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ANDRÁS REZESSY

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András Rezessy*

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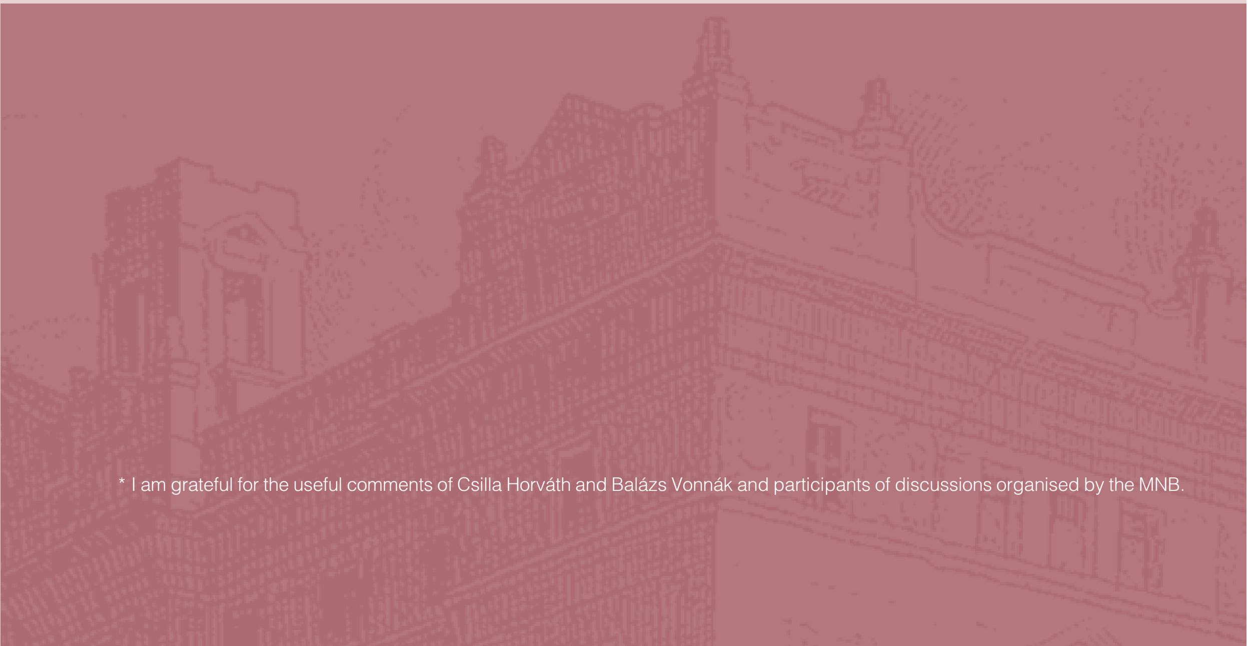

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Estimating the immediate impact of monetary policy shocks on the exchange rate and other asset prices in Hungary

(A monetáris politika azonnali hatása az árfolyamra és egyéb eszközárakra Magyarországon)

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Contents

Abstract

The paper estimates the immediate impact of Hungarian monetary policy on three classes of asset prices: the exchange rate of the forint vis-à-vis the euro, spot and forward government bond yields and the index of the Budapest Stock Exchange. The endogeneity problem is treated with the method of identification through heteroskedasticity as described by Rigobon and Sack (2004). The results suggest a significant impact on the exchange rate in one day i.e. an increase in the policy rate leads to an appreciation of the domestic currency, which is in line with the classic intuition. The effect increases markedly when the estimation is carried out with a two-day window suggesting the inefficiency of markets in incorporating monetary policy decisions in asset prices in a short period of time. Monetary policy affects spot yields positively, but the effect gradually dies out as the horizon gets longer. This can be explained with the impact on forward yields, as the results suggest a positive impact on short-term and a negative impact on long-term forward yields meaning that a surprise change in the policy rate leads to a rotation of the forward curve. The method does not provide interpretable and significant results for the stock exchange index.

JEL classification: E44, E52

Keywords: Monetary transmission mechanism, Asset prices, Exchange rate, Yield curve, Stock market, Identification, Heteroskedasticity

Összefoglalás

A tanulmány a magyar monetáris politika azonnali hatását vizsgálja három eszközár-kategóriára: a forint árfolyamára, az azonnali és forward állampapír-piaci hozamokra valamint a BUX indexre. Az endogenitás problémáját az elemzés Rigobon és Sack (2004) által leírt heteroszkedaszticitáson alapuló identifikáció módszerével kezeli. Az eredmények alapján egy meglepetésszerű kamatemelés hatására egy nap alatt az árfolyam erősödik, ami a klasszikus intuícióval összhangban áll. Ez a hatás lényegesen megnő, ha a hatást kétnapos időtávon vizsgáljuk, ami a pénzpiacok hatékonytalanságára utalhat annyiban, hogy rövid idő alatt nem teljes mértékben árazzák be a monetáris politika által okozott meglepetéseket az eszközárakba. A monetáris politika az azonnali hozamokra pozitívan hat, ám ez a hatás a lejárat hosszának növekedésével jelentősen lecsökken. Ennek oka a monetáris politika forward hozamokra gyakorolt hatásában keresendő, mivel a rövid horizonton pozitív, ám a hosszabb horizontokon egyre erősödő negatív hatást mutatnak az eredmények, vagyis egy meglepetésszerű kamatlépés a forwardgörbe elfordulásával jár együtt. Ugyanakkor a módszer nem ad értelmezhető eredményeket a BUX index esetében.

1. Introduction

Monetary policy exerts its influence on the economy through several channels, and asset prices play a major role in the propagation of changes in the monetary stance. Mishkin (2001) mentions debt instruments, the exchange rate, stock market prices and real estate prices as the major assets from the point of view of the transmission mechanism of monetary policy. In order to assess how the transmission mechanism works in reality, it is necessary first to get a picture how the central bank's decisions affect the prices of these assets. As part of the series of studies of the Magyar Nemzeti Bank on the monetary transmission mechanism, this paper analyses the immediate impact of monetary policy on three classes of asset prices: the exchange rate, market interest rates and the stock exchange index.

Theory does not provide an unambiguous answer how monetary policy affects the exchange rate. The traditional view maintains that an increase in the domestic interest rate makes domestic debt more attractive to foreign investors and generates demand for the domestic currency. In a standard uncovered interest parity (UIP) framework, an increase in the domestic interest rate implies a strengthening of the domestic currency assuming that exchange rate expectations and the risk premium are unchanged. However, there can be several factors that can complicate this relationship, some of which can even lead to a 'perverse' opposite relationship. Blanchard (2004) and Stiglitz (1999) point out that – under certain circumstances depending among others on the level of indebtedness and share of foreign financing in a country – a large increase in the domestic interest rate might result in an increase of default risk thus reducing the attractiveness of domestic debt which can lead to a weakening of the currency. In addition, Garber and Spencer (1995) describe how the dynamic hedging activity in options markets can lead to a 'perverse' effect of monetary policy on the spot exchange rate.

The theoretical predictions of the likely reaction of market interest rates to monetary policy are also mixed. Standard theories of monetary transmission suggest that monetary contraction leads to higher short-term and long-term interest rates, i.e. an upward shift in the yield curve (Mehra, 1996). Some add that because long-term rates are an average of expected future short-term rates based on the expectation hypothesis of the term structure, monetary policy has a smaller impact on long-term rates (see for instance Cook and Hahn, 1989). Other studies emphasise, however, that while monetary tightening raises short-term interest rates, it reduces expected future inflation through higher real rates on the short term and therefore expected short-term interest rates for future years decline (Mehra 1996, Romer and Romer 2000, Ellingsen and Söderström 2001). Based on the expectation hypothesis of the term structure, this can imply a negative impact on long-run rates on sufficiently long maturities provided that the impact on expected inflation is sufficiently large. Therefore the impact on long-term yields depends on the size of the reaction of short-term rates and on the impact on average expected inflation for future years.

Concerning the impact of monetary policy on stock prices, theory predicts a negative reaction, i.e. a rise in the interest rate leads to a fall in stock prices (see for instance Thorbecke, 1997 and Mishkin, 2001). In a standard stock valuation model, the value of a firm's shares is equal to the present value of its expected future net revenues. Monetary easing can therefore increase the value of the firm on the one hand by reducing the discount factor and on the other hand by increasing the firm's future nominal revenues.

Earlier studies on how Hungarian monetary policy can influence asset prices include Kiss and Vadas (2005), who examine the role of housing markets in the transmission mechanism. Vonnák (2005) uses a structural vector autoregression approach to trace the impact of monetary policy shocks on macroeconomic variables including the nominal exchange rate and market interest rate. Pintér and Wenhardt (2004) use the event study method to estimate the immediate impact on forward government bond yields. This paper uses a slightly different approach from that adopted by the latter paper, which is able to provide consistent estimates for the immediate response of the exchange rate as well, in which case the event study method fails.

The event study method is commonly used in the literature to analyse the impact of monetary policy on various asset prices. The main assumption of this approach is that if one considers a certain subsample of all observations – e.g. days of monetary policy decisions – the only important source of innovations in a given asset price is monetary policy. However, Rigobon and Sack (2004) point to the limitations of this approach which becomes especially relevant if common shocks or shocks to the asset price itself are present in the subsample chosen for the analysis. Hungarian data indicate that this is a serious problem in the case of the exchange rate, and less so in the case of yields which implies that other methods are necessary to analyse the reaction of the exchange rate.

Rigobon and Sack (2004) propose a method called identification through heteroskedasticity which can provide consistent estimates even in cases when the event study estimate is biased due to common shocks or asset price shocks. This paper uses this method to investigate how the interest rate decisions of the Magyar Nemzeti Bank affected the exchange rate of the forint vis-à-vis the euro throughout the first three years following the widening of the exchange rate band in the middle of 2001. The paper also examines the impact of monetary policy on spot government bond yields, on forward yields to assess the impact on the term structure and also on the stock exchange index.

The paper is structured as follows. Section 2 presents the theoretical considerations of identifying the impact of monetary policy and provides a brief description of the estimation method applied here. Section 3 presents the baseline results obtained with the heteroskedasticity-based method, compares those with the event study method and checks the robustness of the baseline results. Finally, Section 4 concludes.

2. Identifying the immediate impact of monetary policy shocks

When trying to estimate the response of asset prices to monetary policy steps, one encounters the problem of endogeneity of the variables. The two variables are simultaneously determined, i.e. the central bank reacts to changes in asset prices while asset prices themselves are also influenced by monetary policy decisions. Another source of endogeneity is the presence of factors that affect both variables e.g. macroeconomic news, changes in the risk premia etc. In the presence of endogeneity, the standard ordinary least squares (OLS) estimation method gives biased estimates and this necessitates the use of other techniques.

One way to identify the response of asset prices to monetary policy commonly used in the literature is the event study method. The main idea here is to use institutional knowledge and to consider only certain periods when changes in the asset price are dominated by news about monetary policy. In practice, this usually implies running an OLS regression on days of policy decisions of the central bank. This method was first used to estimate the impact of monetary policy on money market yields by Cook and Hahn (1989) in the case of US. An application of the event study method for Hungarian data is provided by Pintér and Wenhardt (2004) who find a significant impact of monetary policy shocks on forward yields up to a 3-year horizon.

Rigobon (2003) and Rigobon and Sack (2004), however, point out that the strict assumption of the event study method – i.e. that the only important source of innovations in a carefully selected subsample of all observations is news about monetary policy – may not be satisfied even in a short window of one day and the estimates obtained may be biased. They propose an alternative identification method which makes less stringent assumptions about the heteroskedasticity present in the data. Their heteroskedasticity-based estimation method can thus lead to consistent estimates even in cases when the event study method suffers from a bias.

Rigobon and Sack (2004) consider the following two-equation system to model the simultaneous relationship of monetary policy and the price of a given asset:

$$\Delta i_t = \beta \Delta s_t + \gamma z_t + \varepsilon_t \quad (1)$$

$$\Delta s_t = \alpha \Delta i_t + z_t + \eta_t \quad (2)$$

where the first equation is a monetary policy reaction function and the second one is an asset price equation. Δi_t is the change in the short-term interest rate, Δs_t is the change in the price of the given asset and z_t is a vector of common shocks. ε_t is the monetary policy shock while η_t is a shock to the asset price. The parameter of interest here is α which measures the reaction of the asset price to changes in the policy variable.

It can be shown that running an OLS regression on (2) will yield a consistent estimate only if the variance of the monetary policy shock σ_ε is infinitely large in the limit relative to the variance of the asset price shock σ_η and to the variance of the common shock σ_z. The event study method assumes that this holds if one considers only a certain subset of all observations, e.g. days of monetary policy decisions. Though in many cases this might be a plausible assumption, it may not always be the case. A further problem of this approach is that it is not possible to test the validity of these strict assumptions.

On the other hand, the heteroskedasticity-based estimator considers two subsets of observations: policy dates – which can be defined as days of monetary policy decisions – and non-policy dates – which can be defined as preceding days – and assumes that the variance of the monetary policy shock increases from non-policy dates to policy dates, while there is no systematic change in the variances of the other shocks from one subset to the other. Thus the method does not assume that only monetary shocks matter on policy dates, but rather that the relative importance of monetary shocks with respect to the other shocks increases between the two subsets. In this sense, non-policy dates are used as a control group in this approach to control for the effect of asset price shocks and common shocks on the covariance of the two variables observed on policy dates this way identifying the effect of monetary policy.

To illustrate the difference between the two approaches further, one can say that the event study method assumes that the OLS estimate is unbiased if one considers only days of policy decisions. In contrast, the heteroskedasticity-based method does not assume unbiasedness on policy days; instead it estimates α from the change in the bias that occurs between the two subsamples.

Assuming the above-mentioned structure of heteroskedasticity and that the parameters α and β are stable across the two subsets and that the structural shocks are not correlated with each other and have no serial correlation, Rigobon and Sack (2004) show that the difference of the covariance matrices of Δs_t and Δi_t calculated for the two subsamples ($\Delta\Omega$) simplifies to:

$$\Delta\Omega = \Omega^{policy} - \Omega^{nonpolicy} = \lambda \begin{bmatrix} 1 & \alpha \\ \alpha & \alpha^2 \end{bmatrix} \tag{3}$$

where:

$$\lambda = \frac{\sigma_\varepsilon^{policy} - \sigma_\varepsilon^{nonpolicy}}{(1-\alpha\beta)^2} \ . \tag{4}$$

Thus, $\Delta\Omega$ is a function of α and a parameter λ, which measures the shift in the monetary policy shock from non-policy dates to policy dates. From this, one can impose three restrictions on the change in the covariance matrix to obtain α (and λ) since there are three independent elements in this matrix.

The estimation can be implemented in two different ways: through an instrumental variables (IV) interpretation or with generalised method of moments (GMM). Though the IV approach is easier to implement, it considers only one of the three possible restrictions. Therefore this estimation method leads to three different estimates, where one is a geometric average of the other two. The GMM approach, on the other hand, takes into account all three restrictions at the same time and provides more efficient estimates. Therefore the GMM estimate provides a cross-check for the multiple estimates obtained with IV. This is useful because even though the multiple IV estimates should be asymptotically equal for a given asset, it can happen that quantitatively they are far from each other if one of the IV estimates has high standard errors. In this case, the quantitative interpretation is more straightforward and more reliable with the help of the GMM estimate.

Another useful feature of the heteroskedasticity-based approach is that it is possible to test the assumptions of the model. This can be done either with the IV method by comparing the multiple estimates using the property that these should be asymptotically equal. A rejection of the hypothesis that this holds indicates that the assumptions are not valid. It is also possible to test the assumptions in the GMM approach. Since we impose three restrictions on the matrix in (3) and estimate only two parameters (α and λ), the system is overidentified and the standard test of overidentifying restrictions can be applied for this purpose. A significant overidentifying test statistic implies that the assumptions of the model are not valid.

3. Empirical application

3. 1. Data

The paper analyses the impact of monetary policy on the exchange rate of the forint vis-à-vis the euro, on spot government bond yields with maturities of 1, 5 and 10 years, on forward yields 1, 5 and 10 years ahead and on the index of the Budapest Stock Exchange (BUX). The spot yields are the benchmark yields published daily by the Government Debt Management Agency Ltd., while the forward yields are estimates made by the MNB using the yield-curve estimation method developed by Svensson (1994). The data are represented as first differences of daily observations, with the exchange rate and the stock index treated as logarithmic differences. Thus, what is measured here is the impact of monetary policy in one day[1].

Policy dates include days of rate-setting meetings of the Monetary Council of the Magyar Nemzeti Bank, while non-policy dates are the preceding working days. Because of the variations in the timing of the variables, the data series are corrected in a way that the observations for policy dates contain the information from the central bank's decisions. The sample covers the period August, 2001 – November, 2004 and contains 160 observations: 80 dates of Monetary Council meetings and 80 non-policy dates. The sample includes the regular meetings of the Monetary Council, which took place every second week until July, 2004 and once every month since then, and also includes four irregular meetings.

[1] The section examining the robustness of the results presents estimations with a two-day window. One could perform the estimation for longer windows measuring the effect of monetary policy on a longer horizon. However, there is a tradeoff here as in a longer estimation window it is less likely that the importance of policy shocks rises sufficiently for the model's assumptions to be satisfied.
The time-frame of the measured effect is not exactly one day, because different variables are recorded at different hours of the day and the timing of the publication of the central bank's interest rate decision varies in the sample. For instance, the exchange rate and the benchmark yields are collected around 15-30 minutes after the publication of the central bank's decision in a large part of the sample, while forward yields are collected the following morning except in the case of irregular meetings of the Monetary Council.

The analysis focuses on unanticipated moves of the central bank, which take financial markets as a surprise[2]. This is captured by the change in the three-month benchmark yield, as it is assumed to change only as much as the central bank's move represents a surprise to the market. Approximating the surprise element of policy rate changes with three-month yields also has the advantage that they are less likely to be influenced by the uncertainty regarding the timing of the central bank's action. It is worth noting that with this approach, keeping the central bank's policy rate unchanged can also represent a surprise to the market which would then be reflected in a change in the short-term yield. In the paper, the term 'policy rate' refers to this approximation of the surprise element.

Since the estimation method is based on the change in the variance/covariance structure of the data from one subsample to the other, it is worth analysing this structure. As can be seen in Table 1, the variance of the policy rate is more than twice as high

Table 1

Variances of the variables and their correlations with the policy rate[3]

	Variances		Correlations with policy rate	
	Non-policy	Policy	Non-policy	Policy
Policy rate	0.14	0.33	n.a.	n.a.
HUF/EUR	0.47	0.66	0.28	-0.09
1Y BMK	0.20	0.27	0.90	0.94
5Y BMK	0.17	0.16	0.76	0.72
10Y BMK	0.11	0.11	0.75	0.57
1Y FW	0.20	0.29	0.55	0.62
5Y FW	0.19	0.16	0.00	-0.40
10Y FW	0.28	0.23	0.31	-0.42
BUX	1.07	1.41	-0.07	-0.15

[2] See Vonnák (2005) for a discussion on the importance of focusing on the surprise element of the central bank's actions in analysing the transmission mechanism of monetary policy. In addition, Kuttner (2001) emphasises that only surprise elements of monetary policy decisions have an impact on market interest rates.

[3] Where HUF/EUR denotes the exchange rate, BMK the spot benchmark yields for the relevant maturities, FW the forward yields with the relevant starting dates and BUX the stock exchange index.

on policy dates as on non-policy dates, which is in line with the assumption that the importance of monetary policy shocks is higher on policy dates.

The correlation structure of the exchange rate shows a positive co-movement with the policy rate on non-policy dates – suggesting that a rise in the short-term interest rate is associated with a depreciation of the forint – whereas the relationship is slightly negative on policy dates[4]. The positive relationship on non-policy dates can be the result of common shocks such as changes in the risk premia or macroeconomic news, which are likely to affect the exchange rate and the short-term interest rate in the same direction. On policy dates, however, when the importance of monetary shocks increases substantially while other shocks are still present, the co-movement becomes slightly negative, which may imply that monetary policy affects the exchange rate negatively. From this correlation structure, one would expect a negative coefficient for the estimate of α in the case of the exchange rate.

This change in the correlations is also visible on the scatter plots of the two variables for the two subsamples in *Figure 1 and 2*. The positive relationship is clearly visible on non-policy dates, while there is a much less discernible direction on policy dates.

Each observation plotted on the graphs can be interpreted as an intersection of the asset price curve and the monetary policy reaction function curve. These intersects are moving because shocks are continuously hitting both curves. If it is almost exclusively the monetary policy curve that is being hit by monetary shocks while the asset price curve is stable and there are no common shocks – that is the assumptions of the event study method are fulfilled – the intersects will be close to the asset price curve. However, the apparently strong role of common shocks in the case of the exchange rate suggests that this may not hold on policy dates and the slope coefficient α estimated with OLS for this subsample will suffer from a positive bias.

On the other hand, given that there is a substantial increase in monetary policy shocks between the two subsamples, the cloud of the intersections of the two curves will be rotated towards the monetary policy curve from non-policy dates to policy dates. As mentioned earlier, the heteroskedasticity-based method estimates α from the change

[4] A rise in the value of the exchange rate variable represents a depreciation of the forint against the euro.

Figure 1

Scatter plot of the exchange rate and the policy rate on non-policy dates

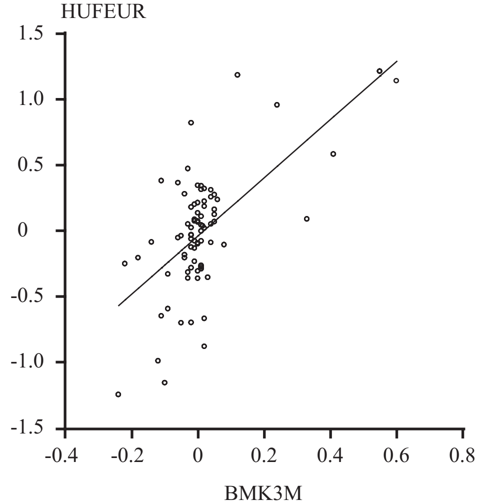
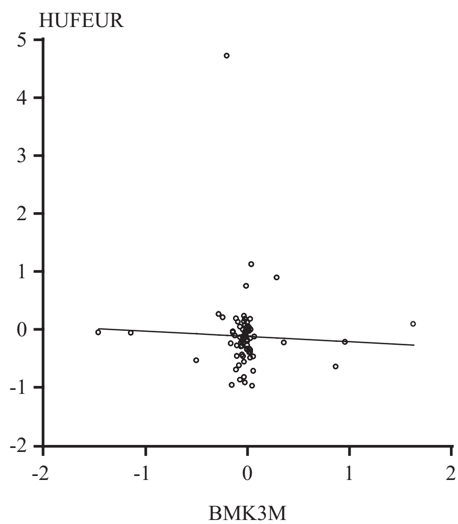


Figure 2

Scatter plot of the exchange rate and the policy rate on policy dates



in the size of the bias, which in this context appears as the rotation of the cloud of realisations. Thus, the correlation structure of the exchange rate suggests that the heteroskedasticity-based method may provide a better estimate of α than the event study method in the case of the exchange rate and also that the difference between the two may be substantial.

The correlations of the benchmark yields with the policy rate show a positive co-movement on non-policy dates which increases on policy dates. This may suggest some role of certain common shocks which push the two variables in the same direction even on non-policy dates. It also suggests that, contrary to the case of the exchange rate, monetary policy might affect the 1-year benchmark yield positively. The correlations of the benchmark yields at longer horizons show a similar structure. Based on this correlation structure, one would expect a much smaller difference between the two estimation methods for the benchmark yields.

Regarding the forward yields, one can find a structure similar to that of the benchmark yields at the short horizon, while the correlation structure of the 5 and 10 year forward yields are more similar to that of the exchange rate. The BUX index shows a negative co-movement for both subsamples which increases substantially for the policy dates.

Figure 3

Scatter plot of the 1-year benchmark rate and the policy rate on non-policy dates

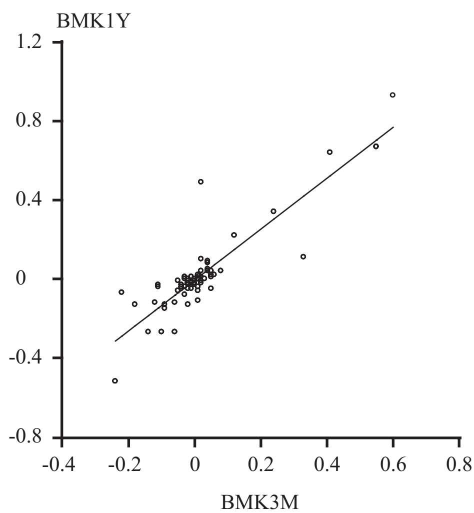
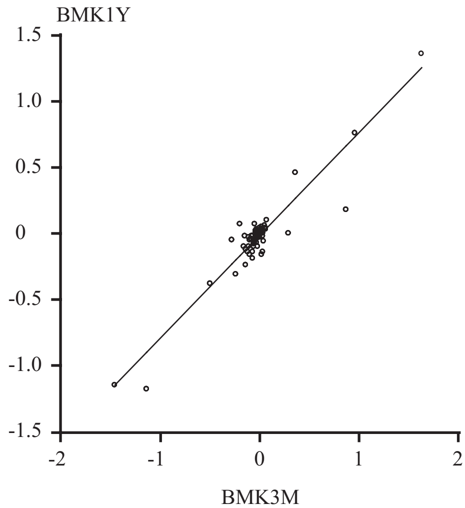


Figure 4

Scatter plot of the 1-year benchmark rate and the policy rate on policy dates



3. 2. Results of the heteroskedasticity-based method

The paper applies both ways of implementation of the heteroskedasticity-based estimation method: the IV and the GMM approach. The estimation is implemented on a joint set of policy dates and non-policy dates for each asset. The instrument for the IV estimation is based on a transformation of the policy rate where the instrument is equal to the policy rate with a positive sign on policy dates and with a negative sign on non-policy dates. For a proof why this is a valid instrument and why it really leads to estimating α from (3), see Rigobon and Sack (2002). The IV estimation can also be carried out with an instrument obtained with a similar transformation of the asset price variables. The coefficients thus obtained are not significantly different from the ones reported here (except for the ten-year forward yield), though they show much higher standard errors.

The IV estimation can be carried out with a standard single-equation two-stage least squares (TSLS) method. In this case, the asset price variable is regressed on the policy rate separately for each asset using the relevant instrument. Alternatively, the estimation can be carried out in a system including all the individual asset price equations using three-stage least squares (3SLS). The latter one is usually preferred as it is more efficient. However, the coefficients obtained with the two IV methods are almost identical and the improvement in efficiency is marginal, therefore only the 3SLS results are reported here. Since the efficiency gain from estimating in system is negligible as compared to single equations in the case of the IV method, the GMM method is carried out only in single equations. A formal description of the implementation of the GMM method is provided in Rigobon and Sack (2004).

As can be seen in *Table 2*, the coefficients are significant with both methods except in the case of the BUX index. The coefficients obtained with IV and GMM are close for all variables except for the stock exchange index. This is important because the two estimations should yield asymptotically equal results provided that the assumptions of the model are satisfied. The overidentifying restrictions are in line with the fact that only the BUX shows strongly different coefficients with IV and GMM. The significant overidentifying test statistic for the BUX index implies that the model's assumptions are not

Table 2

The results of the instrumental variables and generalised method of moments estimations

	IV		GMM			
	Coefficient	Std. error	Coefficient	Std. error	Overid. restr.	t-stat. of λ
HUF/EUR	-0.60*	0.28	-0.54*	0.21	1.93	3.5*
1Y BMK	0.66*	0.05	0.70*	0.05	3.05	4.17*
5Y BMK	0.21*	0.06	0.26*	0.04	1.75	4.54*
10Y BMK	0.10*	0.04	0.11*	0.03	0.07	3.88*
1Y FW	0.48*	0.09	0.55*	0.08	2.25	3.76*
5Y FW	-0.24*	0.08	-0.25*	0.08	2.92	3.41*
10Y FW	-0.50*	0.12	-0.39*	0.12	2.56	4.61*
BUX	-0.68	0.56	-20.10*	9.41	12.65*	1.13

** Significant at 5% level.*

satisfied in this case, while the overidentifying restrictions cannot be rejected for any of the other variables.

The heteroskedasticity-based method shows a negative coefficient for the exchange rate. It implies that a 50 basis-point surprise rate hike results in an immediate 0.27-0.30 percent appreciation of the forint. Thus, the results show no evidence of the presence of a 'perverse' effect of monetary policy on the exchange rate, the direction of the impact is in line with the classic intuition. Though it is not possible to test the UIP hypothesis with this method due to the lack of high-frequency data on exchange rate expectations, if one assumes that these expectations do not react to changes in the policy rate, the result is in line with the UIP condition.

Considering benchmark yields, the results indicate that monetary policy has a positive impact on spot government bond yields. A 50 basis-point surprise increase of the central bank's policy rate leads to a 33-35 basis-point rise in the 1-year benchmark yield and this effect reduces to around 10 and 5 basis points for the 5 and 10-year yields respectively. This is in line with the intuition and implies that monetary policy can affect short-term yields – with a positive sign – but has a much more limited impact on long-term yields. The effect of monetary policy almost dies out at the ten-year horizon. The structure of the impact of monetary policy on forward yields helps explain this phenomenon.

The estimated impact of monetary policy on the 1-year forward yield is close to that on the 1-year benchmark yield; it is only slightly below the latter one. On the other hand, an unexpected 50 basis-point rate-hike results in a 12 basis-point fall in the 5-year, and a 20-25 basis-point fall in the 10-year forward yield. In other words, monetary policy affects the short end of the forward yield curve positively and has a negative impact on the longer end of the curve, which increases with maturity. Thus, the results suggest that an unanticipated change in the policy rate leads to a rotation of the forward curve. Based on the expectation hypothesis of the term structure, this implies that the impact of monetary policy on spot yields diminishes gradually as the maturity increases.

The result suggesting a rotation of the forward curve in response to monetary shocks is in line with the insight from the literature that emphasises the role of expected future inflation in long-term forward yields. As these yields can be interpreted as the market's expectations for the future short-term interest rates, the results indicate that a surprise central bank rate-hike leads to an increase in the short-term horizon and a decrease in the long-term horizon of the expected future path of short-term interest rates. The explanation of this can be that a surprise increase in the policy rate may signal a reinforced commitment of the central bank to its mandate of achieving and maintaining price stability allowing lower interest rates in the long-run with the help of higher interest rates temporarily in the short-run. This may have been an important factor in the years following 2001, when the central bank started an inflation targeting regime with the aim to help fulfil its mandate.

As mentioned earlier, the highly significant overidentifying test statistic for the BUX implies that the model's assumptions are not satisfied in this case and therefore these results are not interpretable. The reasons for this can be that the parameters, α, β or the shocks to the BUX index or the common shocks show instability between the two subsamples.

3. 3. Comparison of the event study and the heteroskedasticity-based methods

Rigobon and Sack (2004) also construct a hypothesis test with which it is possible to test formally whether the results obtained with the event study method are biased. *Table 3* compares the results of the GMM and event study methods and presents the biasedness tests[5].

A quick comparison of the coefficient estimates reveals that the two methods give similar results for spot and forward yields. The event study approach produces significant coefficients for these variables just as the GMM, and the differences between the coefficients are usually at the second decimal. On the other hand, the event study method fails to give a significant coefficient for the exchange rate, as the parameter obtained is strongly below the GMM estimate in absolute value. This difference in the size of

[5] The biasedness tests comparing the event study and the IV estimates mainly lead to the same conclusions and therefore they are not reported.

Table 3

Comparison of the event study and the heteroskedasticity-based methods

	Event study		GMM		Biasedness test
	Coefficient	Std. error	Coefficient	Std. error	
HUF/EUR	-0.09	0.22	-0.54*	0.21	-38.36*
1Y BMK	0.78*	0.03	0.70*	0.05	4.98*
5Y BMK	0.35*	0.04	0.26*	0.04	14.74*
10Y BMK	0.19*	0.03	0.11*	0.03	54.85*
1Y FW	0.53*	0.08	0.55*	0.08	0.25
5Y FW	-0.19*	0.05	-0.25*	0.08	0.79
10Y FW	-0.30*	0.08	-0.39*	0.12	0.79
BUX	-0.65	0.48	-20.10*	9.41	4.28*

bias for the exchange rate and for interest rates can be explained with the different correlation structures as outlined in section 3.1.

The GMM-based result shows that the unbiased coefficient is strongly negative for the exchange rate. However, there was indication of a strong presence of common shocks which presumably push the policy rate and the exchange rate in the same direction thereby reducing the negative impact of monetary policy even on policy dates. As the event study method ignores this issue, the result obtained with this approach is biased upwards and thus it gets close to zero. The biasedness test provides strong evidence that the event study approach gives a biased result in the case of the exchange rate.

In the case of the benchmark yields, the tests indicate that the event study results are biased, though they are quantitatively closer to the GMM coefficients than in the case of the exchange rate. The event study estimates exceed the GMM values for all the benchmark variables which can again be the result of common shocks ignored by the former method.

Finally, forward yields represent the only asset class, where the biasedness tests cannot reject the hypothesis that the event study method provides unbiased estimates.

For long-term forward yields – as their coefficients are negative similarly to that of the exchange rate – the event study results are smaller in absolute value than the GMM results, but the size of the bias is small therefore the coefficients remain significant. It is worth noting that in this case, the event study approach is more efficient than the heteroskedasticity-based method.

3. 4. Robustness

There are several aspects from which the robustness of these results can be checked. The stability of the coefficients in time is assessed by performing the estimations on a smaller time-frame: from August, 2001 until December 2002. The reason why this sub-period is especially interesting is that it excludes the year 2003, in which Hungarian financial markets experienced several episodes of extreme turbulence. As *Table 4* shows, the results for the spot and forward yields obtained for this period are similar to the baseline estimation, but there is a slightly positive but insignificant coefficient for the exchange rate. This could imply that only the large changes in the policy rate –

Table 4

Results for the period August, 2001- December, 2002

	IV		GMM			
	Coefficient	Std. error	Coefficient	Std. error	Overid. restr.	t-stat. of λ
HUF/EUR	0.32	0.34	0.10	0.11	5.29*	2.07*
1Y BMK	0.94*	0.06	1.03*	0.02	6.63*	1.92
5Y BMK	0.34*	0.05	0.33*	0.03	3.76	1.98*
10Y BMK	0.17*	0.04	0.16*	0.02	1.33	2.09*
1Y FW	0.77*	0.11	0.83*	0.06	6.49*	2.33*
5Y FW	0.02	0.09	0.04	0.04	4.49*	2.27*
10Y FW	-0.14	0.20	-0.13	0.07	1.20	2.17*
BUX	-1.72	1.27	-1.24	0.28	11.73*	2.10*

which were associated with the turbulent episodes of 2003 – have had a significant impact on the exchange rate. However, caution is necessary when interpreting these results as the methods applied are asymptotic estimations and therefore require large samples. The fact that the sample is much smaller may explain some of the differences as compared to the baseline estimation.

To investigate the importance of large moves in the policy rate, the estimation is also implemented on the entire sample with the exclusion of these observations[6] (*Table 5*). The coefficients for the benchmark and forward yields are similar to the baseline estimation, however the assumptions of the model are not satisfied in many cases. The t-statistics for the λ coefficients are considerably lower than in the baseline estimations. A possible reason for this can be that the exclusion of the largest monetary policy steps renders the rise in the variance of policy shocks insufficient to reach identification in some cases which can be one factor behind the breakdown of the model. On the other hand, the model's assumptions are sat-

Table 5

Results for the entire sample excluding large changes in the policy rate

	IV		GMM			
	Coefficient	Std. error	Coefficient	Std. error	Overid. restr.	t-stat. of λ
HUF/EUR	-0.81	0.94	-1.01	0.59	0.62	1.85
1Y BMK	0.42	0.24	0.77*	0.09	4.66*	2.94*
5Y BMK	-0.24	0.34	0.37*	0.05	8.09*	2.00*
10Y BMK	-0.06	0.20	0.10	0.07	2.10	1.81
1Y FW	0.03	0.41	-0.58	0.79	0.11	2.40*
5Y FW	0.23	0.32	-0.20	0.21	11.12*	2.51*
10Y FW	-1.03	0.58	0.03	0.20	4.97*	1.67
BUX	-5.13	2.66	2.33	5.16	14.24*	-0.69

[6] The excluded observations are days on which the central bank changed the base rate by at least 100 basispoints. There are altogether 6 such occasions in the sample.

isfied for the exchange rate, the λ coefficient is weakly significant and both heteroskedasticity-based methods give a negative coefficient larger than the baseline results. While the coefficient obtained with 3SLS is insignificant, the GMM result is weakly significant providing weak evidence that small monetary policy steps can also have an impact on the exchange rate, which in fact may be somewhat greater than the impact of large steps.

Finally, I also check whether the results change when the estimation is carried out with a two-day data window[7]. As can be seen in *Table 6*, there is a marked difference for the exchange rate, as the coefficients obtained for two days are around 3-6 times higher than the result with a one-day window. This large difference can be interpreted as a failure of the model to provide stable coefficients. Another and perhaps more realistic explanation can be the inefficiency of financial markets as it takes time for

Table 6

Results obtained with a two-day data window

	IV		GMM			
	Coefficient	Std. error	Coefficient	Std. error	Overid. restr.	t-stat. of λ
HUF/EUR	-3.62	1.95	-1.74*	0.51	1.49	2.69*
1Y BMK	0.24	3.20	0.18	0.19	0.03	2.42*
5Y BMK	0.08	0.40	-0.04	0.12	3.45	2.47*
10Y BMK	-0.72	0.51	-0.15	0.09	2.36	2.36*
1Y FW	-0.57	0.36	0.46	0.12	11.49*	3.09*
5Y FW	-0.65	0.63	-0.19*	0.11	4.15*	1.85
10Y FW	-0.41	0.32	1.20	1.05	5.38*	-1.24
BUX	-0.68	0.41	-1.23	1.16	1.44	1.45

[7] There is a technical difficulty in the implementation here because there are two occasions in the sample when two policy decisions took place on consecutive days. As it is impossible to define policy and non-policy dates in a two-day window without overlaps in these two occasions, these observations are omitted from the sample.

market participants to fully adjust to monetary policy shocks[8]. The GMM estimate is strongly significant and the very low overidentifying test statistic for the exchange rate supports the validity of this result. It is close to the result of Vonnák (2005) stating that a 25 basis-point rate-hike results in a 1 per cent immediate appreciation of the nominal exchange rate on quarterly data.

On the other hand, the coefficients for spot yields are smaller than the baseline results and suggest no significant impact of monetary policy on yields in a two-day window. It would be interesting to see what kind of response in the term structure lies behind this, but the method provides no interpretable results for forward yields. Nonetheless, the point estimates of spot yields' reactions show a similar structure to the baseline results, i.e. there is a positive impact on the short horizon which falls as the horizon increases. An interesting result is that the coefficients become slightly negative for long-term spot yields. This can be partially explained by the small response of the short end of the curve and highlights again the importance of inflation expectations for long-term interest rates.

An interesting feature of the two-day results is that the model gives a valid result for the BUX index. The coefficient is negative, in line with the theoretical prediction, though it is not significant. This result indicates that monetary policy in Hungary does not have a substantial influence on the stock exchange index.

[8] It is important to note, however, that the data for the exchange rate and benchmark yields are collected some 15-30 minutes after the publication of the central bank's decision in a large part of the sample. Thus, what the results show is that markets fail to incorporate fully the innovation from the central bank's decision in the exchange rate in such a short time-frame.

4. Conclusion

The paper estimates the immediate impact of Hungarian monetary policy on three classes of asset prices: the exchange rate of the forint vis-à-vis the euro, market interest rates and the stock exchange index. The endogeneity problem – which stems from the simultaneous relationship of monetary policy and asset prices and from the presence of common shocks – is treated with the method of identification through heteroskedasticity as described by Rigobon and Sack (2004).

The results obtained with the heteroskedasticity-based method support the validity of the classic impact of monetary policy on the exchange rate for Hungary for the period 2001-2004. There is evidence of a significant negative impact on the exchange rate in one day suggesting that a 50 basis-point surprise increase in the policy rate causes 0.3 percent appreciation. This negative effect increases by around 3-6 times when the estimation is carried out with a two-day window suggesting the inefficiency of markets in incorporating monetary policy decisions in asset prices in a short period of time. Though it is not possible to test the UIP hypothesis with this method due to the lack of high-frequency data on exchange rate expectations, if one assumes that these expectations do not react to changes in the policy rate, the results are in line with the UIP condition.

The results provide evidence that monetary policy affects spot yields positively, but this effect gradually dies out as the horizon gets longer. This can be explained with the impact on the term structure of the yield curve, as the results suggest a positive impact on short-term and a negative impact on long-term forward yields implying that a surprise change in the policy rate leads to a rotation of the forward curve. The minor impact on long-term spot yields and the negative impact on long-term forward yields are in line with the insight provided among others by Romer and Romer (2000) and Ellingsen and Söderström (2001) who emphasise that the reaction of long-term yields to monetary policy depends strongly on the impact of the monetary policy shock on expected future inflation.

In the baseline estimation, the method does not provide interpretable results for the stock exchange index. When the estimation is carried out with a two-day data window, the method provides a valid result: a negative but insignificant coefficient. The sign is in line with the intuition, which suggests that monetary contraction leads to a fall in the stock index. However, the insignificant coefficient indicates that this impact is not substantial in Hungary.

The significant negative coefficient for the exchange rate shows robustness in several alternative estimations. In these estimations, the results for spot yields follow a similar pattern as in the baseline case with a positive response declining gradually as the horizon increases, though there is less information in this case as the method does not produce valid results in many cases. There is very little information about the robustness of the results for forward yields, since the model usually does not provide interpretable results in the robustness checks for this variable. Indirect evidence is available though, as the declining tendency of the response of spot yields suggests a very low, possibly negative impact on long-term forward yields in all alternative estimations.

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