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Short-Term Effects of Monetary Interventions on Euro Exchange Rate

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I. Introduction

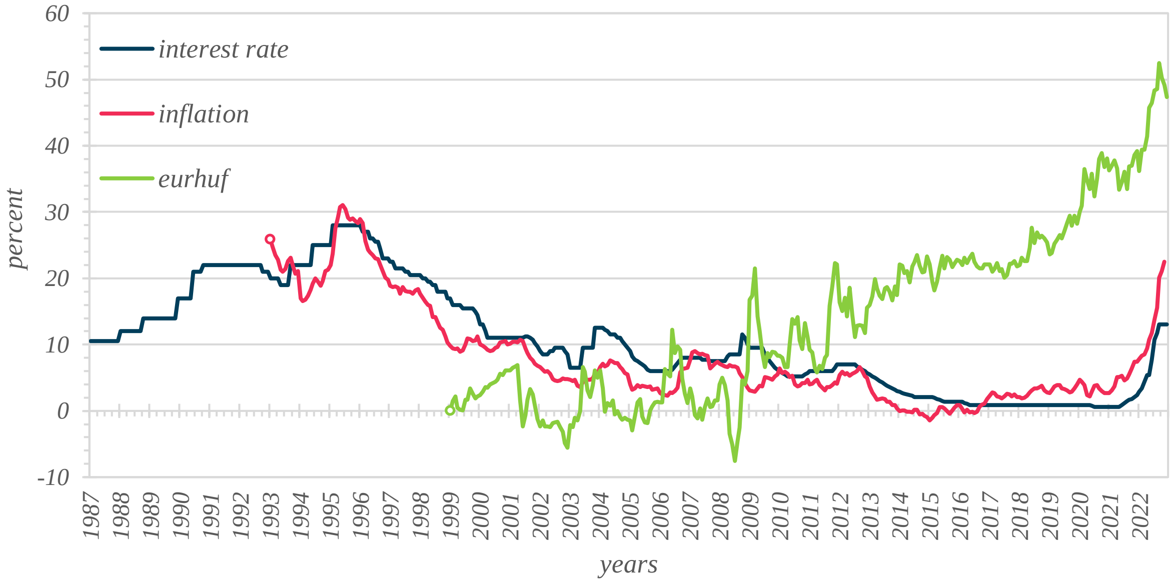
1. Relevance

On the 27th of September 2022 three major decision was made by MNB[1], the central bank of Hungary: raising the base interest rate by 125 basis point to 13%; closing the 16-month-long tightening cycle; and putting greater emphasis on using other monetary policy tools. (Matolcsy, 2022) According to the deputy governor of MNB, it was a very conventional decision regarding the base rate as they could achieve a sufficiently strict environment. The restriction will be continued in the next months by tightening liquidity. (Virág, 2022) The announcement and reports strongly emphasize that they have an inflation target and are currently fulfilling it. This is a signal to the market that exchange rates are not a priority at the moment. However, this was not received well by public opinion. *"The National Bank has let the forint go"* – said many of the lay people in response to this step. This statement reflects two main things. Firstly, people usually do not understand or are not interested in the other instruments of monetary policy, such as the rate of required reserve and open market operations. Conversely, setting a base interest rate is widely intelligible. Central banks raising interest rates indicates active fighting against high inflation while decreasing it means the end of a high inflationary environment. Secondly, the exchange rate of forint against harder currencies was highly volatile in the second half of 2022. Even those who typically do not deal with exchange rates started to follow the daily prices. Almost all Hungarian media reported breaking records for the euro's price. It was also generally known that this series of events considerably influenced the decisions about interest rates. So, when the MNB announced the end of increasing interest rates, many became desperate. This is based on a very simple but oversimplified chain of thought: the goods bought are directly or indirectly connected to the country's import, which is paid by foreign currency. If the forint depreciates against those currencies, the goods became more expensive. Inflation has begun growing more and more rapidly in 2021 but it accelerated by the end of 2022. Besides this increasing pressure on households, the euro reached its highest value ever, 434.22 forints. It was a historical peak even if we look at the daily closing price, which was 428.71 forints. Furthermore, it happened only after two weeks after the announcement. At that point, people felt let down as the MNB "stopped fighting" against the expensive euro and high inflation.

[1] Magyar Nemzeti Bank (National Bank of Hungary)

It is easy to understand the relationship between the base interest rate and inflation. The Monetary Policy Council make its decision based on macroeconomic factors and indicators, especially on the inflation rate. In case of higher inflation, a higher interest rate can be expected. However, it cannot be said to be entirely true the other way around. Whether inflation will decrease is not determined solely by the interest rate, even if it seems so. There are other instruments as mentioned above. This mutual relationship can be seen in Figure *I-1*. On the other hand, the euro exchange rate movement cannot be seen as correlated to these two indicators.

Figure I-1 *Monthly development of Interest Rate and Inflation in Hungary alongside the EUR/HUF Exchange Rate*



Note: *interest rate* indicates the central bank base rate defined by the MNB, *inflation* indicates the consumer price index year-on-year changes, and *eurhuf* indicates the exchange rate change of EUR/HUF compared to the value when the euro was first introduced.
Source: BIS and MNB.

Apart from my curiosity, the reason for the choice of the subject lies in its high topicality. In recent years, only a few studies were published related to the relationship between exchange rates and monetary policy in Hungarian aspects. It is unsurprising as the MNB does not have an exchange rate policy. (MNB, 2014) The Monetary Council, in agreement with the Government, abolished the band fixing of the forint exchange rate against the euro from February 26, 2008, and decided to introduce a fully floating exchange rate system. That was an important step towards the introduction of the euro in Hungary, it creates more favourable conditions for the central bank to achieve the inflation target and thereby to meet the Maastricht nominal criteria. (Monetary Council, 2008) Nevertheless, it is worth examining the impact of the MNB's declarations on the forint exchange rate as they now unofficially make their decisions in consideration of its increasingly volatile movement. The market, especially the foreign exchange market, is much more sensitive in such turbulent times.

The structure of my thesis is the following: after introducing the subject and its Relevance, I articulate my main Hypothesis with the methods I will examine it. Then in the first part of the Data section, in the Methodology part, I present the Monetary transmission mechanism’s main elements, especially its exchange rate and expectations channel. The utilized VAR models are presented in the Models for economic analysis part. The second part of the Data section is a Description of variables, such as Inflation, Interest rate and Exchange rate. This is followed by the third, main section: Exchange rate channel which is divided into two parts: in the first, I examine indirectly (Long-term effects), then in the second one, in a more direct way (Short-term effects). After that, I reach my Conclusions and write a summary. At the end of my thesis, I list the used literature in the References and put the relevant but too long or too detailed information to include in the main body of my work in the Appendix.

2. Hypothesis

Examining the monetary shocks on an exchange rate is not as intuitive as one would think at first. In theory, the demand for the Hungarian currency on the foreign exchange market should increase due to a raise in interest rates. If one can get substantial interest income from investments held in forints, it increases the attractiveness of the currency. In reality, however, this is not what happens, or it happens to a much smaller degree. There are more general economic, political, and fiscal reasons that have a larger impact on the exchange rate. Despite all these, in my thesis, I try to find and measure monetary shocks, specifically, the impact of increasing or decreasing base interest rates.

As mentioned in the previous section, the subject of my study is related to the latest tightening cycle in Hungary. To be more precise, 2021-22’s interest rate increases, which has the crucial goal of saving the forint from drastic depreciation. It may sound strange, but in such circumstances, the fact that the forint weakened “only” to the level of about 400 compared to the euro can be seen as a success of the central bank's interest rate policy. So, my hypothesis is based on the opinions that state the MNB’s ineffective policies and that it gave the forint exchange rate up. I attempt to prove the opposite. Thus, according to my main hypothesis, *the forint exchange rate cannot be influenced in the short-term only by monetary decisions, namely increasing interest rates.* This statement has to be approached with certain qualifications. I reflect on them in the appropriate sections.

My hypothesis will be examined through an empirical analysis. This consists of two parts. Firstly, I try to prove it indirectly by showing the long-term effects of monetary decisions. Of course, this does not preclude the possibility of having a short-term effect. So, in the second part, I apply a more direct way by observing the immediate environment of the exchange rate, around the time of an interest rate change. During the long-term part, the base interest rate, inflation rate and exchange rate will be utilised in a vector autoregression model and then I will make predictions using impulse response functions. In the short-term part, I will investigate using statistical hypothesis tests. The listed methods are quantitative ones, but the analysis will be combined with qualitative elements.

II. Data

1. Methodology

1. Monetary transmission mechanism

Monetary policy influences the decisions of economic actors through many channels, primarily the development of aggregate demand. The monetary policy transmission mechanism is the process by which monetary policy decisions affect the economy, ultimately output and prices. (Vonnák, et al., 2017) The literature groups the channels in different ways. Mishkin (1995) defines four of them. In my thesis, it is combined with the MNB's addition. The four plus one channels are:

- The Interest Rate Channel
- The Exchange Rate Channel
- Other Asset Price Effects
- Credit Channel
- Expectations

Each of these channels represents a specific mechanism through which monetary policy actions reach commodity market demand. The central bank's decisions on the base rate, as well as its communication referring to future decisions, first have an impact on the financial markets, as market interest rates, asset prices and the forint exchange rate react quickly. This is followed by the product market reaction, as companies and consumers adapt to financial market developments, thus changing aggregate demand. Companies react to the changing demand by changing the quantity of products they produce and their prices so that monetary policy ultimately affects output and inflation as well.

The Exchange Rate Channel and Expectations are paid special attention by my thesis; therefore, I will present them in more detail in the following.

A rising or falling central bank base rate can not only directly affect pricing and production decisions as mentioned above, but also through the exchange rate channel. In the case of free international capital movements, the exchange rate may react sensitively to the interest rate policy. Interest parity creates a connection between interest rates and the exchange rate. Since an international portfolio investor is free to choose the currency in which he keeps his money, the expected returns realized in the different currencies – in terms of the same currency – cannot differ permanently. The actual return is determined by the interest rate and exchange rate changes together. If interest and exchange rate gains combined fall short of the returns available elsewhere, investors will turn away from that currency until either interest rates or exchange rate appreciation makes it competitive again.

The exchange rate channel plays a prominent role especially in small, open countries such as Hungary because the price of imported goods and the competitiveness of export products are directly affected by the value of the domestic currency. Following a devaluation, for example, the external demand for export products increases, but the import of foreign products that become more expensive may decrease. The domestic output thus expands as a whole, while prices – due to more expensive goods entering foreign trade – also rise. (Felcser, et al., 2015) In other words, when domestic real interest rates fall (denoted by *IR*), domestic forint deposits become less attractive relative to deposits denominated in foreign currencies. As a result, the value of forint deposits relative to other currency deposits falls, and the forint depreciates ($E\uparrow$). The lower value of the domestic currency makes domestic goods cheaper than foreign goods, thereby causing a rise in net exports (*NX*) and hence in aggregate output (*GDP*) and consumer prices (*CPI*). (Mishkin, et al., 2011) The schematics for the monetary transmission mechanism that operates through the exchange rate are

Equation II-1 *Expansionary monetary policy*

$$IR \downarrow \Rightarrow E \downarrow \Rightarrow NX \uparrow \Rightarrow GDP \uparrow \Rightarrow CPI \uparrow$$

Equation II-2 *Contractionary monetary policy*

$$IR \uparrow \Rightarrow E \uparrow \Rightarrow NX \downarrow \Rightarrow GDP \downarrow \Rightarrow CPI \downarrow$$

The number of Hungarian literature related to exchange rate channel is low, at least in recent years. That is because MNB does not have an exchange rate policy since 2008. (Monetary Council, 2008) However, some Hungarian experts examined the effects of the monetary transmission mechanism through exchange rates considering different aspects. According to Vonnák (2006) it is essential to distinguish between two types of financial shocks, monetary policy shocks and risk premium shocks. Based solely on the correlation between the interest rate and the exchange rate, it may seem that a monetary tightening weakens the forint (see Table *III-2* later). Since the role of the risk premium is less significant in developed countries, the empirical literature has paid little attention to this problem. Rezessy (2005) included the immediate exchange rate effect of monetary policy shocks. His identification strategy was based on the fact that monetary policy shocks are larger on the day of the Monetary Council's rate-setting meetings than on other days. He showed a significant immediate effect with the expected sign, as well as an even greater effect on the day following the interest rate-setting. Karádi (2005) presents a more complicated model of monetary policy and the exchange rate, where the central bank affects the exchange rate through two channels: one is the usual effect of the interest rate, and the other is the influence of exchange rate expectations. The importance of the model is obvious from the past Hungarian monetary policy. At the time of the sliding devaluation system, expectations were anchored by the pre-announced rate of devaluation. After 2008, Bihari and Valentinyi (2010) deal with the relationship between interest rates, inflation, and growth in Hungary. Based on monetary policy considerations, they dispute the justification of the lower interest rate and the weaker exchange rate in the Hungarian environment.

Expectations, the channel that is considered a Hungarian speciality, is an important element of the transmission mechanism either independently or integrated into other channels. If the objective of the monetary policy is credible, then the economic actors associate their expectations with the objective, or in the case of inflation targeting to the inflation target. (see in Figure *II-1* later) If an inflationary shock hits the economy, economic actors will not count on inflation significantly different from the target in the medium term. In this case, pricing behaviour and wage demands do not mean additional inflationary pressure, and the inflation target will be reached with a smaller growth sacrifice. (Felcser, et al., 2015) When making their decisions, economic actors take into account not only the current market conditions but also their future development. Expectations also play an important role in the operation of some already analysed channels, especially in the reaction of asset prices and exchange rates. How interest rate moves affect the entire yield curve is primarily determined by what market participants think about the future direction and effectiveness of the monetary policy. The reaction of the exchange rate and other asset prices is also significantly determined by the assessment of the future monetary policy. This mostly depends on the monetary policy rule observed in the past, i.e., the transmission is rule dependent. Since the development of money market variables depends not only on the current interest rate decision but also on expectations regarding the future development of interest rates, expectations also play a role in the other channels of transmission. In addition, due to companies' forward-looking pricing, if companies expect that there will be higher inflation in the future, they will already start raising their prices, so the expected future inflation already causes a price increase in the present. (Vonnák, et al., 2017)

2. Models for economic analysis

Most data in macroeconomics and finance come in the form of time series, a set of repeated observations of the same variable, such as Gross Domestic Product, Consumer Price Index, or Exchange Rate. (Cochrane, 1997) More commonly, a time series is a sequence taken at successive equally spaced points in time. Thus, it is a sequence of discrete-time data. Having this property, it has more potential but also has its limitations compared to cross-sectional data. Its greatest advantage is that it can be used for regression analysis by itself. In this autoregression model, the variable of interest is estimated using a linear combination of past values of the variable. These are called lags. The term autoregression indicates that it is a regression of the variable against itself. However, it has some limitations that are relevant in the case of examining monetary policy shocks. On the one hand, it gives statistically reliable results only in the short-term and studies showed that monetary policy interventions may have a long-term effect. (Vonnák, 2021)And on the other hand, in macroeconomics, there is more than one variable that can affect one another.

To solve this, vector autoregression (henceforth VAR) model was formed. (Sims, 1980) It extends the idea of univariate autoregression to *k* time series regressions, where the lagged values of all *k* series appear as regressors. (Stock, et al., 2020) The VAR model has proven to be especially useful for describing the dynamic behaviour of economic and financial time series and forecasting. In addition, the VAR model is also used for structural inference and policy analysis, relevant to this thesis. (Stock, et al., 2001) VAR models are characterised by their order, which refers to the number of earlier time periods the model will use. So, in general, a p^{th}-order VAR refers to a VAR model which includes lags for the last p time periods. A p^{th}-order VAR is denoted "VAR(p)" and it is written as

Equation II-3 *Univariate VAR(p) model*

$$y_t = c + \sum_{i=1}^{p} \alpha_i y_{t-i} + \varepsilon_t$$

where the variables of the form y_{t-i} indicate that variable's value i time periods earlier and are called the "i^{th} lag" of y_t. The variable c is a k-vector of constants serving as the intercept of the model. α_i is a time-invariant ($k \times k$)-matrix and ε_t is a k-vector of error terms. I believe it is important to present a system of two equations because it will be frequently referenced in my thesis. A VAR(p) with two variables could be written in matrix form which is a more compact notation, but to be consistent I will use it as the following equivalent system of two equations:

Equation II-4 *System of Bivariate VAR(p) models*

$$y_{1,t} = c_1 + \sum_{i=1}^{p} \alpha_{1,i}\, y_{1,t-i} + \sum_{i=1}^{p} \alpha_{2,i}\, y_{2,t-i} + \varepsilon_{1,t}$$

$$y_{2,t} = c_2 + \sum_{i=1}^{p} \alpha_{1,i}\, y_{1,t-i} + \sum_{i=1}^{p} \alpha_{2,i}\, y_{2,t-i} + \varepsilon_{2,t}$$

Here, each variable in the model has one equation. The current (time t) observation of each variable depends on its own lagged values as well as on the lagged values of each other variable in the VAR.

There are three broad types of VAR models, the reduced form, the recursive form, and the structural VAR (SVAR) model. The reduced-form VAR model was discussed above but the SVAR model has an even more important role when examining monetary shocks. VAR models explain the endogenous variables solely by their own history, apart from deterministic regressors. In contrast, SVAR models allow the explicit modelling of contemporaneous interdependence between the dependent variables. Hence, these types of models try to bypass the shortcomings of VAR models. (Pfaff, 2008) In my thesis, however, I will stick with using the reduced form VAR model in consideration of its limits and by avoiding misinterpretations.

Another useful tool during the analysis of monetary macroeconomics is the impulse response function (henceforth IRF). It is used to describe how the economy reacts over time to exogenous impulses or shocks and is modelled in the context of a VAR. Impulses that are often treated as exogenous from a macroeconomic point of view include changes in the monetary base, base interest rates or other monetary policy parameters. IRFs describe the reaction of endogenous macroeconomic variables such as GDP, and CPI at the time of the shock and over subsequent points in time. (Lütkepohl, 2008)

Measuring the transmission of monetary policy is by no means a trivial task. The same is true for other branches of economic policy, however, the typically quick reaction and impact mechanism of monetary policy make it particularly difficult. In addition to the importance of the topic, methodological challenges also play a role in the fact that the relevant empirical literature is extremely extensive. (Vonnák, et al., 2017) The difficulty of the task comes from several sources which must be kept in mind during my analysis:

- It is not clear which variable can be used to capture the monetary policy steps.
- The monetary policy steps are largely themselves reactions to the state of the economy, so it is difficult to isolate the impact of monetary policy on economic processes.
- The effect of monetary policy steps also depends on what further steps are expected by the economic actors, so the effect of the same step can change from time to time.

2. Description of variables

1. Inflation

In economics, inflation is an increase in the general price level of goods and services in an economy. The common measure of inflation is the inflation rate, the annualized percentage change in a general price index. As prices do not all increase at the same rate, the consumer price index (CPI) is often used for this purpose. (Mankiw, 2002) The most important goal of economic policy is to ensure sustainable and stable economic growth in the long term. The central bank can support this by keeping inflation at a low level with its predictable and credible monetary policy.

The primary goal of the MNB, defined by law, is to achieve and maintain price stability. To implement this, it has been using the inflation targeting system since the summer of 2001. (MNB, 2023) The MNB can achieve the inflation target by changing the central bank base rate to an appropriate extent and schedule. In Hungary, the MNB's main decision-making body, the Monetary Council, decides on the level of the central bank's interest rate. An important element of the inflation targeting system and monetary policy decision-making is the quarterly inflation forecast prepared by the staff of the central bank, which is published in the "Inflation Report". The basic function of inflation forecasting is to assist decision-makers. The forecast assumes endogenous monetary policy. This means that the macroeconomic path of the forecast is prepared considering the monetary policy that reacts to inflationary prospects and real economic processes.

The inflation targeting system began operating in June 2001, when targets were set for December 2001 and 2002. After that, an inflation target was set every year until the end of 2006, at least two years in advance. In August 2005, the MNB set a medium-term inflation target for the period starting in 2007, which was set at 3 percent of the consumer price index published by the Central Statistical Office. (Monetary Council, 2005) The targets can be seen in Table *II-1* and are illustrated in Figure *II-1* alongside the inflation.

Table II-1 *Inflation targets*

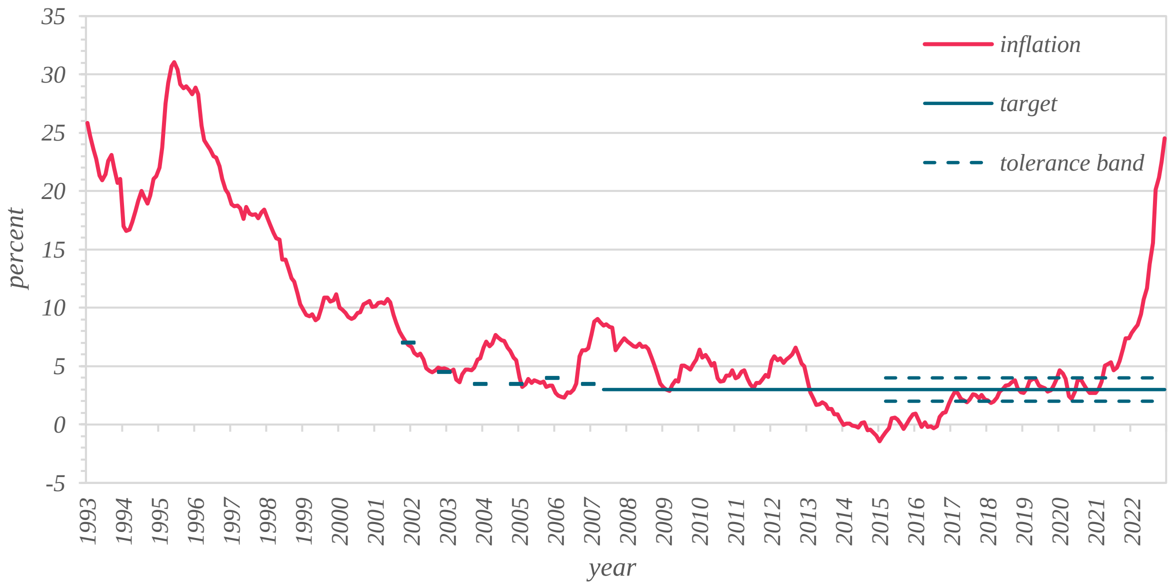
Target	To be achieved by	Appointment date
7%	*2001. December*	*2001. June*
4.50%	*2002. December*	*2001. June*
3.50%	*2003. December*	*2001. December*
3.50%	*2004. December*	*2002. October*
4%	*2005. December*	*2003. October*
3.50%	*2006. December*	*2004. November*
3%	*continuously*	*2005. August*
3% ±1 percentage point	*continuously*	*2015. March*

Source: MNB.

It is a common practice among central banks that use a medium-term, continuously valid inflation target that it is revised after a certain period – usually within 3-5 years. The MNB decided that the review of the medium-term target will take place upon entry into the common European Exchange Rate Mechanism (ERM II), but no later than 3 years after the date of target designation. The revisions left the 3 percent value of the medium-term target in effect, and in addition, the inflation target was supplemented with a tolerance band of ±1 percentage point in 2015. The ex-ante tolerance band shows that inflation may fluctuate around this level because of shocks to the economy. (MNB, 2023) Figure *II-1* also includes the continuous inflation target with the tolerance band.

The year 2022 was unusually turbulent in many aspects. Inflation raised to a historical peak in almost every country (see Figure *VI-2* in Appendix), and it did not happen otherwise in Hungary. This, of course, influences the central bank's decisions. To make its policy understandable to the public and traceable, the MNB reports on the past and expected development of Hungarian inflation in its publication entitled "Inflation Report" – mentioned earlier – and evaluates the macroeconomic processes that determine inflation. The main reasons according to these reports are the following. In the first five months of last year, due to the high energy and raw material prices, companies repriced their products and services significantly more than the average of previous years, which led to an increase in domestic inflation. (MNB, 2022) More than half of the rise in inflation since the summer is linked to food prices, which can be explained by the efficiency and productivity problems of the Hungarian food industry in addition to global processes. In the autumn months, the increase in household energy prices had an additional price-increasing effect, furthermore, the price cap on fuels was abolished in December. This amendment of measure contributed to the increase in inflation in 2022. (MNB, 2022)

Figure II-1 *Inflation Targets and Monthly Inflation in Hungary*



Note: *inflation* indicates the consumer price index year-on-year changes, and *target* indicates the inflation rate to be achieved within the *tolerance band*, set by the MNB.
Source: BIS and MNB.

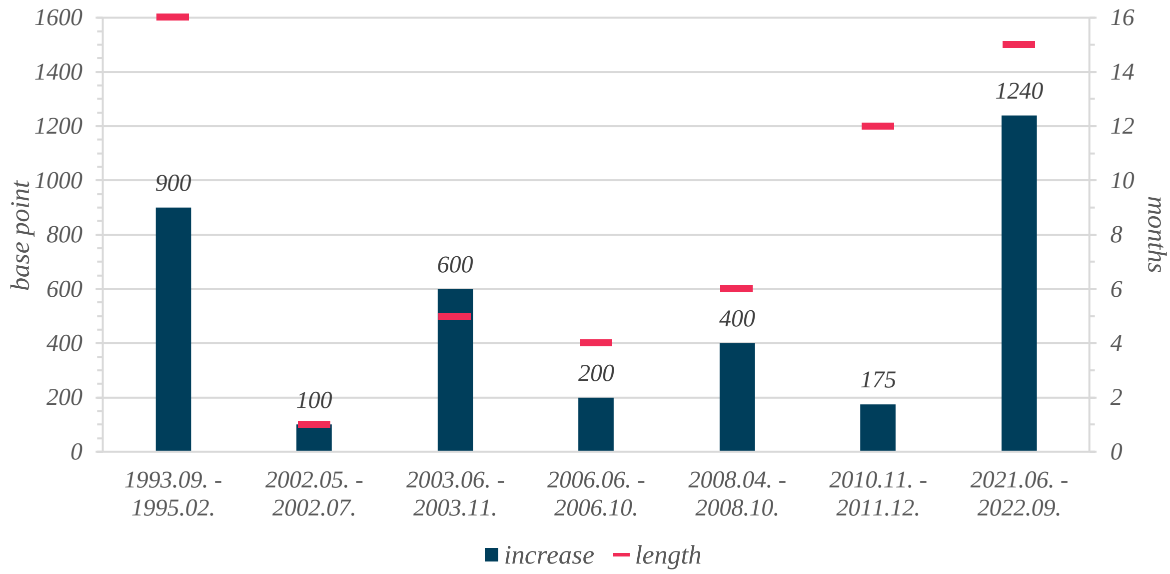
2. Interest rate

The central bank base rate is the reference interest rate of a given country, with which the country's central bank can regulate the country's economy. The central bank base rate in Hungary is the reference interest rate that the MNB pays commercial banks for the two-week maturity bonds. Since commercial banks always have to deposit certain amounts with the central bank – this is the reserve obligation – and the central bank provides them with credit, MNB can influence the entire banking and financial system through this interest rate, which also affects the real economy. The central bank base rate affects the interest payable on bank deposits and loans. At the same time, this no longer applies directly in Hungary. Most banks already tie their loans to BUBOR (Budapest Interbank Offered Rate), BIRS (Budapest Interest Rate Swap), and reference interest rates on government securities.

The primary goal of central banks is price stability, that is, to keep inflation under control. All this can be achieved by raising or lowering the base interest rate. Although central banks' interest rate decisions are usually determined by inflation targets, they can also change the base rate for several other reasons. A related goal is recession or business cycle regulation. In other words, to make the recession short and the prosperity lasting.

However, the tightening cycle of 2021 and 2022 is different from the previous ones. Never before has the MNB raised rates as much as it has in the past two years. Since last summer they have tightened conditions by a total of 1,240 basis points – see Figure *II-2*. Of course, this is not surprising, since inflation is at its highest level in more than two decades. However, it is surprising that the central bank expects further strengthening of the dynamics of price increases, despite this, it put an end to the interest rate hikes. (Beke, 2022) In the last thirty years, there has been no example of a similar interest rate rising cycle as the one that the MNB has just concluded. On Tuesday, the 27th of September, the Monetary Council raised the base interest rate by another 125 basis points to 13%, but then György Matolcsy announced the end of interest rate increases. (Matolcsy, 2022)

Figure II-2 *Extent and Length of Tightening Cycles in the past 30 years*



Note: on this figure the MNB's tightening cycles can be seen where *increase* indicates how many base points they raised the interest rates and *length* indicates how long it took. Source: MNB.

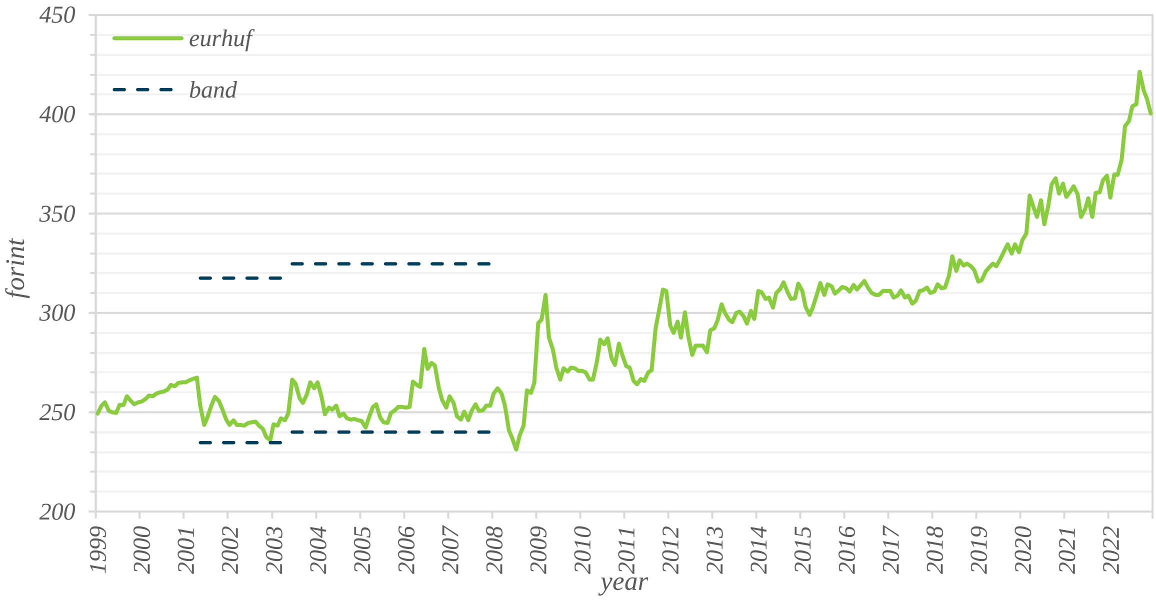
If we look at the steps made by the MNB since 1990, we find a total of seven periods when the base interest rate rose permanently, these can be identified as tightening cycles. In terms of time, the current one was not the longest one, since between September 1993 and February 1995, 16 months passed with the increase of the base interest rate. Of course, this did not mean that the MNB increased every month. The just concluded cycle was certainly unique in that the interest rate was continuously raised for 15 months. Moreover, the total tightening of 1,240 basis points was by far the largest since 1990.

3. Exchange rate

An exchange rate regime is a way a monetary authority of a country manages its currency about other currencies and the foreign exchange market. It is closely related to monetary policy and the two are generally dependent on many of the same factors, such as economic scale and openness, inflation rate, the elasticity of the labour market, financial market development, capital mobility, etc. (Oatley, 2012) There are two major regime types: floating (or flexible) exchange rate regime exists where exchange rates are determined solely by market forces and often manipulated by open-market operations, and fixed (or pegged) exchange rate regimes, exist when a country sets the value of its currency directly proportional to the value of another currency or commodity.

The exchange rate system of the member countries of the European Union outside the eurozone is the European Exchange Rate Mechanism (ERM or in its current form ERM-II). The new EU members who have not yet adopted the euro join this system. In 2001, Hungary introduced a band that was the same as the ERM-II exchange rate band, allowing a 15 percent exchange rate movement both up and down around the central parity – see Figure *II-3* – in the hope that within a few years, it would fulfil the criteria for joining the euro, join ERM-II, and then to the eurozone. (Monetary Council, 2001) In the following years, however, the forint euro convergence reversed, and due to the deterioration of economic indicators, the country moved away from the introduction of the euro. In this new environment, the exchange rate system of the forint received many criticisms, the International Monetary Fund repeatedly urged Hungary to switch to a floating exchange rate system, and Hungarian economists suggested the same. So, Hungary made this step on 26th February 2008. (Monetary Council, 2008)

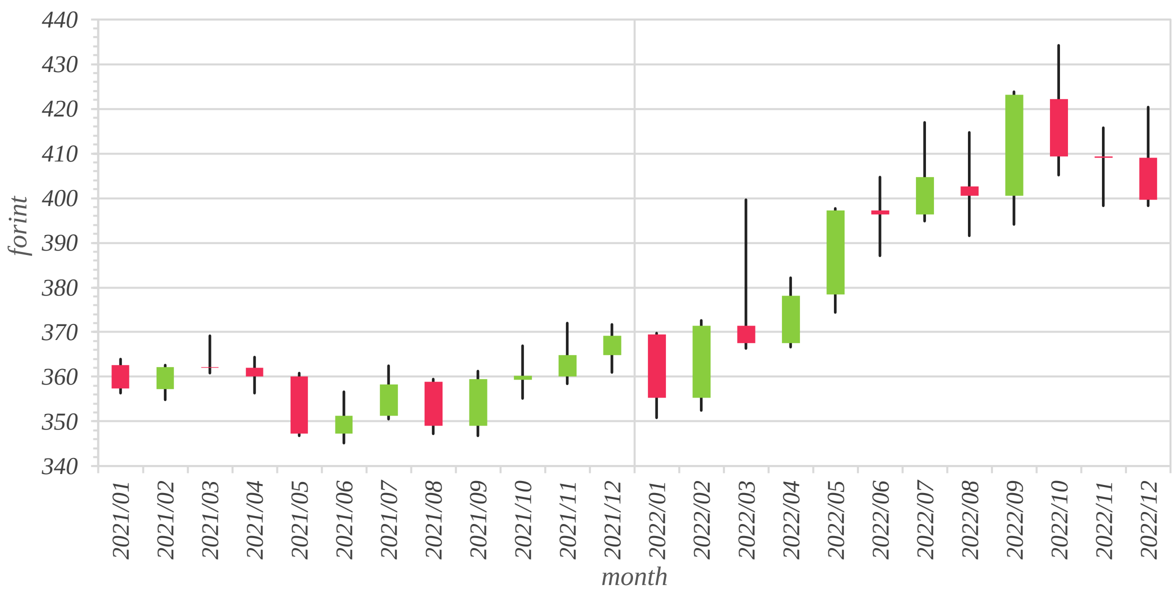
Figure II-3 *Monthly EUR/HUF Spot Exchange Rate with the Exchange Rate Band*



Note: *eurhuf* indicates the monthly spot exchange rate of EUR/HUF while *band* indicates the exchange rate band, the extent of which is 15% in the stronger and weaker direction around a middle parity fixed against the euro. Since the "offset" of the band on June 4th 2003, the middle parity has been HUF 282.36 against the euro, the "strong" edge is HUF 240.01, and the "weak" edge is HUF 324.71. Previously, from the introduction of the 30% band on May 4th 2001, the average parity was HUF 276.1.
Source: MNB.

In Figure *II-3* not only the exchange rate band can be seen but the entire development of forint euro exchange rate since its introduction. During the time of using a band, the exchange rate was predictable even if it converged rather to the lower bound. After that, the positive trend is noticeable which means a depreciation of the forint against the euro. The last two years, however, is especially interesting. For that, it is shown in Figure *II-4* in more detail. The exchange rate was relatively stable in 2021. But in 2022, it became highly volatile, as can be observed in the relation of open, close, highest, and lowest prices of the euro. This was primarily driven by external factors and matters related to foreign relations. The first and most important factor causing the weakening of the forint was the war conflict that broke out in the neighbouring country. After the strengthening of the forint at the beginning of the year, on February 24th, after the outbreak of the Russian-Ukrainian conflict, the domestic currency immediately fell by 2.2% against the euro (from the level of 356.5 to the level of 364.5), and then the gradual weakening continued until the beginning of October, peaking at HUF 430.65. The other determining factor that weakened the exchange rate was the agreement on EU resources. In this regard, the market might count on that several billion forints worth of foreign exchange resources would arrive in Hungary, which would be converted into forints. Furthermore, the difference in the interest policy of the European and American regions helped the dollar to strengthen against the euro and thus led to the weakening of the forint. (Beke, 2022)

Figure II-4 *Monthly EUR/HUF Spot Exchange Rate in 2021 and 2022*



Note: this candlestick chart shows the exchange rate's open, high, low, and close prices for the months. The real body (wider part) represents the price range between the open and close of that month's trading. The real body filled red means the close was lower than the open; and if it is green, it means the close was higher than the open. The narrow line part shows the highest and lowest value of the euro, denominated in forint in a month.
Source: BLOOMBERG.

III. Exchange rate channel

1. Long-term effects

1. Preparations

For modelling, all the input data must be prepared properly. The earlier introduced variable are the inflation, interest rate, and exchange rate, henceforth denoted as *CPI*, *IR*, and *EUR* respectively. *CPI* is the monthly consumer price index and was collected from BIS's[2] database. (BIS, 2023) This data set contains monthly time series from 1993. *IR* is the base interest rate in Hungary set by MNB. This was downloaded from the official website of the central bank. (MNB, 2023) MNB lists the base interest rate from 1987. *EUR* denotes EUR/HUF exchange rate. This was saved from the database of Bloomberg and contains data from 1999. I work with the monthly close price of euro. These three data sets were aligned and combined into one. So, the input file's columns are the date, consumer price index, base interest rate, and EUR/HUF exchange rate.

There are empty rows in the dataset for example there was no euro exchange rate back in 1993. I work only with full rows, but it must be filtered anyway. An estimate based on the observations of a period containing both a fixed exchange rate system and an inflation targeting system will probably give a distorted result compared to the real processes of both regimes. (Vonnák, et al., 2017) According to the exact dates shown in Inflation and Exchange rate sections, there is a cross-section in the dataset. The current, continuous inflation targeting system started in August of 2005, meanwhile, the exchange rate band was phased out on 26th February 2008. Therefore, I use the data from March of 2008 during this part of my analysis.

2. Descriptive statistics

First, I describe the variables using indicators and tests characteristic of macroeconomic time series data. Such data is usually represented on a line chart showing its development over time. I have already done it in sections of Description of variables but I consider it important to also show a figure of the used data only. It is in Figure *VI-1* in the Appendix.

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[2] Bank of International Settlements

A common assumption in many time series techniques is that the data are stationary. A stationary process has the property that the mean, variance and autocorrelation structure do not change over time. If a line would be drawn through the middle of a stationary process (through the middle of the variables in Figure *VI-1*) then it should be flat. It may have seasonal cycles, but overall, it does not trend up or down. However, it applies in the case of neither *IR*, *CPI*, nor *EUR*. It is stated not only by looking at the plot but by testing it. One of the most used statistical tests when it comes to analysing the stationary of a series is an augmented Dickey-Fuller (ADF) test. (Dickey, et al., 1979) It tests the null hypothesis that a unit root is present in a time series model. The alternative hypothesis is stationarity. The results are summarised in Table *III-1*. According to this, the null hypothesis cannot be rejected thus all three variables are non-stationary.

Table III-1 *Augmented Dickey-Fuller Tests on the Variables*

Variable	Dickey-Fuller	Lag order	p-value
IR	*0.0902*	*5*	*0.99*
CPI	*2.1100*	*5*	*0.99*
EUR	*-2.9295*	*5*	*0.19*
alternative hypothesis: stationary			

Note: tested on data from 2008 to 2022. Source: BIS, BLOOMBERG, and MNB.

In general, non-stationarity must be handled for modelling by taking logs and/or differences. VAR estimates are consistent if variables are stationary. That is, spurious correlations from causality could not be distinguished. Generally, in a VAR model, the stationarity of your time series is needed to guarantee the consistency of the estimations. (Sims, 1980) However, I am interested in the dynamic relationships among the time series, and I know the nature of the data that these correlations are not spurious – as it is a VAR with macroeconomic data, then the accuracy of model fitting data is more important than consistency and, therefore, I do not use differenced data. Taking differences implies a loss of estimation power i.e., long-run covariance of the endogenous variables. And taking a log is not possible since there are negative values in the sample (for example, inflation was negative around 2015)

Another important element of analysing time series is the above-mentioned autocorrelation. Autocorrelation is a mathematical representation of the degree of similarity between a given time series and a lagged version of itself over successive time intervals. (Box, et al., 1976) It is the base of an AR model thus it is of the VAR's. It can also be referred to as lagged correlation or serial correlation, as it measures the relationship between a variable's current value and its past values. To measure and show it, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) can be utilised.

The ACF starts at a lag of 0, which is the correlation of the time series with itself and therefore results in a correlation of 1. The ACF plot can provide answers to whether the observed time series is white noise/random, or whether the observed time series can be modelled with an MA (Moving Average) model. It is shown in Figure *VI-3*, Figure *VI-4*, and Figure *VI-5* in Appendix. However, I use VAR models and for that, using PCAF is recommended. It can tell if the observed time series be modelled with an AR model and in what order. For these reasons, I do not interpret any of the ACF results, only the PACF's.

Begin with the partial autocorrelation of the *IR* variable, plotted in Figure *III-1*. It shows strong positive partial autocorrelation ($\rho_1 \sim 0.99$)[3], and two weak but still significant negative partial autocorrelation ($\rho_2 \sim -0.17$ and $\rho_3 \sim -0.09$). These statistical characteristics of the central bank time series reflect the gradualness of interest rate increases. The strong autocorrelation indicates that the level of interest at a given time is influenced by what the level of interest was the previous time. Csermely and Rezessy (2007) showed an interesting fact that after an interest rate change in a particular direction, the interest rate is 3-4 times more likely to change in the same direction, rather than in the opposite direction. This indicates that central banks attempt to avoid sudden reversals in the interest rate cycle.

The next variable is the *CPI* which is shown in Figure *III-2*. The autocorrelation of inflation raises the issue of persistence. It is a central matter both for economic policymakers and theorists. For policymakers, the issue is how far should they look forward and how rapidly their policy actions take effect. (Dixon, et al., 2006) So, the PACF plot also shows strong positive

[3] ρ_i indicates the i^{th} lag

Figure III-1 *Partial Autocorrelogram of IR*

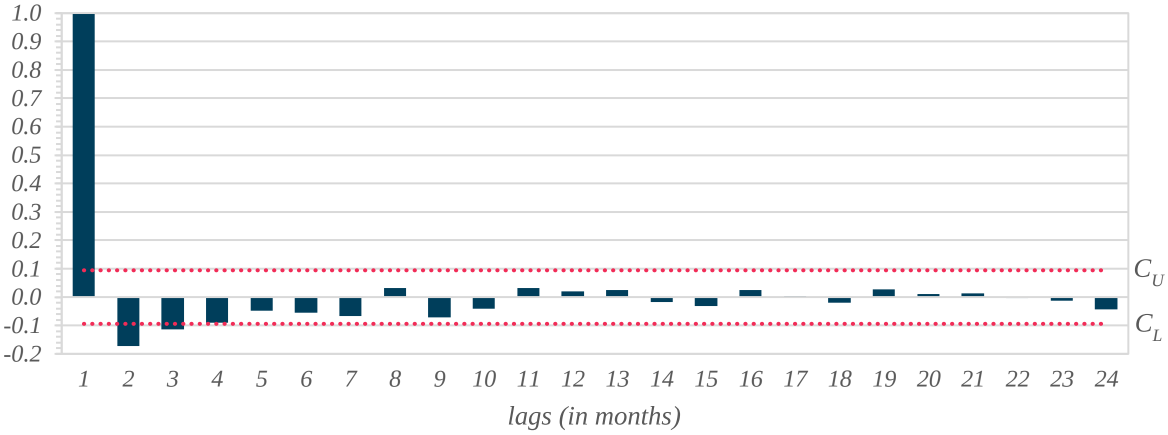


Figure III-2 *Partial Autocorrelogram of CPI*

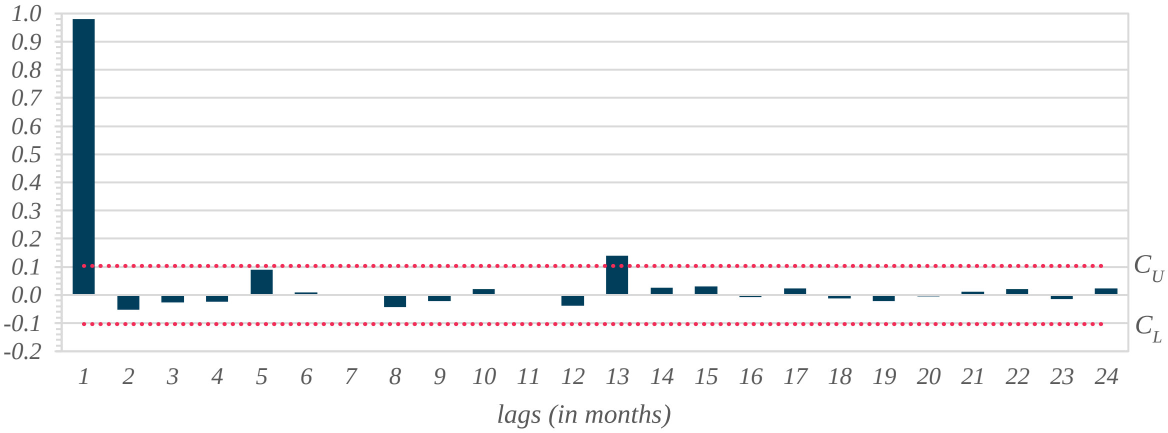
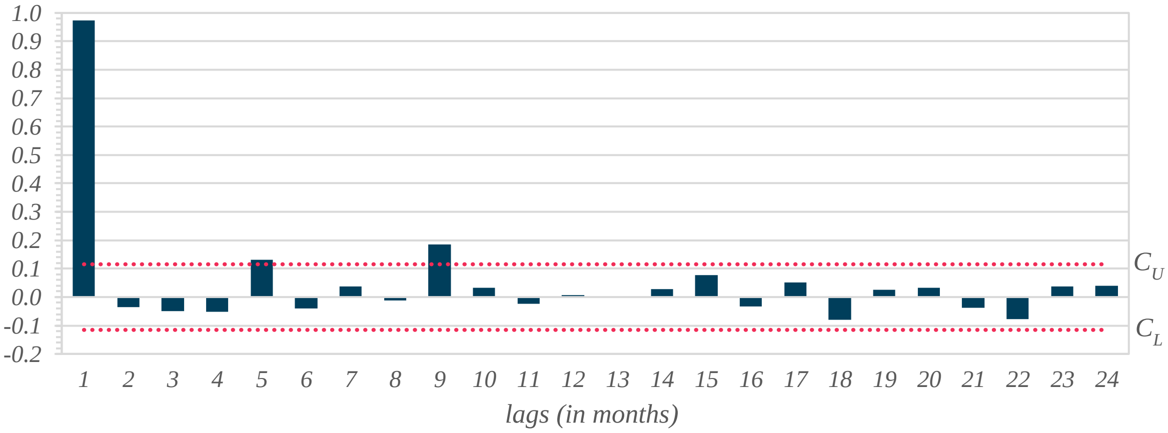


Figure III-3 *Partial Autocorrelogram of EUR*



Note: the auto-correlogram is a chart of autocorrelation statistics. It is used for checking randomness in a data set. If random, autocorrelations should be near zero for any and all time-lag separations. If non-random, then one or more of the autocorrelations will be significantly non-zero. C_U denotes the upper critical bound, while C_L denotes the lower critical bound, and the area between them depicts the 95% confidence interval.
Source: BIS, BLOOMBERG, and MNB.

partial autocorrelation ($\rho_1 \sim 0.98$). In addition, Figure *III-2* shows a significant spike at lag 13 of the PACF ($\rho_{13} \sim 0.14$) which is an indication of seasonal variation in the data set. The seasonality occurs shortly after a year. Finally, the partial autocorrelation of variable *EUR* is shown in Figure *III-3*. There is a strong positive partial autocorrelation at the first lag ($\rho_1 \sim 0.97$), and two much weaker but still significant positive partial autocorrelation ($\rho_5 \sim 0.13$ and $\rho_9 \sim 0.19$).

The next step is examining possible interactions between the three variables (*IR*, *CPI*, and *EUR*). For this purpose, correlation is the most used indicator which describes any statistical relationship, whether causal or not, between two variables. Since there are three variables, it is more convenient to summarize the correlations in a matrix. Such matrices are Table *III-2* and Table *III-3*. In these, each cell in the table shows the correlation between two variables. The first one examines the correlation between the variables over the entire time when data is available while the second one does after 2008 – this is relevant to my research.

Table III-2 *Correlation Matrix of Variables over the entire time series*

	IR	*CPI*	*EUR*
IR	*100%*	*92.19%*	*-57.94%*
CPI	*92.19%*	*100%*	*-3.77%*
EUR	*-57.94%*	*-3.77%*	*100%*

Table III-3 *Correlation Matrix of Variables after 2008*

	IR	*CPI*	*EUR*
IR	*100%*	*64.93%*	*-25.67%*
CPI	*64.93%*	*100%*	*38.41%*
EUR	*-25.67%*	*38.41%*	*100%*

Note: for the calculation of each correlation coefficient only pairwise complete observations were used. Redundant results were paled.
Source: BIS, BLOOMBERG, and MNB.

The correlation between *IR* and *CPI* is almost linear if we examine the entire time series but it is still stronger than medium in the case of the data after 2008. This is not at all surprising as this relationship is casual. In one way at least, since it is known that the base interest rate is set according to the rate of inflation. Whether it is casual otherwise, is debated and widely researched. The next two variables, *IR*, and *EUR*, also show a stronger than medium correlation but with a negative sign. It is true even after 2008, only to a smaller degree. In practice, higher interest rates offer lenders in an economy a higher return relative to other countries. Therefore, higher interest rates attract foreign capital and cause the exchange rate to rise – making the forint stronger than the euro. So, it means the depreciation of the euro against the forint, explaining the negative sign. At last, the correlation between *CPI* and *EUR* is close to zero except after 2008. It may suggest that with the appreciation of the euro inflation increases – in accordance with Equation *II-1*.

To be more precise with correlation indicators, a combination of two variables' correlation and autocorrelation is introduced: cross-correlation. It is a measurement that tracks the movements of two or more sets of time series data relative to one another. It is used to compare multiple time series and objectively determine how much they match up with each other and at what point the best match occurs.

With three variables there are three possible combinations of a cross-correlation. These are shown in Figure *III-4*, Figure *III-5*, and Figure *III-6*. In all figures, by definition, the extent of the correlation at the 0^{th} lag is identical to the values in Table *III-3*. Before and after this, 12-12 lags were examined which means a total of two years period. In Figure *III-4*, the relationship between *IR* and *CPI* can be seen. It is highest at 0^{th} lag ($\rho_0 \sim 0.65$) and lower in the surroundings. After the -9^{th} lag, the correlation is not even significant. The correlation between *IR* and *EUR* is shown in Figure *III-5*. Before ($\rho_0 \sim -0.26$) it is constantly increasing as far as ($\rho_{-12} \sim -0.56$), after it, however, stagnates. And at last, Figure *III-6* shows the cross-correlation between *CPI* and *EUR*. It reaches its highest value at ($\rho_2 \sim 0.39$) compared to ($\rho_0 \sim 0.38$). So, the difference is quite small. After the -4^{th} lag, the correlation is not significant anymore.

Analysing the different types of correlations between each variable and even between the lagged itself helped to uncover the underlying drivers of the relationship between interest rates, inflation, and exchange rate. The obtained information contributes mainly to determine the appropriate number of lags in the various VAR models. Furthermore, it implies which lagged variables shall pay special attention to, in the already built models. Overall, the correlation matrix, auto-correlogram and cross-correlogram are useful tools in monetary policy and in my thesis for analysing the relationships between monetary policy variables and macroeconomic variables, which can inform the design and implementation of effective monetary policies for policymakers and analysis tools for me.

Figure III-4 *Cross-correlogram of IR and CPI*

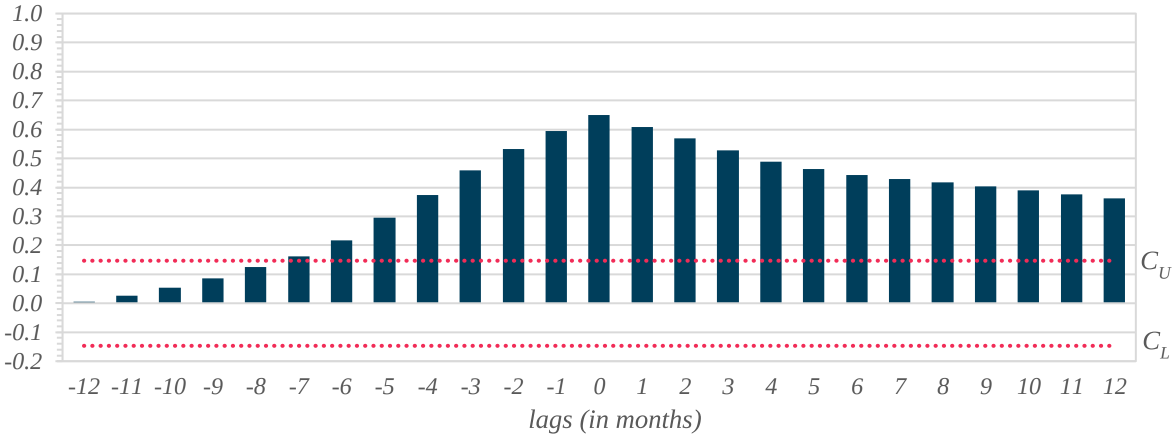


Figure III-5 *Cross-correlogram of IR and EUR*

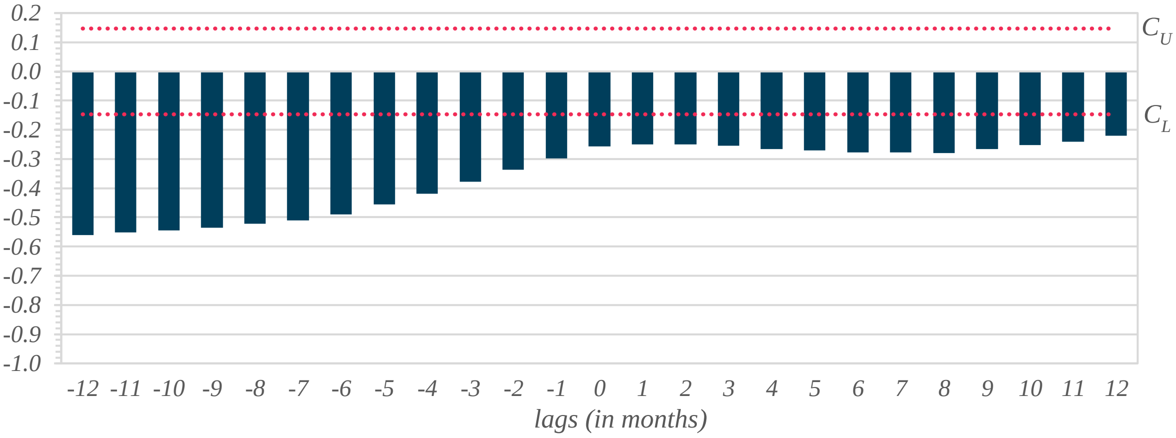
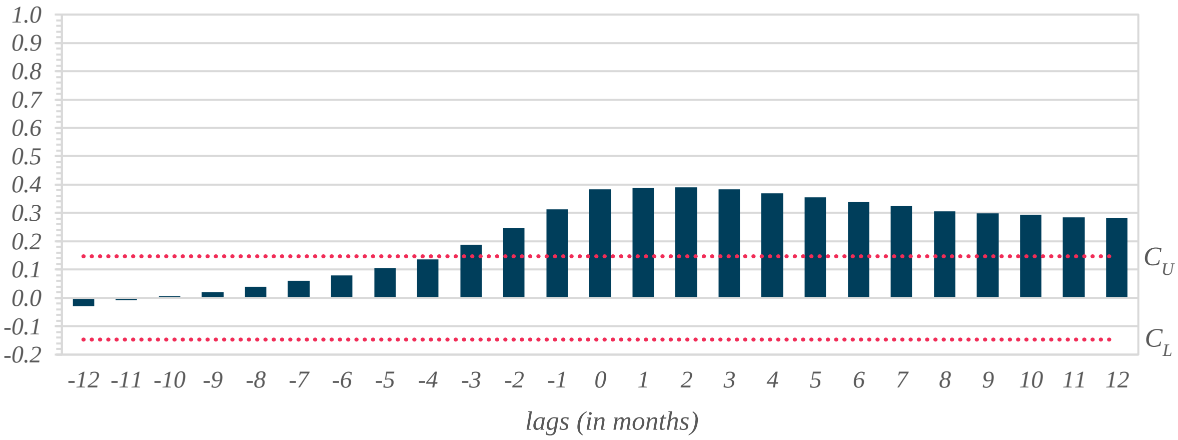


Figure III-6 *Cross-correlogram of CPI and EUR*



Note: the cross-correlogram is a way to visualize the cross-correlation between two time series data. It shows the cross-correlation coefficient between two signals plotted as a function of the time lag between them. C_U denotes the upper critical bound, while C_L denotes the lower critical bound, and the area between them depicts the 95% confidence interval. Source: BIS, BLOOMBERG, and MNB.

3. Bi- and Multivariate VAR models

After choosing the variables and analysing their properties, the next step in building a VAR model is to specify the length of the lags. It can be determined using either F-tests or information criteria. (Stock, et al., 2001) I will utilise the information criteria alongside the macroeconomic considerations. The purpose of choosing optimal lag is to reduce residual correlation. Literature provides various choices such as Akaike (AIC), Hannah-Quinn (HQ), Bayesian (BIC), and Akaike's Final Prediction Error (FPE). These criteria can and do suggest different lag orders, thus I must rely on my research question – that is, I examine long- or medium-term effects. Table *III-4* contains the results of the function which returns information criteria and final prediction error for sequential increasing the lag order up to a VAR(*p*)-process.

Table III-4 *Information Criteria and FPE for different VAR(p)*

Variables in a VAR model	Maximum lag order	AIC(*p*)	HQ(*p*)	BIC(*p*)	FPE(*p*)
IR and *CPI*	*24*	*23*	*7*	*6*	*15*
IR and *EUR*	*12*	*11*	*2*	*2*	*11*
CPI and *EUR*	*12*	*5*	*2*	*1*	*5*
IR and *CPI* and *EUR*	*24*	*23*	*6*	*2*	*15*

Note: Lag orders that were not applied were paled.
Source: BIS, BLOOMBERG, and MNB.

In the case of models with variables *IR* and *CPI*, I choose the lag length of 15 months which makes the estimation period more than a year (described in Equation *VI-1* and Equation *VI-2*). For models consisting of *IR* and *EUR* the best choice was 11 months, almost a year. It is described in Equation *III-1* and Equation *III-2*. Examining on medium-term requires shorter time intervals, so, the models with *CPI* and *EUR* lag only 5 months and are described in Equation *VI-3*. And at last, the VAR model with all three variables is estimated with lag order 6 which is exactly half a year. This system of equations is described in Equation *III-3*. The equations and models that are not relevant from the point of view of this thesis but provide important results are in the Appendix.

First, I present the estimation results for the VAR(11) model consisting of only two variables, *IR* and *EUR*. This concludes the relationship between these two variables and does not reckon any other exogenous factor. In Equation *III-1*, IR is the response variable explained by its own lags and *EUR*'s lags. Estimation results based on this equation are summarised in Table *III-5*.

Equation III-1 *VAR(11) equation of IR*

$$\widehat{IR} = \sum_{p=1}^{11} IR_p + \sum_{p=1}^{11} EUR_p + c$$

Table III-5 *Estimation results for equation IR in a bivariate VAR model of IR and EUR*

Variable	Lag (*p*)	Estimate	Standard Error	t-value	p-value	Significance
IR	*1*	*1.6896*	*0.0815*	*20.7240*	*< 2e-16*	***
	2	*-0.8616*	*0.1516*	*-5.6850*	*6.96e-08*	***
	3	*0.3838*	*0.1273*	*3.0140*	*0.0030*	**
	4	*-0.3391*	*0.1046*	*-3.2410*	*0.0015*	**
	5	*0.1795*	*0.1034*	*1.7360*	*0.0847*	·
	6	*-0.0305*	*0.1077*	*-0.2830*	*0.7775*	
	7	*-0.0829*	*0.1099*	*-0.7540*	*0.4523*	
	8	*0.2184*	*0.1175*	*1.8590*	*0.0650*	·
	9	*-0.4893*	*0.1189*	*-4.1160*	*6.44e-05*	***
	10	*0.5425*	*0.1214*	*4.4690*	*1.57e-05*	***
	11	*-0.2161*	*0.0793*	*-2.7250*	*0.0072*	**
EUR	*1*	*0.0083*	*0.0034*	*2.4610*	*0.0150*	*
	2	*-0.0007*	*0.0046*	*-0.1540*	*0.8778*	
	3	*-0.0110*	*0.0045*	*-2.4310*	*0.0163*	*
	4	*0.0112*	*0.0046*	*2.4290*	*0.0164*	*
	5	*-0.0089*	*0.0047*	*-1.9080*	*0.0584*	·
	6	*-0.0006*	*0.0046*	*-0.1250*	*0.9005*	
	7	*0.0027*	*0.0045*	*0.5880*	*0.5573*	
	8	*-0.0042*	*0.0045*	*-0.9450*	*0.3460*	
	9	*0.0111*	*0.0044*	*2.5120*	*0.0131*	*
	10	*-0.0092*	*0.0045*	*-2.0530*	*0.0419*	*
	11	*0.0026*	*0.0033*	*0.7860*	*0.4330*	
constant	-	*-0.3625*	*0.4117*	*-0.8800*	*0.3801*	

Note: the coefficient is statistically significant at a 10% level ('·'), at 5% level ('*'), at 1% level ('**'), at 0.1% level ('***'). Residual standard error: 0.252 on 145 degrees of freedom. R-Squared: 0.9943. Adjusted R-squared: 0.9935.

On the other hand, in Equation *III-2 EUR* is the response variable with the explanatory variables of *IR* and *EUR*. The VAR estimation results for this equation are in Table *III-6*.

Equation III-2 *VAR(11) equation of EUR*

$$\widehat{EUR} = \sum_{p=1}^{11} IR_p + \sum_{p=1}^{11} EUR_p + c$$

Table III-6 *Estimation results for equation EUR in a bivariate VAR model of IR and EUR*

Variable	Lag (*p*)	Estimate	Standard Error	t-value	p-value	Significance
	1	*2,0970*	*2,0275*	*1,0340*	*0.3027*	
	2	*-4,3906*	*3,7688*	*-1,1650*	*0.2459*	
	3	*8,8066*	*3,1664*	*2,7810*	*0.0061*	**
	4	*-8,9262*	*2,6022*	*-3,4300*	*0.0008*	***
	5	*6,2685*	*2,5719*	*2,4370*	*0.0160*	*
IR	*6*	*-8,4469*	*2,6779*	*-3,1540*	*0.0020*	**
	7	*4,5706*	*2,7338*	*1,6720*	*0.0967*	·
	8	*-0,8164*	*2,9219*	*-0,2790*	*0.7803*	
	9	*-0,9337*	*2,9561*	*-0,3160*	*0.7526*	
	10	*3,3599*	*3,0189*	*1,1130*	*0.2676*	
	11	*-1,7191*	*1,9723*	*-0,8720*	*0.3849*	
	1	*0,9447*	*0,0838*	*11,2770*	*< 2e-16*	***
	2	*0,0794*	*0,1143*	*0,6940*	*0.4885*	
	3	*-0,0592*	*0,1122*	*-0,5280*	*0.5986*	
	4	*-0,2158*	*0,1143*	*-1,8880*	*0.0610*	·
	5	*0,1691*	*0,1160*	*1,4580*	*0.1471*	
EUR	*6*	*0,0692*	*0,1150*	*0,6020*	*0.5482*	
	7	*-0,0981*	*0,1122*	*-0,8740*	*0.3836*	
	8	*-0,2079*	*0,1116*	*-1,8620*	*0.0646*	·
	9	*0,2602*	*0,1101*	*2,3640*	*0.0194*	*
	10	*0,0648*	*0,1118*	*0,5790*	*0.5632*	
	11	*-0,0288*	*0,0825*	*-0,3490*	*0.7273*	
constant	-	*8,7015*	*10,2385*	*0,8500*	*0.3968*	

Note: the coefficient is statistically significant at a 10% level (‘·’), at 5% level (‘*’), at 1% level (‘**’), at 0.1% level (‘***’). Residual standard error: 6.266 on 145 degrees of freedom. R-Squared: 0.97. Adjusted R-squared: 0.9655

Interpreting the VAR model results is not a trivial task. Especially not, if it includes only a few a variable. The estimation sample data covers a very strange period. Between 2008 and 2022 Some of the major economic events that concerned Hungary are the Global Financial Crisis (2008-2009), the Hungarian Debt Crisis (2010-2012), followed Hungary's Economic Recovery (2013-2019), then the COVID-19 Pandemic (2020-2022). So, besides the usual textbook variables, there are potentially a thousand other variables that influence the mechanism of monetary policy, therefore the quantitative results are not so easily explainable.

In the case of Equation *III-1*, when IR is the response variable, the results can be explained by the following question: considering which variable lags the Monetary Council made its decision when determining the base interest rate? In response to the change in the *EUR* exchange rate, the interest rate might be increased/decreased after 3-4-5 months on average, as these variables are statistically significant in the model. When the *EUR* is the response variable in Equation *III-2*, the question is how and when monetary decisions affected the exchange rate. The model might suggest that it changes after 3-4-5-6-7 months on average. The sign of the coefficient is hard to explain as for 3, 5, and 7 months it is positive, but for 4 and 6 it is negative. A kind of periodicity can be discovered. However, it can be established that the interest rate does not necessarily affect the exchange rate in the short term. The first and second lag of the *IR* variable – i.e., 1 and 2 months – does not have a statistically significant effect on the *EUR* variable.

After examining the statistical relationship between the *IR* and *EUR* variables, I introduce another VAR model involving a control variable – *CPI*. This results in a more complex model, however, in a shorter term – only half a year.

Equation III-3 *System of Multivariate VAR(6) equations for IR, CPI and EUR*

$$\widehat{IR} = \sum_{p=1}^{6} IR_p + \sum_{p=1}^{6} CPI_p + \sum_{p=1}^{6} EUR_p + c$$

$$\widehat{CPI} = \sum_{p=1}^{6} IR_p + \sum_{p=1}^{6} CPI_p + \sum_{p=1}^{6} EUR_p + c$$

$$\widehat{EUR} = \sum_{p=1}^{6} IR_p + \sum_{p=1}^{6} CPI_p + \sum_{p=1}^{6} EUR_p + c$$

Table III-7 *VAR(6) estimation results for all variables*

Response Variable		*IR*		*CPI*		*EUR*	
Explanatory Variable	Lag (*p*)	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance
IR	*1*	*1,331 (±0,0824)*	***	*0,2431 (±0,0997)*	*	*-0,5198 (±1,3680)*	
	2	*-0,4228 (±0,1366)*	**	*-0,0369 (±0,1653)*		*0,7514 (±2,2677)*	
	3	*0,2101 (±0,1402)*		*0,0443 (±0,1696)*		*5,2618 (±2,3264)*	*
	4	*-0,2348 (±0,141)*	·	*-0,4646 (±0,1706)*	**	*-7,0772 (±2,3407)*	**
	5	*0,151 (±0,1423)*		*0,5739 (±0,1722)*	**	*4,1305 (±2,3623)*	·
	6	*-0,0744 (±0,0919)*		*-0,2821 (±0,1111)*	*	*-3,3545 (±1,5246)*	*
CPI	*1*	*0,0366 (±0,0658)*		*1,2294 (±0,0796)*	***	*-0,4469 (±1,0921)*	
	2	*0,0615 (±0,0995)*		*-0,1674 (±0,1204)*		*0,4507 (±1,6516)*	
	3	*-0,1099 (±0,0946)*		*-0,1867 (±0,1144)*		*-0,7322 (±1,5703)*	
	4	*-0,0165 (±0,1048)*		*-0,0557 (±0,1268)*		*-1,0877 (±1,7392)*	
	5	*0,1111 (±0,1091)*		*0,2539 (±0,1319)*	·	*1,4494 (±1,8105)*	
	6	*-0,0392 (±0,0701)*		*-0,1203 (±0,0848)*		*1,0875 (±1,1639)*	
EUR	*1*	*0,0058 (±0,0048)*		*-0,0061 (±0,0058)*		*0,8888 (±0,0794)*	***
	2	*0,0039 (±0,0063)*		*0,0035 (±0,0076)*		*0,1271 (±0,1047)*	
	3	*-0,0121 (±0,0062)*	·	*0,0005 (±0,0075)*		*-0,1332 (±0,1024)*	
	4	*0,0056 (±0,0064)*		*0,0296 (±0,0077)*	***	*-0,153 (±0,1060)*	
	5	*-0,0064 (±0,0067)*		*-0,0297 (±0,0081)*	***	*0,1788 (±0,1108)*	
	6	*0,0025 (±0,0051)*		*0,0115 (±0,0062)*	·	*0,025 (±0,0853)*	
constant	-	*0,1897 (±0,6449)*		*-2,909 (±0,7800)*	***	*22,4982 (±10,7023)*	*
Residual standard error		*0.3873*		*0.4684*		*6.427*	
Multiple R-Squared		*0.9874*		*0.9868*		*0.9696*	
Adjusted R-squared		*0.9859*		*0.9853*		*0.9660*	

Note: the coefficient is statistically significant at a 10% level (‘·’), at 5% level (‘*’), at 1% level (‘**’), at 0.1% level (‘***’). Standard Error is in parentheses under coefficient.

By involving a control variable – namely the CPI, the model is expected to give a clearer explanation. In this case, the VAR results described by Equation *III-3* confirm the previous results. There is still no significant coefficient related to the first and second lag of variable *IR* when the response variable is the *EUR*.

There are two further models with the possible combination of the three variables in the Appendix. The VAR model consists of only *IR* and *CPI* (Equation *VI-1* and Equation *VI-2*) shows clearly that the base interest rate affects inflation over a year. The results are in Table *VI-1* and Table *VI-2*. In addition, Equation *VI-3* concludes only *CPI* and *EUR*. The results summarised in Table *VI-3*, might suggest a possible relationship between the euro exchange rate's depreciation and the inflation's increase, realising possibly through the net import.

4. Impulse Respond Functions

The IRF can be used to understand how an economy responds to monetary shocks, such as changes in interest rates. In the context of this case, variable *EUR* responds to a monetary shock, *IR*. The interpretation of the functions illustrated in Figure *III-7* and Figure *III-8*: when *IR* increases by 1%, *EUR* is changed by a given forints on the next period. The two figures show similar results. In the first months, it responds by increasing ~1 forints, but given the confidence interval, it may converge to the negative domain. In the following months, it increases rapidly but then the impact slowly converges back to zero.

Figure III-7 *IR F based on VAR(11) model*
Response of EUR to IR

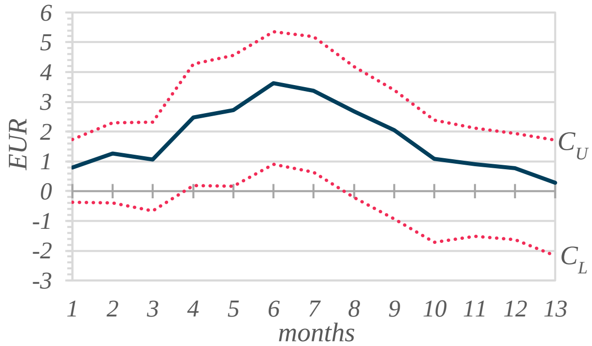
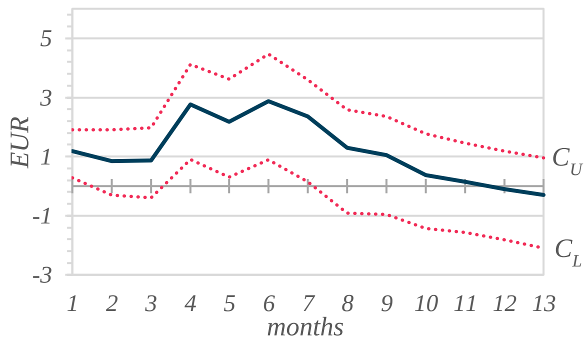


Figure III-8 *IRF based on VAR(6) model*
Response of EUR to IR



Note: the IRFs are forecasted for the next 13 months. C_U denotes the upper critical bound, while C_L denotes the lower critical bound, and the area between them depicts the 95% confidence interval.
Source: BIS, BLOOMBERG, and MNB.

2. Short-term effects

1. Daily exchange rate

In the second part of my thesis analysis, I take a closer look at the euro forint exchange rate and how monetary policy tightening affects it in the short-term. For this, I utilize two databases. The first lists the official base interest rates on a historical scale in Hungary. (MNB, 2023) Its exact date and extent are summarised in Table *III-8* and filtered only to 2022. The other database contains the daily EUR/HUF nominal exchange rate and is collected from Bloomberg.

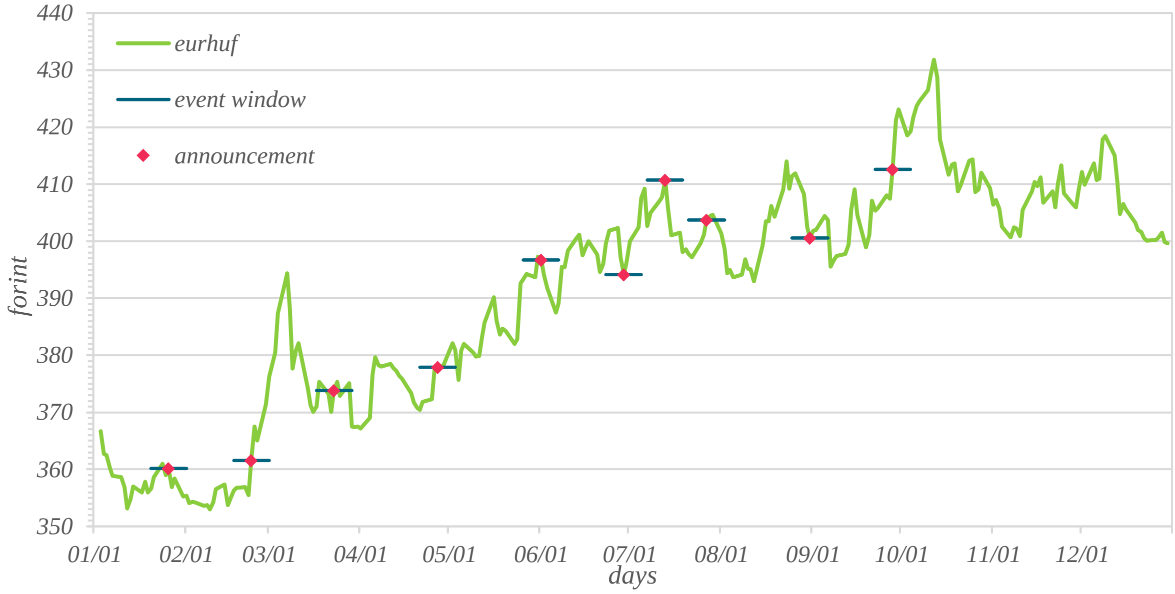
Table III-8 *The date and extent of the central bank interest rate decrees*

Date in 2022	Base Interest Rate
01-26	*2,90%*
02-23	*3,40%*
03-23	*4,40%*
04-27	*5,40%*
06-01	*5,90%*
06-29	*7,75%*
07-13	*9,75%*
07-27	*10,75%*
08-31	*11,75%*
09-28	*13,00%*

Source: MNB.

There were 10 official announcements about the date and extent of the central bank base interest rate in 2022. These occur almost every month, and it passes at least two weeks between two such dates. These two weeks mean, however, only 9 trading days. It has to be acknowledged when specifying the examined event window. In every case, day 0 is the date listed in Table *III-8*. The event window can cover 4 days before and after this date otherwise the data would overlap, and the tests would be biased. It is not advisable to work with larger event windows anyway as under longer time other macroeconomic and political events could influent the exchange rate. Visualising the examined data, I plotted the daily EUR/HUF spot exchange rate, marked the dates when the MNB increased the interest rate and the largest possible event window in Figure *III-9*.

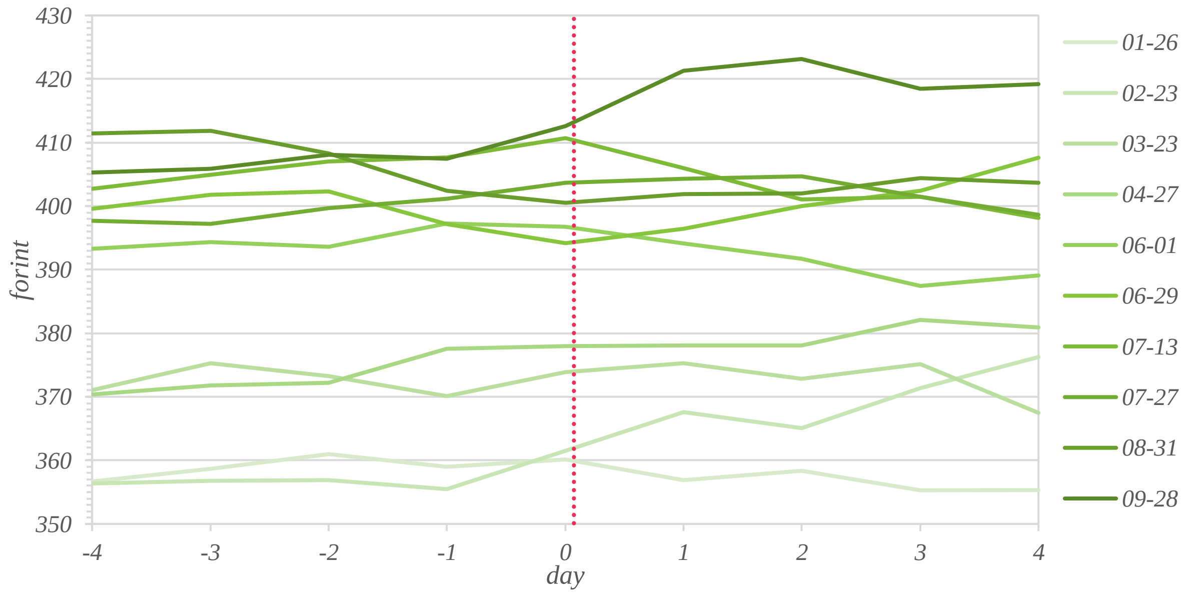
Figure III-9 *Daily euro forint exchange rate in 2022*
with the event windows around the MNB announcements



Note: on this figure *eurhuf* denotes the daily closing euro price in forint, *announcement* denotes the date when the MNB increased the base interest rate, and *event window* denotes the examined data before and after this date.
Source: MNB and BLOOMBERG.

Looking at all event windows from much closer in Figure *III-10*, two things can be told: the forint depreciates against the euro through the year (by the lines getting greener) but no obvious appreciation or depreciation occurs around the days of the event dates.

Figure III-10 *Daily euro forint exchange rate during the event windows*



Note: on this figure *day 0* indicates the date when the MNB increased the base interest rate.
Source: BLOOMBERG.

To be able to handle and analyse this data properly, it must be transformed. When examining exchange rates, it is a common practice to take their changes instead of their nominal value. There are two equivalent methods to do this. The first is by taking the quotient of consecutive values (Equation *III-4*) and the second is by taking the difference of consecutive logarithmical values (Equation *III-5*).

Equation III-4 *Daily EUR/HUF change by taking quotient*

$$\Delta EUR_d = \frac{EUR_{d,t}}{EUR_{d,t-1}} - 1$$

Equation III-5 *Daily EUR/HUF change by taking the logarithmic difference*

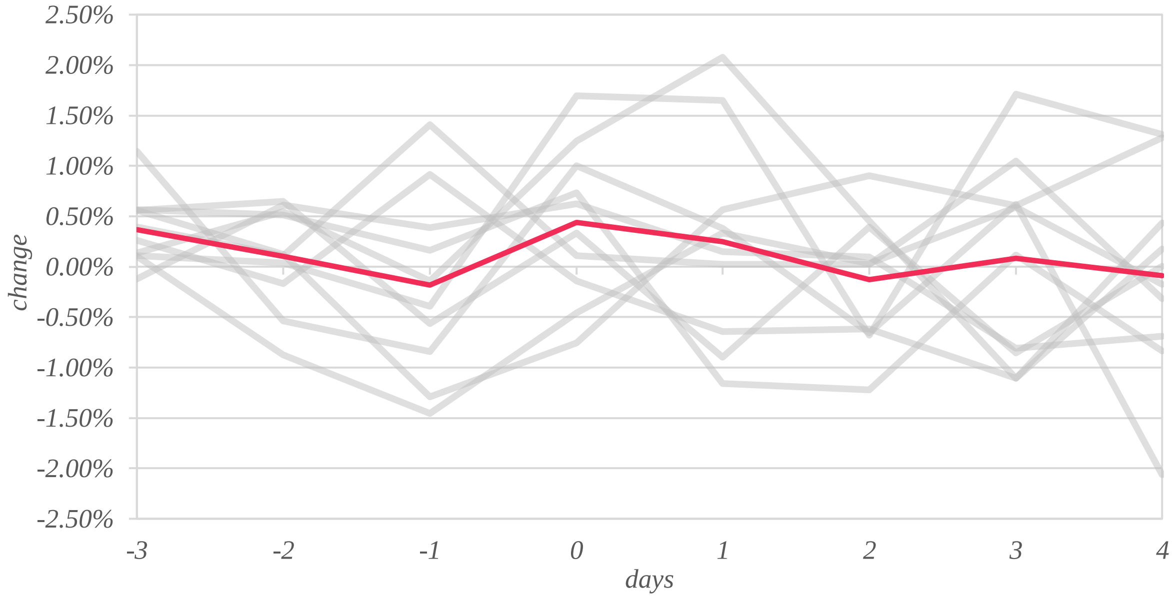
$$\Delta EUR_d \approx ln(EUR_{d,t}) - \ln(EUR_{d,t-1})$$

Note: *EUR_d* denotes the daily euro forint exchange rate in percentage.

After calculating the daily changes in the exchange rates, it is necessary to separate the data set into two parts. One of them includes the data occurring in the event windows and the other one includes the data outside of it. Therefore, the event sample size is 90 – as there are 10 announcement events with a 9-day long event window – and the test sample size is 170. These can be considered large samples, so no assumptions are required for the statistical tests. For the following denotation, $\bar{X}_e$ is the mean of event sample, and $\bar{X}_t$ is the mean of test sample.

The processed data during the event windows are summarised in Table *VI-4* in Appendix. This can be aggregated and analysed in two ways. Firstly, taking an average horizontally, when a given trading day and exchange rate change are the determining factor. This one is plotted in Figure *III-11*. The 10 individual sample line plots are paled and their aggregated value, the mean is highlighted. It was essential as I was curious about the effect of the specific MNB interest rate decisions. It can be seen that the exchange rate change is volatile in a certain (±2%) domain but there is no noticeable outlier value. However, looking at the mean line, there is a slight increase in change to day 0. The other kind of aggregation is taking an average vertically, from the surroundings trading days of announcement dates. This results, of course, 10 mean values that are shown in Figure *III-12*.

Figure III-11 *Daily euro forint exchange rate changes during the event windows*



Note: in this figure, the data on *day 0* shows the change that happened between the previous day's closing price and the announcement day's closing price. The *red line* in the middle indicates the average of the 10 samples – which are paled.
Source: BLOOMBERG.

Looking at the average percentage change in the exchange rate during certain event windows in Figure *III-12*, a kind of periodicity can be observed. Another fact is that the two highest changes occurred when the MNB increased the base interest rates in February and September.

Figure III-12 *Average change in euro forint exchange rate during the event windows*

Note: the average change is calculated using an 8-day-long event window.
Source: BLOOMBERG.

2. Statistical hypothesis tests

To prove my hypothesis, that there is no significant change in the euro forint exchange rate in short term, different kinds of statistical hypothesis tests must be conducted. One type of it is the t-test which is used to determine whether there is a significant difference between the mean of a population and a known or hypothesised value or between the means of two samples.

First, I conduct a one-sample t-test. This test is used to determine whether a sample mean is significantly different from a hypothesised population mean. In this case, this mean is equal to zero because this would suggest that the exchange rate was not changing over time and was in equilibrium. The null hypothesis is that the sample mean is equal to zero ($H_0: \bar{X}_e = 0$), while the alternative hypothesis is that the sample mean is not equal to zero ($H_1: \bar{X}_e \neq 0$). The test results are in Table *III-9*. Except for one case, the p-value results are larger than 10%, which means that we cannot reject the null hypothesis at all usual significance levels. The sample means are equal to zero thus they did not change significantly. The only exception is the one that occurred on the 23rd of February, but this is not surprising as the forint depreciated drastically against the euro because of the war that broke out on the following day in the adjoining country.

Secondly, I conduct a two-sample t-test. This is for better comparability as in 2022 there was an increasing trend in the exchange rate that results a more likely positive mean in changes. The test is used to determine whether there is a significant difference between the means of the two samples. The null hypothesis is that the sample means are equal ($H_0: \bar{X}_e = \bar{X}_t$), while the alternative hypothesis is that the sample means are not equal ($H_1: \bar{X}_e \neq \bar{X}_t$). After I confirmed that the variances of the two samples are statistically equal, which is a prerequisite for a two-sample t-test, I proceed to conduct the t-tests. The results for these tests are in Table *III-10*. In every case, the p-value results are larger than 10%, which means that we cannot reject the null hypothesis at all usual significance levels. The event sample means are equal to the test sample mean thus they did not change significantly in any direction.

Table III-9 *One-Sample t-Test*

Date (2022)	p-value
01-26	*0,8379*
02-23	*0,0993·*
03-23	*0,7662*
04-27	*0,1329*
06-01	*0,5878*
06-29	*0,4404*
07-13	*0,6344*
07-27	*0,8789*
08-31	*0,3485*
09-28	*0,2464*

Note: tested null hypothesis is $H_0: \bar{X}_e = 0$

Table III-10 *Two-Sample t-Test*

Date (2022)	p-value
01-26	*0,6896*
02-23	*0,1263*
03-23	*0,6782*
04-27	*0,2088*
06-01	*0,4769*
06-29	*0,5473*
07-13	*0,5336*
07-27	*0,9238*
08-31	*0,2794*
09-28	*0,3121*

Note: tested null hypothesis is $H_0: \bar{X}_e = \bar{X}_t$

3. Robustness testing

After conducting the one-sample and two-sample t-tests, it is important to test its robustness. Robustness testing refers to the practice of testing the sensitivity of a statistical method to violations of its underlying assumptions. The goal of robustness testing is to determine how well a statistical method performs when its assumptions are not met or are only partially met.

In this case, the extent of the event window can be such a problem. Choosing its maximal value (±4 days) encountered limitations. However, this parameter can be changed to smaller as I investigate in the short-term. So, the possible event window sizes are 1, 2, 3, and the original 4. The performed t-test results with different event window parameters are summarised in Table *III-11* and Table *III-12*. In these, the last column with the 4-day long event window is identical to the results in Table *III-9* and Table *III-10*. The robustness testing can be accounted successful as there was no considerable change in the p-values. Only two small differences to mention in the case of the one-sample t-tests: around the 23rd of February, with a 3-day long event window the result is the same, however with 2- and 1-day long (i.e., smaller event window), the null hypothesis cannot be rejected anymore. And around the 27th of July with a 1-day long event window, on the contrary, the null hypothesis has to be rejected.

Table III-11 *P-values of the One-Sample t-Tests conducted with smaller event windows*

Date (2022)	Event Window			
	1	2	3	4
01-26	*0,6103*	*0,6026*	*0,8379*	*0,8379*
02-23	*0,4417*	*0,2084*	*0,0993·*	*0,0993·*
03-23	*0,9493*	*0,9839*	*0,7662*	*0,7662*
04-27	*0,3310*	*0,1280*	*0,1329*	*0,1329*
06-01	*0,7618*	*0,3475*	*0,5878*	*0,5878*
06-29	*0,8020*	*0,9440*	*0,4404*	*0,4404*
07-13	*0,5018*	*0,6952*	*0,6344*	*0,6344*
07-27	*0,0803·*	*0,4533*	*0,8789*	*0,8789*
08-31	*0,3956*	*0,3780*	*0,3485*	*0,3485*
09-28	*0,1568*	*0,3060*	*0,2464*	*0,2464*

Note: tested null hypothesis is $H_0: \bar{X}_e = 0$, at a 10% (‘·’), at 5% (‘*’), at 1% (‘**’), and at 0.1% (‘***’) significance level.

Table III-12 *P-values of the Two-Sample t-Tests conducted with smaller event windows*

Date (2022)	Event Window			
	1	2	3	4
01-26	*0,5275*	*0,5067*	*0,6896*	*0,6896*
02-23	*0,4815*	*0,2428*	*0,1263*	*0,1263*
03-23	*0,8661*	*0,8652*	*0,6782*	*0,6782*
04-27	*0,3929*	*0,1742*	*0,2088*	*0,2088*
06-01	*0,6738*	*0,2877*	*0,4769*	*0,4769*
06-29	*0,7371*	*0,9477*	*0,5473*	*0,5473*
07-13	*0,4528*	*0,6048*	*0,5336*	*0,5336*
07-27	*0,1187*	*0,6071*	*0,9238*	*0,9238*
08-31	*0,3475*	*0,3188*	*0,2794*	*0,2794*
09-28	*0,1736*	*0,3562*	*0,3121*	*0,3121*

Note: tested null hypothesis is $H_0: \bar{X}_e = \bar{X}_t$, at a 10% (‘·’), at 5% (‘*’), at 1% (‘**’), and at 0.1% (‘***’) significance level.

IV. Conclusion

The central issue of my thesis is the short-term impact of monetary policy interventions – especially setting the base interest rate – on the euro forint spot exchange rate in 2022. The main cause of this research theme was the MNB's announcement to stop increasing the interest rate and the following drastic forint depreciation against the stronger currencies such as the euro. The public and even many professionals believed that there is a causality but at least a solid relationship between the two events. A general opinion started to spread across the media, namely, the MNB does not deal with the price level and the exchange rate anymore. In reality, they just changed their approach to crisis management. However, the judgment remained the same: the MNB has ineffective policies and abandon fighting against the high euro exchange rate. To disprove this, I articulated my hypothesis that *the forint exchange rate cannot be influenced in the short-term only by monetary decisions, namely increasing interest rates.* My thesis aims to improve the public perception of the MNB's work and expertise as well, thereby enhancing the MNB's social judgment.

To prove my hypothesis, I conducted heavily quantitative research. For this, I started my thesis with an academic review, including the monetary transmission mechanism (how monetary decisions affect on real economy) and the commonly used models examining it. This is followed by describing all the variables that I use during model building and placing them in the context of monetary economics. In the first part of my analysis, I utilised several VAR models to prove my hypothesis from an indirect approach. The models showed that monetary intervention – interest rates, to be more precise – has effects on exchange rates mainly in the medium- and long-term. Nevertheless, it is important to highlight that in certain cases, the monetary transmission mechanism may work differently in practice than what is outlined in the theoretical framework. The reason for this is that, in practice, various transmission channels often cannot function as efficiently as expected according to the theory, for some reason or another. Such a reason for example in the case of Hungary, in addition to the interest rate channel of monetary policy, the functioning of the exchange rate channel was also limited due to the high proportion of debt denominated in foreign currency. In general, in the case of expansionary monetary policy, currency depreciation can contribute to the balance sheet adjustment process through its favourable effects on output and income flows. However, in Hungary, due to the high proportion of foreign currency debt held by economic actors, a possible exchange rate depreciation before the conversion to the forint could have had an unfavourable impact on their income situation, resulting in restrained demand despite stimulating exports.

Showing that increasing the interest rates has effects mainly in the medium- and long-term is inadequate. There is still the possibility that these changes in monetary policy can affect in the short-term. Thus, in the second part of my thesis, I use a much more direct approach to my question. MNB announcements about interest rates can have a significant impact on daily exchange rates – at least in theory. If a central bank increases interest rates, it can make the currency more attractive to investors who seek higher returns on their investments. This increased demand for the currency can cause its exchange rate to rise. But it is not the case in practice. Only changing the interest rate does not have the power to significantly influent the exchange rate on a daily base. This statement – together with my hypothesis – is proved by conducting numerous one- and two-sample t-tests. In the case of the first one, the sample mean’s divergence from zero is examined, while in the case of the second one, the sample mean’s divergence from the whole year’s mean is examined. The accuracy of the tests is supported by multiple robustness tests.

The conclusion of my thesis is that the forint exchange rate in the short term is not solely affected by monetary decisions, such as increasing interest rates, as evidenced by both the literature review and the results of macroeconomic models and statistical tests. Therefore, my hypothesis is accepted, and it can be concluded that *the forint exchange rate cannot be influenced only by monetary decisions, namely increasing interest rates*.

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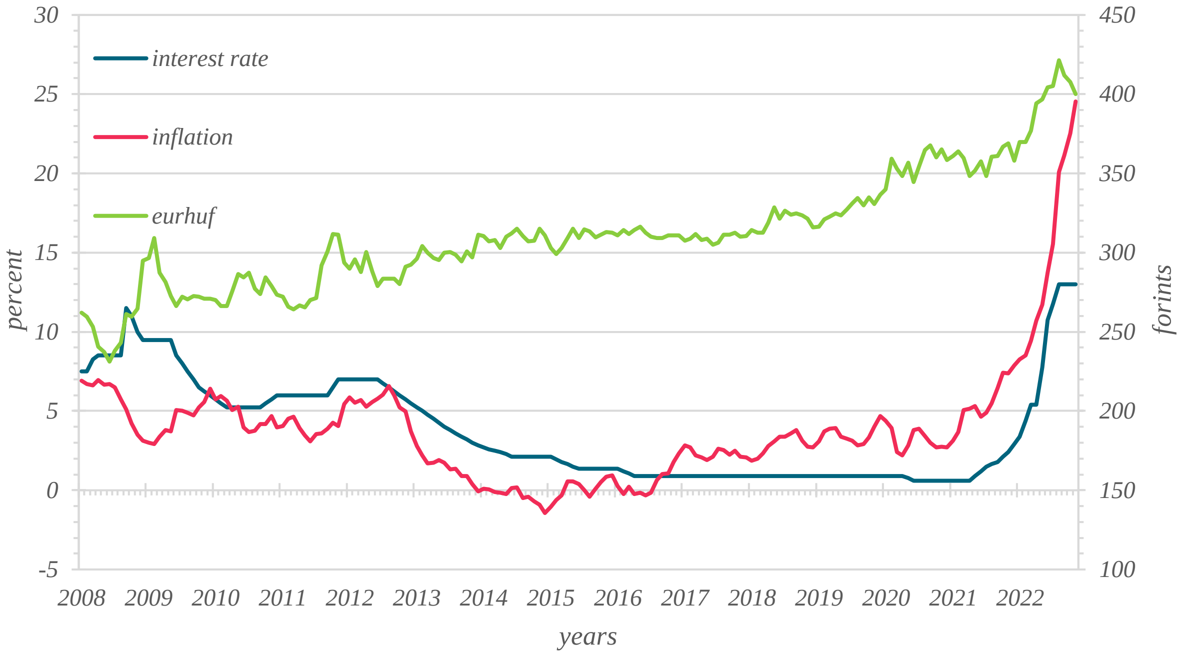
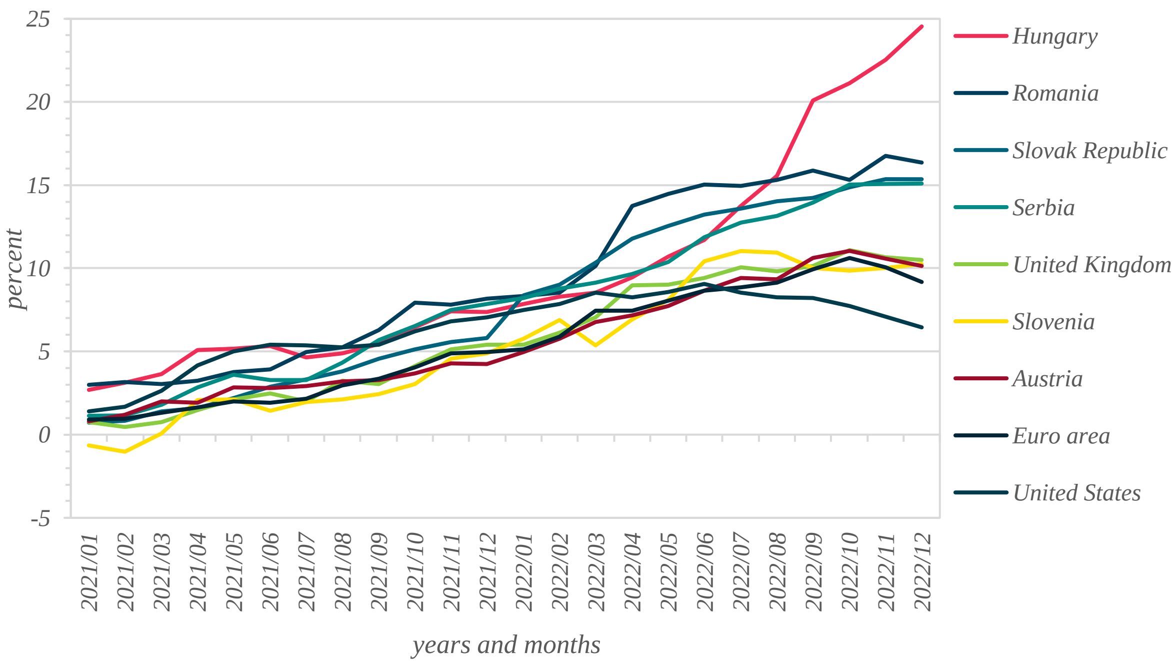
VI. Appendix

Figure VI-1 *Monthly development of variables IR, CPI, and EUR from 2008*



Note: *interest rate* indicates the variable *IR*, *inflation* indicates the variable *CPI*, and *eurhuf* indicates the variable *EUR* in nominal value.
Source: BIS, BLOOMBERG, and MNB.

Figure VI-2 *Monthly development of the inflation in certain countries in 2021-2022*



Note: this figure shows the monthly development of the inflation (CPI) in Hungary, in its neighbouring countries, and in the EU, UK, and US in 2021 and 2022.
Source: BIS.

Figure VI-3 *Autocorrelogram of IR*

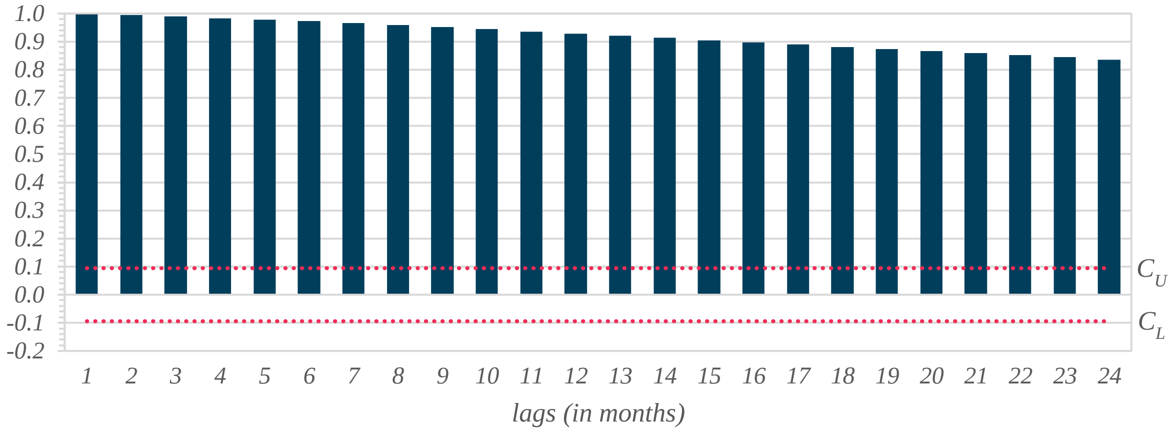


Figure VI-4 *Autocorrelogram of CPI*

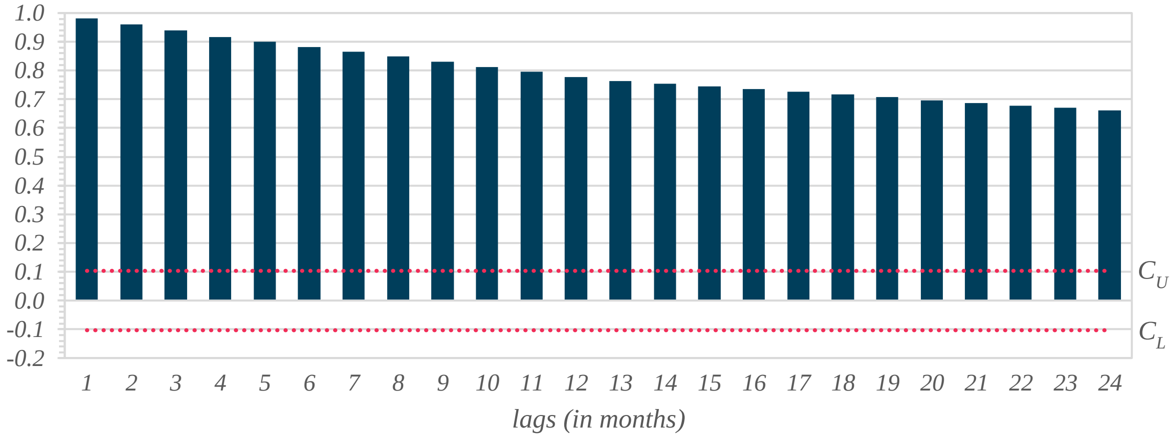
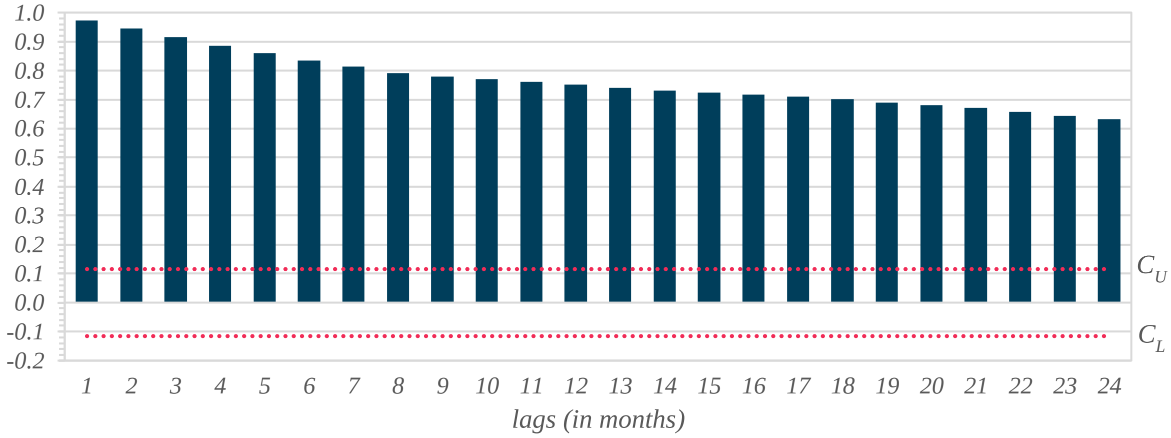


Figure VI-5 *Autocorrelogram of EUR*



Note: the (auto)correlogram is a chart of (auto)correlation statistics. It is used for checking randomness in a data set. If random, autocorrelations should be near zero for any and all time-lag separations. If non-random, then one or more of the autocorrelations will be significantly non-zero. C_U denotes the upper critical bound, while C_L denotes the lower critical bound, and the area between them depicts the 95% confidence interval.
Source: BIS, BLOOMBERG, and MNB.

Equation VI-1 *VAR(15) equation of IR*

$$\widehat{IR} = \sum_{p=1}^{15} IR_p + \sum_{p=1}^{15} CPI_p + c$$

Table VI-1 *Estimation results for equation IR in a bivariate VAR model of IR and CPI*

Variable	Lag (p)	Estimate	Standard Error	t-value	p-value	Significance
	1	*1.8656*	*0.0869*	*21.4730*	*< 2e-16*	***
	2	*-1.2999*	*0.1768*	*-7.3540*	*0.0000*	***
	3	*1.0962*	*0.2100*	*5.2200*	*0.0000*	***
	4	*-1.3558*	*0.2184*	*-6.2070*	*0.0000*	***
	5	*1.2349*	*0.2470*	*5.0000*	*0.0000*	***
	6	*-1.0214*	*0.3000*	*-3.4050*	*0.0009*	***
	7	*0.5897*	*0.2025*	*2.9120*	*0.0042*	**
IR	*8*	*-0.0788*	*0.1126*	*-0.6990*	*0.4856*	
	9	*-0.3725*	*0.1040*	*-3.5820*	*0.0005*	***
	10	*0.5602*	*0.1114*	*5.0280*	*0.0000*	***
	11	*-0.4605*	*0.1181*	*-3.9010*	*0.0002*	***
	12	*0.4273*	*0.1206*	*3.5420*	*0.0005*	***
	13	*-0.3789*	*0.1217*	*-3.1140*	*0.0023*	**
	14	*0.2618*	*0.1225*	*2.1360*	*0.0345*	*
	15	*-0.0933*	*0.0809*	*-1.1530*	*0.2508*	
	1	*-0.0443*	*0.0512*	*-0.8660*	*0.3883*	
	2	*0.1791*	*0.0794*	*2.2560*	*0.0257*	*
	3	*-0.2219*	*0.0780*	*-2.8450*	*0.0052*	**
	4	*0.1038*	*0.0787*	*1.3200*	*0.1892*	
	5	*0.0437*	*0.0797*	*0.5490*	*0.5843*	
	6	*-0.1105*	*0.0811*	*-1.3630*	*0.1752*	
	7	*0.0902*	*0.0782*	*1.1540*	*0.2505*	
CPI	*8*	*0.0369*	*0.0775*	*0.4760*	*0.6345*	
	9	*-0.0534*	*0.0768*	*-0.6960*	*0.4875*	
	10	*0.0085*	*0.0764*	*0.1110*	*0.9117*	
	11	*-0.0467*	*0.0753*	*-0.6210*	*0.5357*	
	12	*0.0813*	*0.0752*	*1.0810*	*0.2816*	
	13	*-0.1550*	*0.0771*	*-2.0120*	*0.0463*	*
	14	*0.2221*	*0.0801*	*2.7730*	*0.0063*	**
	15	*-0.1124*	*0.0507*	*-2.2150*	*0.0285*	*
constant	-	*0.0093*	*0.0399*	*0.2340*	*0.8156*	

Note: the coefficient is statistically significant at a 10% level (‘·’), at 5% level (‘*’), at 1% level (‘**’), at 0.1% level (‘***’). Residual standard error: 0.242 on 133 degrees of freedom. R-Squared: 0.9947. Adjusted R-squared: 0.9935.

Equation VI-2 *VAR(15) equation of CPI*

$$\widehat{CPI} = \sum_{p=1}^{15} IR_p + \sum_{p=1}^{15} CPI_p + c$$

Table VI-2 *Estimation results for equation CPI in a bivariate VAR model of IR and CPI*

Variable	Lag (p)	Estimate	Standard Error	t-value	p-value	Significance
	1	0.4198	0.1421	2.9540	0.0037	**
	2	-0.1693	0.2892	-0.5850	0.5593	
	3	0.7746	0.3436	2.2550	0.0258	*
	4	-2.1637	0.3574	-6.0550	0.0000	***
	5	2.4710	0.4040	6.1160	0.0000	***
	6	-2.2241	0.4908	-4.5310	0.0000	***
	7	1.0918	0.3313	3.2950	0.0013	**
IR	8	-0.4746	0.1843	-2.5750	0.0111	*
	9	0.5393	0.1701	3.1700	0.0019	**
	10	-0.2114	0.1823	-1.1590	0.2484	
	11	-0.1540	0.1932	-0.7970	0.4267	
	12	0.3752	0.1973	1.9010	0.0595	·
	13	-0.2940	0.1990	-1.4770	0.1420	
	14	0.4035	0.2005	2.0130	0.0462	*
	15	-0.3713	0.1323	-2.8050	0.0058	**
	1	1.2033	0.0837	14.3750	< 2e-16	
	2	-0.0559	0.1299	-0.4300	0.6676	
	3	-0.2829	0.1276	-2.2170	0.0283	*
	4	-0.0977	0.1287	-0.7590	0.4490	
	5	0.3444	0.1304	2.6400	0.0093	**
	6	-0.0163	0.1327	-0.1230	0.9022	
	7	-0.2297	0.1279	-1.7960	0.0748	·
CPI	8	0.1268	0.1269	0.9990	0.3195	
	9	0.0761	0.1256	0.6060	0.5456	
	10	-0.0313	0.1250	-0.2510	0.8026	
	11	-0.0249	0.1231	-0.2020	0.8403	
	12	-0.4199	0.1230	-3.4130	0.0009	***
	13	0.3769	0.1261	2.9890	0.0033	**
	14	0.0617	0.1310	0.4710	0.6385	
	15	-0.0535	0.0830	-0.6450	0.5203	
constant	-	0.1219	0.0653	1.8670	0.0641	·

Note: the coefficient is statistically significant at a 10% level (‘·’), at 5% level (‘*’), at 1% level (‘**’), at 0.1% level (‘***’). Residual standard error: 0.3959 on 133 degrees of freedom. R-Squared: 0.9918. Adjusted R-squared: 0.99.

Equation VI-3 *System of Bivariate VAR(5) equations for CPI and EUR*

$$\widehat{CPI} = \sum_{p=1}^{5} CPI_p + \sum_{p=1}^{5} EUR_p + c$$

$$\widehat{EUR} = \sum_{p=1}^{5} CPI_p + \sum_{p=1}^{5} EUR_p + c$$

Table VI-3 *Estimation results for equation CPI and EUR in a bivariate VAR model of CPI and EUR*

Variable	Lag (p)	Estimate	Standard Error	t-value	p-value	Significance
CPI	*1*	*1.2828*	*0.0747*	*17.1800*	*< 2e-16*	***
	2	*-0.1421*	*0.1213*	*-1.1710*	*0.2434*	
	3	*-0.1562*	*0.1194*	*-1.3080*	*0.1928*	
	4	*-0.0278*	*0.1337*	*-0.2080*	*0.8353*	
	5	*0.0813*	*0.0890*	*0.9130*	*0.3627*	
EUR	*1*	*-0.0082*	*0.0057*	*-1.4440*	*0.1506*	
	2	*0.0101*	*0.0078*	*1.3020*	*0.1947*	
	3	*0.0020*	*0.0078*	*0.2570*	*0.7974*	
	4	*0.0257*	*0.0081*	*3.1980*	*0.0017*	**
	5	*-0.0245*	*0.0060*	*-4.0860*	*0.0001*	***
constant	-	*-1.6790*	*0.4640*	*-3.6190*	*0.0004*	***

Note: Residual standard error: 0.5084 on 163 degrees of freedom. R-Squared: 0.9836. Adjusted R-squared: 0.9826

Variable	Lag (p)	Estimate	Standard Error	t-value	p-value	Significance
CPI	*1*	*-0.0667*	*0.9964*	*-0.0670*	*0.9467*	
	2	*0.1135*	*1.6193*	*0.0700*	*0.9442*	
	3	*-0.9049*	*1.5933*	*-0.5680*	*0.5709*	
	4	*-0.8709*	*1.7845*	*-0.4880*	*0.6262*	
	5	*2.2139*	*1.1881*	*1.8630*	*0.0642*	•
EUR	*1*	*0.9237*	*0.0759*	*12.1750*	*< 2e-16*	***
	2	*0.1521*	*0.1037*	*1.4660*	*0.1445*	
	3	*-0.1328*	*0.1046*	*-1.2700*	*0.2060*	
	4	*-0.1742*	*0.1074*	*-1.6210*	*0.1069*	
	5	*0.2376*	*0.0800*	*2.9710*	*0.0034*	**
constant		*-2.2512*	*6.1909*	*-0.3640*	*0.7166*	

Note: the coefficient is statistically significant at a 10% level ('•'), at 5% level ('*'), at 1% level ('**'), at 0.1% level ('***'). Residual standard error: 0.5084 on 163 degrees of freedom. R-Squared: 0.9836. Adjusted R-squared: 0.9826.

Table VI-4 *Data of event window exchange rate in percentage change*

Day	Announcement Date										Average
	01-26	02-23	03-23	04-27	06-01	06-29	07-13	07-27	08-31	09-28	
-3	*0,56%*	*0,11%*	*1,14%*	*0,39%*	*0,26%*	*0,56%*	*0,56%*	*-0,12%*	*0,10%*	*0,13%*	*0,37%*
-2	*0,65%*	*0,04%*	*-0,54%*	*0,11%*	*-0,16%*	*0,12%*	*0,51%*	*0,61%*	*-0,87%*	*0,55%*	*0,10%*
-1	*-0,56%*	*-0,40%*	*-0,84%*	*1,41%*	*0,92%*	*-1,29%*	*0,16%*	*0,38%*	*-1,46%*	*-0,14%*	*-0,18%*
0	*0,33%*	*1,69%*	*1,00%*	*0,11%*	*-0,14%*	*-0,75%*	*0,73%*	*0,62%*	*-0,46%*	*1,25%*	*0,44%*
1	*-0,90%*	*1,65%*	*0,38%*	*0,03%*	*-0,64%*	*0,57%*	*-1,16%*	*0,15%*	*0,33%*	*2,08%*	*0,25%*
2	*0,39%*	*-0,68%*	*-0,66%*	*0,03%*	*-0,62%*	*0,90%*	*-1,22%*	*0,10%*	*0,03%*	*0,45%*	*-0,13%*
3	*-0,85%*	*1,71%*	*0,62%*	*1,04%*	*-1,11%*	*0,61%*	*0,11%*	*-0,81%*	*0,59%*	*-1,11%*	*0,08%*
4	*0,00%*	*1,31%*	*-2,06%*	*-0,32%*	*0,44%*	*1,28%*	*-0,84%*	*-0,69%*	*-0,18%*	*0,17%*	*-0,09%*
Average	*-0,05%*	*0,68%*	*-0,12%*	*0,35%*	*-0,13%*	*0,25%*	*-0,14%*	*0,03%*	*-0,24%*	*0,42%*	*-0,05%*

Note: the data summarised in this table is a percentage change of euro forint exchange rate in 2022 around the marked dates.
Source: BLOOMBERG, and MNB.