycle: after September 2021, banks changed the conditions of housing loans in almost every month.

Analysing the ratio of the conditions and the cumulative changes in the BIRS not only in the beginning but also for each month, with a simple average across banks (*Figure 4*), the transmission is observed to vary in speed over the various repricing periods. In the first identified repricing period, full transmission was completed in three to four months on average, with an overall transmission of 82 per cent until the end of the period, following the continued rise in the reference rate. In the second repricing period characterised by a contracting reference rate, transmission stood at merely 50 per cent after three to four months, but averaged 83 per cent by the end of the period, meaning that banks permanently raised their spreads in this period. In the rising yield environment that began in January 2021, a steady decline in spreads can be observed, as not a single bank's tightening implemented until September 2021 reached the extent of the BIRS rise in the first two months of the year (80 basis points), and on average banks' interest rate increases amounted to only 36 per cent of the BIRS rise recorded since the beginning of the year. After this, transmission began to pick up, but the extent of repricing only rose to 60 per cent until January 2022.

Figure 4
Cumulative change in the 5-year BIRS as well as the cumulative change in the interest rate conditions of the CCFHLs with an initial interest rate fixation of 5 years at individual banks relative to the cumulative change in the BIRS until the end of the preceding month

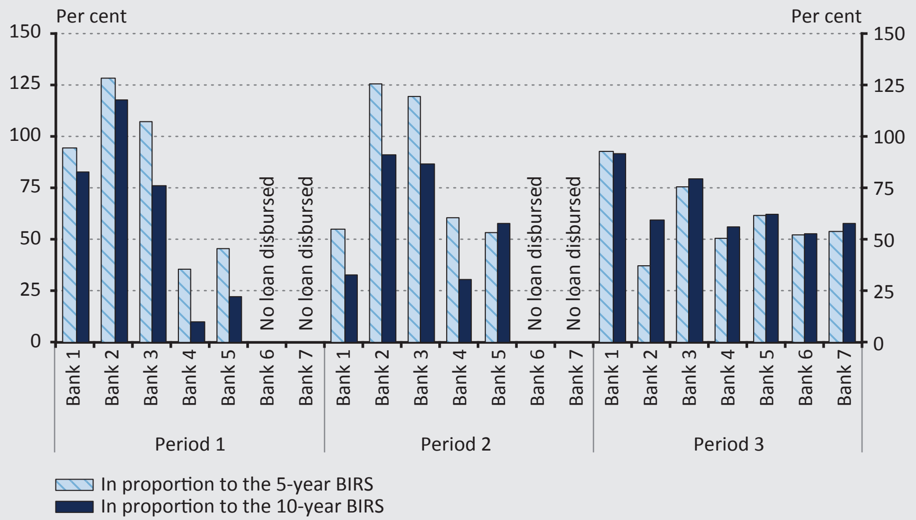


Note: The comparison only covers the seven largest credit institutions operating in Hungary that offer CCFHLs.

Source: Based on bank website data

The results obtained for the products with an interest rate fixation of 5 years were compared to the relationship between the conditions of the CCFHLs with an initial interest rate fixation of 10 years and the monthly changes in the 10-year BIRS. It was observed that the conditions of the products with an initial interest rate fixation of 5 or 10 years were typically changed by banks in the same periods, with differences in timing seen only rarely, and the repricing periods were also identical. By contrast, in the first and second identified repricing periods, the extent to which the cumulative change in the 10-year BIRS appeared in the average conditions of the large banks under review after the start of the given period fell short of the transmission seen in the case of the products with interest rate fixation of 5 years by 20 and 23 percentage points on average, respectively (*Figure 5*). However, the same significant difference was not observed in the repricing period that started in January 2021, partly owing to the fact that while the 5-year BIRS increased more steeply than the 10-year BIRS, there are banks that usually change the conditions for the loans with an interest rate fixation of 5 and 10 years uniformly, which, of course, was reflected as a higher ratio of transmission in the case of 10-year conditions.

Figure 5
Changes in the interest rate conditions of the fixed-rate CCFHL products relative to the cumulative change in the 5-year and 10-year BIRS at the end of the identified period



Note: The comparison only covers the seven largest credit institutions operating in Hungary that offer CCFHLs.

Source: Based on bank website data

4. Examining the repricing of interest rates with time series econometrics

4.1. Methodology

In a simple vector autoregressive (VAR) model without constant and exogenous explanatory variables, all variables are explained with the lagged values of their own or of the other variables. According to *Lütkepohl* (*2005*), a K-dimensional stationary VAR(p) process can be written as follows:

$$\boldsymbol{y}_t = A_1\, \boldsymbol{y}_{t-1} + \cdots + A_p\, \boldsymbol{y}_{t-p} + \boldsymbol{u}_t\ , \qquad (3)$$

where the K × 1-sized vector denotes the time series to be modelled, A_j (j = 1, ..., p) are K × K-sized coefficient matrices, and the error term is K-dimensional white noise with an expected value of 0 and a variance-covariance matrix of Σ*u*.

If the observations are available, the coefficients and the error terms can be estimated with the ordinary least squares method (OLS). If there is a significant long-run equilibrium relationship, also known as cointegration, between the time series observed, a vector error correction model (VECM) should be used instead of the VAR model.

Due to the correlations in the time lag structure of the variables, the estimated coefficient values of the VAR model do not necessarily offer much information in themselves, as the causalities can only be appropriately interpreted by using impulse response functions. Impulse response functions show the ceteris paribus impact of a unit shock to a given model variable exerted on all model variables. Based on *Pfaff* (*2008*), they can be determined through the Wold moving average decomposition of the VAR(p) process:

$$\boldsymbol{y}_t = \Phi_0 \, \boldsymbol{u}_t + \Phi_1 \, \boldsymbol{u}_{t-1} + \Phi_2 \, \boldsymbol{u}_{t-2} + \cdots , \tag{4}$$

where and can be calculated recursively from the equation

$$\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} \, \mathrm{A}_j \tag{5}$$

where s = 1, 2, …, and $A_j = 0$ for all j > p.

The Σu matrix may not necessarily be diagonal, so there may be a simultaneous correlation between the error terms in the different equations. If these correlation values differ significantly from zero, independent (uncorrelated) structural shocks should be identified using a structural vector autoregressive model to produce impulse response functions that can be appropriately interpreted from the perspective of economics.

4.2. Examining cointegration

In the relevant section of the literature, the interest rate transmission mechanism is usually examined using a vector error correction model (VECM), however, it can only be applied if the time series in the estimation are cointegrated. The most widely used method for testing cointegration is the Johansen test. In the creation of the model, the test was performed for analysing the relationship between the loans with an initial interest rate fixation of 1–5 years and 5–10 years and the interbank rate for the corresponding maturities as well as the adjusted cost of funds. The aggregate interest rate statistics included in the estimation and the BIRS rates are available from January 2007 with monthly frequency, and the latest observation was from November 2021 at the time when the estimation was performed.

Accordingly, using the entire available time series, the model is based on 179 observations for each variable.

According to the Johansen tests performed for all of the observations available in the period, no cointegration can be detected for either the loans with an initial interest rate fixation period of 1–5 years or those with a fixation of 5–10 years (for the test results, see *Tables 3.a*), *3.b*), *3.c*) and *3.d*) in the *Annex.* Besides taking into account the information criteria pertaining to the optimal number of lags, Johansen tests were also performed with a four-period lag of the BIRS and the adjusted cost of funds time series, because, based on the VAR model presented in the next section, the fourth lagged value of the BIRS and the adjusted cost of funds has the strongest explanatory power regarding the evolution of the APR. The cointegration is not confirmed by the Johansen tests performed based on this method either.

Moreover, the cointegration test was performed for all subperiods that lasted for at least 60 months to obtain better confirmation of the lack of a cointegration. The tests run for the subperiods were performed for 7,381 periods for the loans with an initial interest rate fixation of 1–5 years and those with a fixation of 5–10 years each. In the former case, based on the number of lags specified taking into account the information criteria, a cointegration between the time series was found at a significance level of 5 per cent in 23.8–24.4 per cent of cases, while in the case of the four lags used based on the experiences of the VAR model estimation, such a relationship was found in 19.3–35.0 per cent of cases (*Table 2*). In the case of the loans with an initial interest rate fixation of 5–10 years, a cointegration between the time series can be detected in 28.2–29.0 and 13.9–15.7 per cent of cases, respectively. This presence of cointegration was not deemed to be sufficient to use a VECM.[12]

[12] In certain periods, cointegration was found in a large number of cases, so another paper may be dedicated to identifying any structural breaks (e.g. near-zero interest rate environment) and asymmetric repricing behaviour. Almost the entire period under review was characterised by a decline in interbank rates, and thus it was deemed that not enough observations were available in both categories to distinguish the repricing in a declining and a rising yield environment (for example, using a threshold VECM or a non-linear ARDL model).

Table 2

Share of subperiods exhibiting cointegration at a significance level of 5 per cent, by the starting year of the time series

Starting year of time series	Total number of estimated periods	5-year BIRS	Adjusted cost of funds	5-year BIRS with a 4-month lag	Adjusted cost of funds with a 4-month lag
Interest rate period of 1–5 years					
2007	1,386	22.2	3.4	93.0	42.2
2008	1,242	25.7	3.2	37.8	7.1
2009	1,098	0	0	0	0
2010	954	0	0	0	0
2011	810	45.7	73.6	39.0	43.5
2012	666	45.5	45.5	49.4	53.2
2013	522	17.8	41.2	2.3	7.1
2014	378	58.5	90.5	11.9	0.8
2015	234	46.2	59.4	23.9	0
2016	90	91.1	78.9	74.4	6.7
2017	1	0	100	0	0
Total	**7,381**	**24.4**	**23.8**	**35.0**	**19.3**

Starting year of time series	Total number of estimated periods	10-year BIRS	Adjusted cost of funds	10-year BIRS with a 4-month lag	Adjusted cost of funds with a 4-month lag
Interest rate period of 5–10 years					
2007	1,386	0	0	0	0
2008	1,242	31.6	27.9	8.1	14.1
2009	1,098	54.3	43.4	24.6	32.9
2010	954	54.8	44.3	54.9	44.3
2011	810	17.9	22.3	13.0	17.2
2012	666	12.2	26.4	0	0.8
2013	522	47.7	76.4	5.6	6.3
2014	378	25.9	29.1	0	0
2015	234	0	0	0	0
2016	90	0	27.8	0	26.7
2017	1	0	100	0	0
Total	**7,381**	**28.2**	**29.0**	**13.9**	**15.7**

Note: Calculated based on the cointegration tests run for the subperiods that lasted for at least 60 months.

4.3. Empirical results

The empirical analysis sought to establish the relationship between the mortgage rates of new loans and (1) interbank rates, as well as the (2) adjusted cost of funds calculated based on the method presented in *Section 1*, using the VAR model described in *Section 4.1.*[13] The model was estimated for the loans with an initial interest rate fixation of 1–5 years and 5–10 years and for the interbank rate for the corresponding maturities. Based on the results of the diagnostics run after the estimation for the loans with an interest rate fixation of 5–10 years,[14] the parameters estimated by the model are unreliable; therefore, the analysis is limited to housing loans with an interest rate fixation of 1–5 years.

Before estimating the model, the time series were tested, and in line with the results of the unit root tests, the stationary time series derived from the first differentials of the variables were incorporated into the models (*Annex Table 4*). Taking into account the conclusions of the tests pertaining to the optimal number of lags, the models included four lags (*Annex Table 5*), which is consistent with banks' repricing practices based on the earlier sections of the paper. The lags used ensured the lack of autocorrelation for the residuals (*Annex Table 6*).

As a first step in examining the relationships between the variables, the Granger causality test was performed on the time series to establish whether the lagged values of interbank rates can help predict the actual value of the lending rate (*Annex Table 7*). The null hypothesis of the test, according to which the change in the IRS does not forecast the change in the APR, can be rejected.[15]

In the next step, the VAR model was estimated to capture short-term shocks. The evolution of lending rates was explained by their own values and the lagged values of the BIRS variable denoting the shock. Accordingly, the following VAR models were estimated:

[13] During the creation of the model, besides the models detailed in the paper, the time series of the Herfindahl–Hirschman index produced by the authors, capturing the concentration among banks and calculated for the total outstanding housing loan portfolio of the Hungarian banking system was also included in the models as an exogenous variable, but it did not have a statistically significant explanatory power for the APR time series.

[14] Based on the Granger causality test, the significance value (p-value) related to the F-test testing the null hypothesis is 0.3151, in other words the change in the APR is not the result of the change in the IRS. A potential explanation for this is that the housing loans with an initial interest rate fixation of 5–10 years are relatively new products on the Hungarian market and have only recently become popular. Most of the housing loans with an initial interest rate fixation of 5–10 years typical earlier were contracts with building societies, the pricing of which is not necessarily aligned with interbank rates due to the special nature of the product.

[15] No reverse causality can be established, in other words the APR does not cause either the IRS or the adjusted cost of funds.

• Model equation of 5-year BIRS and APR:

$$\begin{pmatrix}\Delta\widehat{BIRS}_t \\ \Delta\widehat{APR}_t\end{pmatrix} = \begin{pmatrix}-0.009 \\ -0.014\end{pmatrix} + \begin{pmatrix}0.264 & 0.020 \\ 0.156 & -0.227\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-1} \\ \Delta APR_{t-1}\end{pmatrix} + \begin{pmatrix}-0.273 & -0.036 \\ 0.102 & 0.045\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-2} \\ \Delta APR_{t-2}\end{pmatrix} + \\ + \begin{pmatrix}0.158 & -0.050 \\ 0.224 & 0.153\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-3} \\ \Delta APR_{t-3}\end{pmatrix} + \begin{pmatrix}0.031 & 0.139 \\ 0.409 & 0.075\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-4} \\ \Delta APR_{t-4}\end{pmatrix} + \begin{pmatrix}\widehat{u_{BIRS,t}} \\ \widehat{u_{APR,t}}\end{pmatrix} \quad (6)$$

• Model equation of adjusted cost of funds (ACF) and APR:

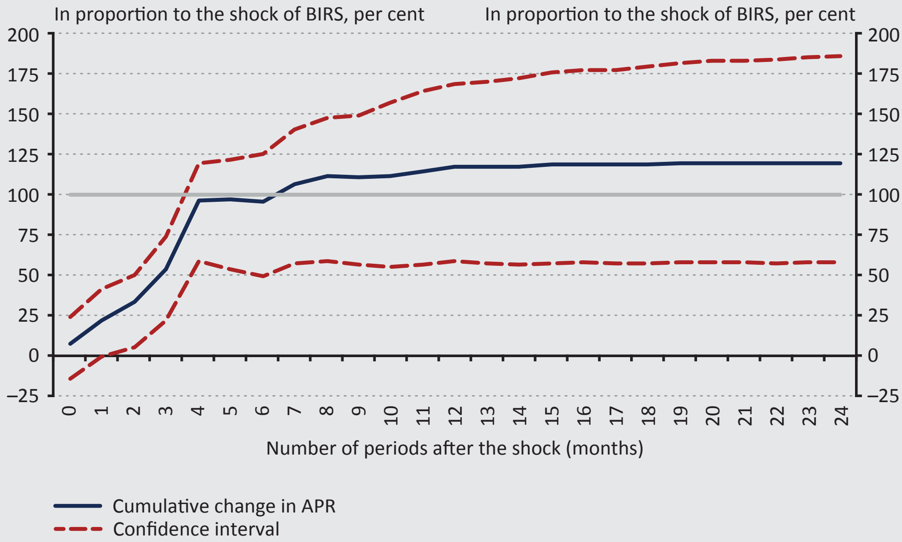
$$\begin{pmatrix}\Delta\widehat{ACF}_t \\ \Delta\widehat{APR}_t\end{pmatrix} = \begin{pmatrix}-0.014 \\ -0.018\end{pmatrix} + \begin{pmatrix}0.116 & 0.044 \\ 0.123 & -0.155\end{pmatrix}\begin{pmatrix}\Delta ACF_{t-1} \\ \Delta APR_{t-1}\end{pmatrix} + \begin{pmatrix}-0.278 & -0.012 \\ 0.090 & 0.088\end{pmatrix}\begin{pmatrix}\Delta ACF_{t-2} \\ \Delta APR_{t-2}\end{pmatrix} + \\ + \begin{pmatrix}0.000 & -0.006 \\ 0.140 & 0.176\end{pmatrix}\begin{pmatrix}\Delta ACF_{t-3} \\ \Delta APR_{t-3}\end{pmatrix} + \begin{pmatrix}-0.028 & 0.132 \\ 0.415 & 0.066\end{pmatrix}\begin{pmatrix}\Delta ACF_{t-4} \\ \Delta APR_{t-4}\end{pmatrix} + \begin{pmatrix}\widehat{u_{ACF,t}} \\ \widehat{u_{APR,t}}\end{pmatrix} \quad (7)$$

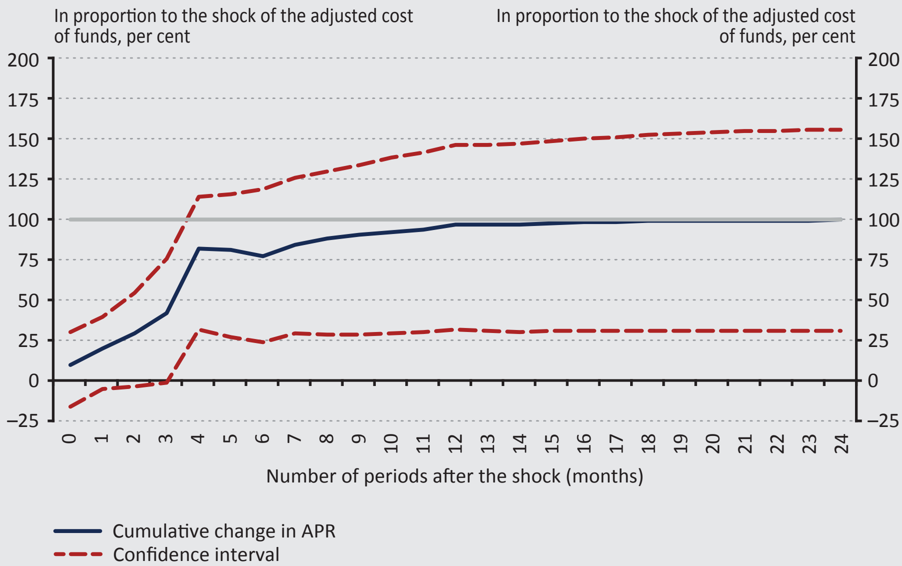
The independent assessment of the estimated parameters does not provide meaningful information on the behaviour of interest rates, as they only reflect partial effects, and examining the full impact, covering lagged and second-round effects, is more interesting. The behaviour of the model can be best illustrated using the impulse response describing the spread of the shock. The orthogonalised[16] impulse response functions show the response of the APR to the unit shock in the VAR error term of the BIRS and the adjusted cost of funds, assuming that all other error terms are unchanged. Since the differences of the individual variables were examined, the cumulative impulse response functions are shown, at a 24-month forward-looking horizon (*Figure 6*).

The most important result from the perspective of the study can be clearly seen in *Figure 6:* the APR has a statistically significant and persistent reaction to the shock to the BIRS and the adjusted cost of funds. The impulse response function attests that the APR changes considerably in the same direction as indicated by the sign of the shock to the BIRS and the adjusted cost of funds, and the change is the strongest in the first couple of months directly following the shock. The impact fades over time, albeit remaining significant and persistent throughout. It can also be stated that the APR can be expected to change by the same extent as the initial shock in four months in response to a unit shock to the BIRS, and after that the value of the impulse response function stabilises near the extent of the initial BIRS shock. The shock to the adjusted cost of funds passes through to the APR somewhat slower and to a more limited extent, but even in that case 80 per cent of the shock appears in the interest rate in just four months. It must be reiterated here that these results only reflect the transmission identified in aggregate interest rate statistics, and they do not mirror banks' typical repricing practices.

[16] The specification of the impulse response function allowed the BIRS and the adjusted cost of funds to be influenced directly only by their own shocks, while the other shocks containing the impact of other factors shaping the spread (which is not relevant for this paper) could only affect them with a lag.

Figure 6
Impulse response function of the shock to the 5-year BIRS and the adjusted cost of funds affecting the APR values of the housing loans with interest rate fixation of 1–5 years (model estimated for the entire period)





Note: 95-per cent bootstrap confidence intervals. The grey line shows the repricing that is identical in extent to the initial shock to the BIRS and the adjusted cost of funds.

Source: Calculations based on MNB data

The fit of the model specification of the entire time series was also examined on a subperiod. The start date of the narrower period was chosen to be March 2013, for several reasons. First, that was the month when the share of housing loans with an initial interest rate fixation of 1–5 years within new loans rose to over 30 per cent, and it can be assumed that banks increasingly adjusted the interest rates of these products to the cost of funds. Second, the pick-up in housing loans after the financial crisis began in 2013, and the market cycle that has lasted since then has been characterised by several structural changes, such as the Fair Bank Act and the debt cap rules as well as the introduction of CCFHL products. The following VAR models were estimated for the subperiod:

• Model equation of 5-year BIRS and APR:

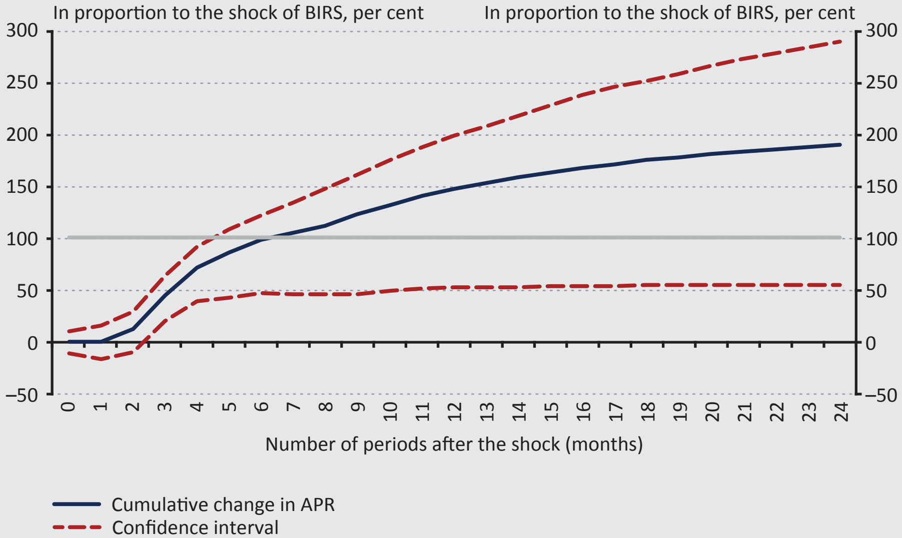
$$\begin{pmatrix}\Delta\widehat{BIRS}_t\\ \Delta\widehat{APR}_t\end{pmatrix}=\begin{pmatrix}0.021\\ -0.020\end{pmatrix}+\begin{pmatrix}0.285 & 0.084\\ -0.002 & 0.043\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-1}\\ \Delta APR_{t-1}\end{pmatrix}+\begin{pmatrix}0.069 & 0.234\\ 0.123 & 0.044\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-2}\\ \Delta APR_{t-2}\end{pmatrix}+$$
$$+\begin{pmatrix}0.021 & 0.283\\ 0.294 & 0.197\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-3}\\ \Delta APR_{t-3}\end{pmatrix}+\begin{pmatrix}-0.159 & -0.081\\ 0.146 & 0.002\end{pmatrix}\begin{pmatrix}\Delta BIRS_{t-4}\\ \Delta APR_{t-4}\end{pmatrix}+\begin{pmatrix}\widehat{u_{BIRS,t}}\\ \widehat{u_{APR,t}}\end{pmatrix} \quad (8)$$

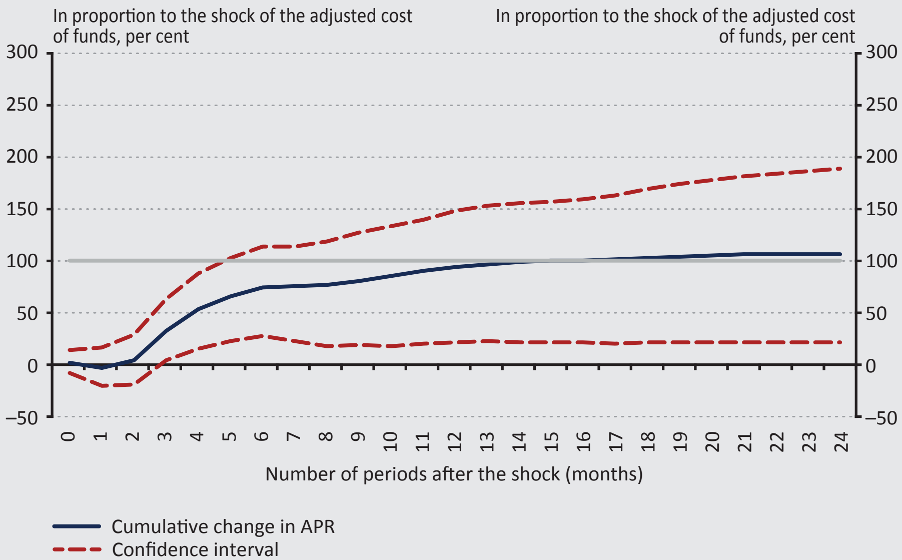
• Model equation of adjusted cost of funds (ACF) and APR:

$$\begin{pmatrix}\Delta\widehat{\mathrm{ACF}}_t\\ \Delta\widehat{APR}_t\end{pmatrix}=\begin{pmatrix}0.003\\ -0.014\end{pmatrix}+\begin{pmatrix}0.228 & 0.073\\ -0.047 & 0.146\end{pmatrix}\begin{pmatrix}\Delta\mathrm{ACF}_{t-1}\\ \Delta APR_{t-1}\end{pmatrix}+\begin{pmatrix}-0.009 & 0.136\\ 0.093 & 0.165\end{pmatrix}\begin{pmatrix}\Delta\mathrm{ACF}_{t-2}\\ \Delta APR_{t-2}\end{pmatrix}\cdot$$
$$+\begin{pmatrix}-0.025 & 0.128\\ 0.270 & 0.161\end{pmatrix}\begin{pmatrix}\Delta\mathrm{ACF}_{t-3}\\ \Delta APR_{t-3}\end{pmatrix}+\begin{pmatrix}-0.206 & 0.033\\ 0.099 & 0.004\end{pmatrix}\begin{pmatrix}\Delta\mathrm{ACF}_{t-4}\\ \Delta APR_{t-4}\end{pmatrix}+\begin{pmatrix}\widehat{u_{\mathrm{ACF},t}}\\ \widehat{u_{APR,t}}\end{pmatrix} \quad (9)$$

Both estimated models showed that the interest rate transmission mechanism has recently slowed down somewhat: based on the impulse response function fitted to the subperiod model, the BIRS shock is expected to almost fully pass through to lending rates in aggregate interest rate statistics in six months, and 75 per cent of the pass-through occurs in the case of the shock to the adjusted cost of funds during the same period, while complete repricing takes more time, just like in the model fitted to the entire period (*Figure 7*). In the case of the model containing the BIRS, repricing amounting to twice the initial shock was seen in the longer run, but this is only because in the longer run the shock triggers a change in the BIRS that is more than twice as large as in the first period (*Annex Table 8*). According to model diagnostics, the model specifications perform well on the subsample: the results show a lack of autocorrelation in residuals, which contain no ARCH effect in any of the model equations, and their distribution can be deemed normal (*Annex Table 6*). In other words, the models have a good fit for the narrow time series.

Figure 7
Impulse response function of the shock to the 5-year BIRS and the adjusted cost of funds affecting the APR values of the housing loans with interest rate fixation of 1–5 years (model estimated for the subperiod)





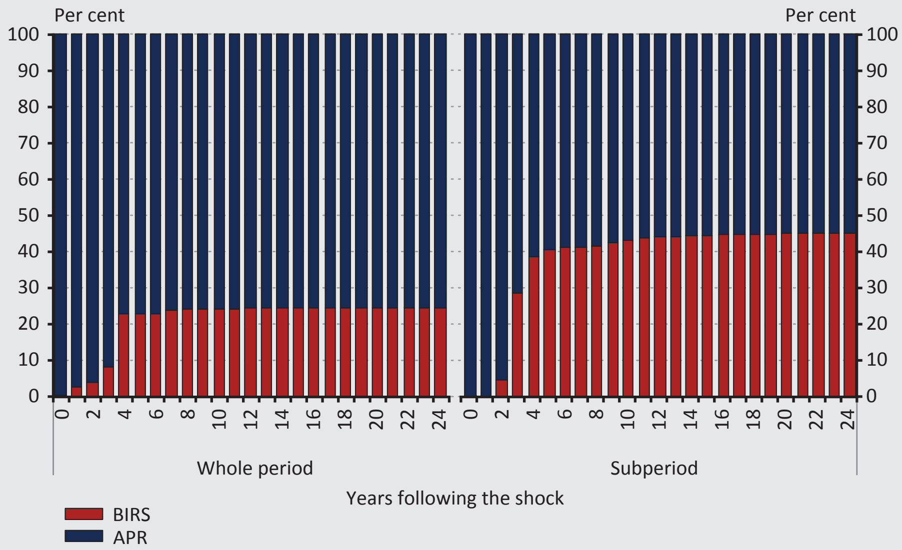
Note: 95-per cent bootstrap confidence intervals. The grey line shows the repricing that is identical in extent to the initial shock to the BIRS and the adjusted cost of funds.

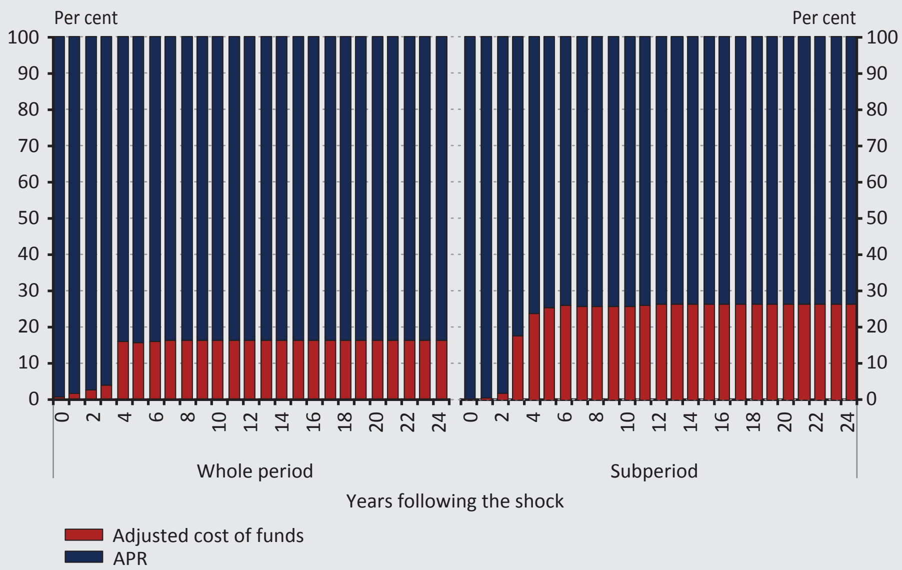
Source: Calculations based on MNB data

The following can be stated based on the comparison of the models estimated for the longer and the shorter time series: in the model for the entire time series, the shocks to the adjusted cost of funds and the BIRS explain 16–24 per cent of the variance in the long-run APR changes, while the same figure is 26–45 per cent for the shorter time series with the same lag structure (*Figure 8*). This suggests that, based on aggregate interest rate statistics, banks increasingly adjust the pricing of their products to the cost of funds, which may be explained by the rise in the share of housing loans with an initial interest rate fixation of 1–5 years within all new loans, as well as by other institutional, structural and market-based factors, which have a varying impact on the data for the subperiod. Variance decomposition also shows that the explanatory power of the BIRS for the APR proved to be stronger than that of the adjusted cost of funds derived by the authors.

Finally, based on the above results, it should be examined how the spread would evolve if it were calculated based on the current value of the average APR and the value of the BIRS from four and six months earlier (lagged spread). Assuming that the results estimated from the models accurately capture banks' time requirement for repricing and thus give a good approximation of the speed of transmission even looking ahead, it could be claimed that banks have persistently changed their spreads when repricing takes longer or shorter than four months, or six months if the results of the subperiod are considered. In other respect, the lagged spread shows the spread expected in four or six months, with the reference rate and other factors being unchanged. This train of thought is illustrated in *Figure 9*, which shows that while the spread calculated without taking into account the time lag was dispersed in a range of several percentage points since the rise in CCFHL products in 2018, the value of lagged spreads in the same period was always close to the 3.5 percentage points allowed by the CCFHL regulations. Based on this, the fluctuation in spreads is mainly derived from banks' delay in repricing, and no intentional and persistent adjustment can be identified in the banking system as a whole.

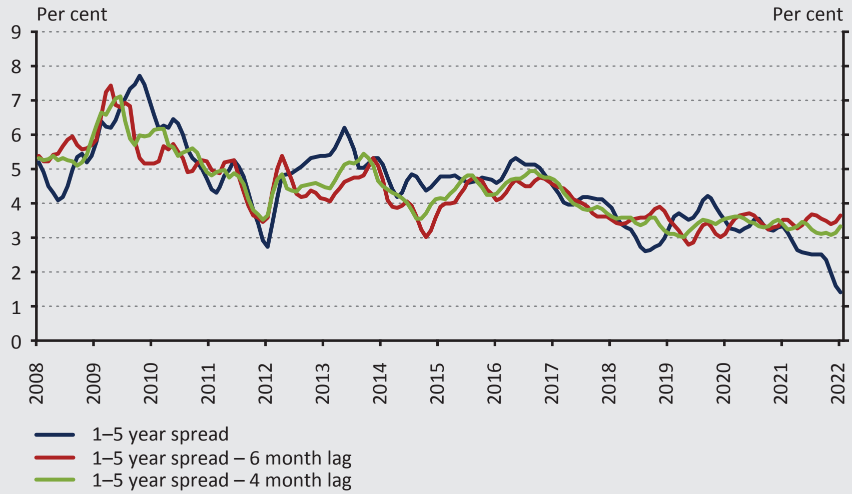
Figure 8
Variance decomposition of the forecast errors of the average APR change





Source: Calculations based on MNB data

Figure 9
Spreads and lagged spreads of the housing loans with interest rate fixation of 1–5 years



Note: The time series calculated with a lag of 4 and 6 months are based on the APR for the given month and the BIRS interest rates from 4 and 6 months earlier. Time series smoothed with three-month averages.

Source: Based on MNB data

5. Conclusions

The analysis examined a crucial element in the interest rate channel of the monetary policy transmission mechanism, namely the relationship between new housing loan rates and interbank rates, employing not only simple statistical methods but also econometric tools. The actual adjustment to interbank rates was examined using the CCFHL credit conditions at the seven largest credit institutions operating in Hungary, starting from January 2018. Three longer repricing periods were examined to see the extent of the cumulative change in the interest rate conditions of the CCFHL loans offered by banks in the individual months, relative to the cumulative BIRS change that occurred until the end of the previous month. It was observed that banks' pricing practices vary: some of them wait for 1 to 3 months in the beginning, while others wait as long as 5 to 8 months. Interest rate stickiness is also suggested by the fact that the extent of banks' initial interest rates adjustment typically fell short of the cumulative change in the BIRS observed until the end of the previous month. It can also be stated that the transmission used by institutions varied in speed and extent depending on the duration of the repricing period.

The estimation on aggregate interest rate statistics showed that, considering the entire time series, a unit shock to the 5-year interbank rate is expected to pass through to the average housing loan rates with an initial interest rate fixation of

1–5 years in four months. The impulse response function fitted to the subperiod model also showed that transmission is the strongest in the third and fourth month following the shock, but the complete interest rate pass-through required an average of six months over this horizon. The shock to the adjusted cost of funds passes through to the APR somewhat slower and to a more limited extent, in the case of both the entire time series and the subperiod. It should be noted, however, that the estimated speed of transmission may be influenced by the distortive effects identified in connection with aggregate interest rate statistics, and therefore banks' typical repricing practices experienced by customers may differ from these.

Several avenues of further research can be determined based on the lessons from this paper. First, a more accurate understanding of the speed of interest rate transmission could be gained if it was estimated using institutions' actual cost of funds. A good starting point for this strand of research could be *Varga* (*2021*), who examined interest rate pass-through based on the interbank rate and banks' weighted average cost of funds, identifying a more stable equilibrium relationship based on the latter. Interesting findings could be presented about banks' pricing behaviour if the interest rate transmission was modelled not only based on aggregate interest rate statistics but also at the level of individual banks. If sufficient data are available in the future, it should also be examined whether the APR adjusts differently depending on whether the cost of funds decreases or increases. Finally, this study and the avenues for research listed here could be extended beyond housing loans to cover other types of bank loans, such as personal loans.

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Annex: Test results of the model

Table 3
Results of the Johansen cointegration tests
a) 1–5-year interest rate fixation (cost of funds: BIRS)

Unit vectors (eigenvalue statistics)	APR	IRS	Constant
APR	1.0	1.0	1.0
BIRS	–1.27	469.33	–1.16
Constant	–3.22	–1 834.12	–6.73

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	2.03	7.52	9.24	12.97
Zero	12.10	13.75	15.67	20.20

Unit vectors (trace statistics)	APR	IRS	Constant
APR	1.0	1.0	1.0
BIRS	–1.27	469.33	–1.16
Constant	–3.22	–1 834.12	–6.73

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	2.03	7.52	9.24	12.97
Zero	14.13	17.85	19.96	24.60

b) 1–5-year interest rate fixation (cost of funds: adjusted cost of funds)

Unit vectors (eigenvalue statistics)	APR	Adjusted cost of funds	Constant
APR	1.0	1.0	1.0
Adjusted cost of funds	–1.76	–6.45	–0.49
Constant	–3.50	2.51	–10.57

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	1.72	7.52	9.24	12.97
Zero	9.10	13.75	15.67	20.20

Unit vectors (trace statistics)	APR	Adjusted cost of funds	Constant
APR	1.0	1.0	1.0
Adjusted cost of funds	–1.76	–6.45	–0.47
Constant	–3.50	2.52	–10.57

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	1.72	7.52	9.24	12.97
Zero	10.82	17.85	19.96	24.60

c) 5–10-year interest rate fixation (cost of funds: BIRS)

Unit vectors (eigenvalue statistics)	APR	IRS	Constant
APR	1.0	1.0	1.0
BIRS	–2.66	0.28	1.42
Constant	1.85	–2.98	–23.27

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	2.15	7.52	9.24	12.97
Zero	5.52	13.75	15.67	20.20

Unit vectors (trace statistics)	APR	IRS	Constant
APR	1.0	1.0	1.0
BIRS	–2.66	0.28	1.42
Constant	1.85	–2.98	–23.26

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	2.15	7.52	9.24	12.97
Zero	7.76	17.85	19.96	24.60

d) 5–10-year interest rate fixation (cost of funds: adjusted cost of funds)

Unit vectors (eigenvalue statistics)	APR	Adjusted cost of funds	Constant
APR	1.0	1.0	1.0
Adjusted cost of funds	–3.72	–0.66	18.08
Constant	1.20	–2.15	–93.28

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	1.65	7.52	9.24	12.97
Zero	10.09	13.75	15.67	20.20

Unit vectors (trace statistics)	APR	Adjusted cost of funds	Constant
APR	1.0	1.0	1.0
Adjusted cost of funds	–3.72	–0.66	–18.08
Constant	1.20	–2.14	–93.28

Number of cointegration vectors	Test statistics	Critical value at 10% significance level	Critical value at 5% significance level	Critical value at 1% significance level
At least one	1.65	7.52	9.24	12.97
Zero	11.74	17.85	19.96	24.60

Table 4
Unit root tests

Time series	APR differenced	IRS differenced	Adjusted cost of funds differenced	APR	IRS	Adjusted cost of funds
Augmented Dickey Fuller test	–4.99	–4.67	–5.61	–2.15	–0.73	–1.89
p-value	0.001	0.001	0.001	0.51	0.97	0.62
Stationarity	Stationary	Stationary	Stationary	Non-stationary	Non-stationary	Non-stationary

Note: Null hypothesis: time series are non-stationary.

Table 5
Optimal number of lags
a) BIRS

Information requirement	Akaike	Hannan–Quinn	Schwarz
Optimal number of lags	4	4	4

b) Adjusted cost of funds

Information requirement	Akaike	Hannan–Quinn	Schwarz
Optimal number of lags	4	4	1

Table 6
The results of the model diagnostics
a) BIRS 5

	Autocorrelation – Portmanteau test	ARCH effect – Lagrange Multiplier test (multivariate)	ARCH effect – Lagrange Multiplier test (APR)	ARCH effect – Lagrange Multiplier test (BIRS)	Normality – Jarque-Bera test
Full time series					
Chi-squared test	45.12	93.35	17.36	43.39	515.43
p-value	0.59	0.001	0.36	0.001	0.001
Narrow time series					
Chi-squared test	42.33	49.46	20.46	7.83	5.03
p-value	0.70	0.30	0.20	0.95	0.28

b) Adjusted cost of funds

	Autocorrelation – Portmanteau test	ARCH effect – Lagrange Multiplier test (multivariate)	ARCH effect – Lagrange Multiplier test (APR)	ARCH effect – Lagrange Multiplier test (adjusted cost of funds)	Normality – Jarque-Bera test
Full time series					
Chi-squared test	51.50	96.84	12.95	40.63	530.65
p-value	0.34	0.001	0.68	0.001	0.001
Narrow time series					
Chi-squared test	44.92	49.96	8.59	17.29	1.90
p-value	0.75	0.28	0.93	0.36	0.38

Table 7
Granger causality tests

a) BIRS 5

Time series	Null hypothesis: the change in the IRS is not the result of the change in the APR	Null hypothesis: the change in the APR is not the result of the change in the IRS
F-test	1.18	12.75
p-value	0.32	0.001

b) Adjusted cost of funds

Time series	Null hypothesis: the change in the adjusted cost of funds is not the result of the change in the APR	Null hypothesis: the change in the APR is not the result of the change in the adjusted cost of funds
F-test	1.25	7.77
p-value	0.28	0.001

Table 8

Cumulative impulse response function values of the unit shock to the 5-year BIRS and the adjusted cost of funds

Number of months elapsed since the shock	Cumulative impulse response function values of the shock to the 1–5-year BIRS				Cumulative impulse response function values of the shock to the 1–5-year adjusted cost of funds			
	Full time series		Narrow time series		Full time series		Narrow time series	
	BIRS 5 -> BIRS 5	BIRS 5 -> APR	BIRS 5 -> BIRS 5	BIRS 5 -> APR	Adjusted cost of funds -> Adjusted cost of funds	Adjusted cost of funds -> APR	Adjusted cost of funds -> Adjusted cost of funds	Adjusted cost of funds -> APR
0	1.000	0.059	1.000	–0.008	1.000	0.102	1.000	0.013
1	1.265	0.201	1.284	–0.010	1.121	0.209	1.229	–0.032
2	1.063	0.314	1.431	0.112	0.860	0.306	1.270	0.045
3	1.089	0.523	1.521	0.444	0.799	0.437	1.254	0.340
4	1.225	0.959	1.461	0.710	0.854	0.852	1.065	0.554
5	1.246	0.984	1.543	0.856	0.904	0.838	1.038	0.688
6	1.202	0.978	1.699	0.981	0.909	0.801	1.105	0.774
7	1.213	1.099	1.826	1.051	0.910	0.875	1.190	0.786
8	1.297	1.166	1.939	1.123	0.966	0.915	1.285	0.800
9	1.311	1.170	2.016	1.227	0.970	0.936	1.327	0.837
10	1.283	1.185	2.059	1.323	0.950	0.955	1.330	0.884
11	1.299	1.222	2.106	1.407	0.957	0.972	1.320	0.937
12	1.325	1.257	2.159	1.480	0.967	1.000	1.313	0.980
13	1.323	1.258	2.211	1.535	0.970	1.003	1.320	1.007
14	1.316	1.261	2.261	1.584	0.971	1.003	1.338	1.023
15	1.322	1.279	2.303	1.632	0.972	1.014	1.356	1.034
16	1.332	1.288	2.337	1.676	0.976	1.020	1.369	1.045
17	1.331	1.287	2.366	1.717	0.976	1.022	1.375	1.058
18	1.328	1.290	2.393	1.754	0.975	1.024	1.377	1.071
19	1.331	1.297	2.418	1.786	0.976	1.027	1.378	1.082
20	1.334	1.300	2.442	1.814	0.977	1.029	1.379	1.091
21	1.333	1.299	2.463	1.839	0.978	1.030	1.383	1.098
22	1.332	1.300	2.482	1.862	0.978	1.031	1.387	1.102
23	1.334	1.303	2.498	1.883	0.978	1.032	1.390	1.106
24	1.335	1.304	2.513	1.902	0.978	1.032	1.393	1.110
25	1.334	1.304	2.526	1.919	0.978	1.033	1.394	1.114