

Deep dive into beggar-thy-neighbour effects of monetary policy spillovers

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ABSTRACT

We analyse the effect of the European Central Bank's (ECB) monetary shock spillover and its impact on the European Union's 9 countries outside the euro area (EA) between 2000 and 2020. We use the sign-restricted Bayesian VAR model and subsequent interpretation by plotting the impulse-response functions. Moreover, we investigate both conventional and unconventional monetary policies and its international transmission. The spillover of monetary policy is growing with the openness of economies and the ongoing deepening of integration. The output responds to the EA's monetary shock flexibly and persistently, but there is considerable heterogeneity across countries. We claim that it is essential for central banks outside the EA to monitor and incorporate the ECB's monetary policy spillover into decision-making processes. In particular, the international transmission of the unconventional monetary policy has a fundamental effect on the development of the price level, thus achieving price stability. In the case of implementing a counter-cyclical policy, it is also necessary to monitor conventional policy. However, there is no need to fight the spillover effect since there is no *beggar-thy-neighbour* problem, i.e., spillover effect works in the same direction in both domestic and foreign country.

KEYWORDS

spillover effect, monetary policy, monetary transmission, BVAR, sign-restricted VAR

JEL CLASSIFICATION INDICIES

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1. INTRODUCTION

Although economists have known the monetary policy spillover since the 18th century, it is becoming increasingly important today due to economies' interconnectedness. Given that the European Union (EU) is by far the most interconnected integration group globally, it is reasonable to assume that monetary spillovers play an essential role in these countries. The European Central Bank's (ECB's) monetary policy affects the variables in the euro area (EA) and other countries of the EU. Thus, in their monetary policy implementation, the EU's monetary authorities must also consider the conduct of monetary policy by the ECB.

International monetary policy spillovers can occur through several channels. The main channel of foreign monetary shock spillover characterizes the international trade and the exchange rate, for example in the Mundell-Flemming-Dornbusch model (Mundell 1960; Fleming 1962; Dornbusch 1976), that is the *trade* channel spilling monetary shock. According to Svensson – van Wijnbergen (1989), the overall effect of international transmission can be positive or negative. It will depend primarily on the intertemporal elasticity of consumption substitution for goods that are substitutes and on the intratemporal elasticity of consumption substitution for complements. According to Potjagailo (2017), another possibility of a spillover of foreign monetary policy is its *financial* channel, the reason is increasing financial integration between countries. If a foreign country is a large and globally significant economy, its monetary policy tightening will increase world interest rates (Svensson – van Wijnbergen 1989; Galí – Monacelli 2005).

This exogenous shock affects all world economies, the money supply's growth in a foreign economy leads to an outflow of capital from this country to the domestic economy, whose currency will strengthen. The trade balance of the domestic country is deteriorating, and the demand for its goods is declining. Thus, its competitiveness is declining. After easing monetary policy in a foreign country, domestic output and employment decline. The spillover of foreign monetary expansion is leading to the impoverishment of the domestic country. This phenomenon is referred to in economic theory as *beggar-thy-neighbour*. The easing of monetary policy in the large monetary area should lead to growth in exports, employment and real output at the neighbouring countries' expense.

In this paper, we calculate the ECB's spillover effect in 9 non-euro countries of the EU. We divide those countries into three groups based on their economic characteristics. We consider Denmark (DK), the United Kingdom (UK) and Sweden (SE), as the old member economies (OME); Bulgaria (BG), the Czech Republic (CZ) and Hungary (HU) as the new member *open* economies (NMOE); and Croatia (HR), Poland (PL) and Romania (RO) as the new member *closed* economies (NMCE). Data covers the period from 2000 to 2020. Our preferred method of estimation is a sign-restricted vector autoregressive model (SRVAR) using the maximum likelihood (ML) method. The procedure is based on the rejection method (Uhlig 2005, 2017), and Bayesian VAR models are then analysed by obtaining median impulse and response selections and plotting them at specified confidence intervals. The Bayesian approach (BVAR) is preferred because it is a computationally simple and pure method of creating a tolerance band for the analysis of response functions (Sims – Zha 1999).

We add some new insights to the existing literature on the spillover effect. First, we deal with the price puzzles using sign restrictions in our VAR models. To avoid distortions, we do not impose them directly on the prices, but we restrict output only. Therefore, our models' only presumption is that ECB's monetary restriction decreases the EA's output. The second innovation is that we use regular interest rates to capture conventional monetary policy and shadow



rates (Wu – Xia 2016) to capture unconventional monetary policy. This approach allows us to compare the different impacts of various policy instruments on the economy. Finally, we distinguish these impacts in various types of economies based on their characteristics.

We then derive some general implications of our findings. First, the most significant spillover effect occurs in NMOEs. Surprisingly, the spillover effect is more potent in OMEs than in NMCEs. Also, the spillover effect is most evident in output. On the other hand, the real exchange rate seems not to react at all in most countries. A key finding is that there is no problem with *bagger-thy-neighbour* within the EU, and the monitored economies are responding to the shock in the same direction. The decline in economic activity in the EA, in response to the tightening of monetary policy, also leads to a slowdown in economic activity and trade in financially interconnected countries. The growth of openness, but also the ongoing integration, is leading to a growing spillover effect. Deepening economic integration towards a single monetary policy would then be particularly beneficial for the OME countries. On the other hand, for the NME countries, involvement in the single monetary area could prevent the destabilizing impact of international transmission shock.

The non-EA central banks need to monitor and incorporate the ECB's monetary policy spillover into decision-making processes. In particular, the international transmission of unconventional monetary policy has a fundamental effect on the development of the price level, thus achieving price stability. In the case of implementing the counter-cyclical stabilization policy, it is also necessary to follow the conventional policy. However, it is not always appropriate to fight by a solid opposing domestic monetary policy against monetary policy spillovers. Georgiadis (2015) demonstrates that states' efforts to prevent international transmission of monetary policy can negatively impact long-term economic growth. Therefore, it is more advantageous for the monitored countries to join the single monetary area. Our results show that central banks in the OME countries are already following ECB's policy implementation.

The paper's outline is as follows: In *Section 2*, we describe the general theoretical framework. *Section 3* presents SRVAR models, our empirical model, and data. *Section 4* illustrates and discusses the estimation results and contains further extensions of our model. *Section 5* concludes.

2. THEORETICAL BACKGROUND OF SPILLOVER EFFECT

2.1. International spillover effect theory

The foundations of monetary policy spillovers were laid in the 18th century by the philosopher and economist David Hume (1741). Hume's law and the price of (automatic) balance of payments adjustment mechanism are particularly important for international monetary policy. The idea that a surplus of exports leads to an inevitable inflow of money from other trading countries underlies Hume's law. The growing money supply in each country leads to an increase in the price level and a consequent decline in domestic goods' competitiveness. A decline in exports and an increase in imports of foreign goods will offset the whole system. We cannot conduct a monetary policy entirely autonomously, regardless of other international trade participants, who are also heavily affected. Also, Hume's law faces several limitations, and we can only use these findings primarily to assess the trade channel of monetary policy spillovers.



During the 20th century, there was an increased interest in monetary policy spillover, but the approaches differ significantly. The first branch of economists deals with the theoretical definition of the channels of international monetary policy transmission. The second branch then focuses on the overall impact of monetary policy spillovers and the discussion of monetary policy cooperation across the global spectrum. The end of the Great Moderation period is the peak of research into monetary policy's international transmission. In recent years, there has been a growing interest in this issue, mostly from central banks in developing countries, facing large monetary areas' economic policy (ter Ellen et al. 2020). Engel (2016) argues that research on international monetary policy transmission subsequently leads to closer cooperation between central banks. The result of cooperation between central banks can then lead to the integration into the single monetary area. The advantage is higher resistance to foreign monetary shocks. Dornbusch et al. (2011) add that there is a close link between spillovers and overall interdependence.

Potjagailo (2017) argues that the traditional model that also focuses on international transmission is the Mundell-Flemming-Dornbusch Model (Mundell 1960; Fleming 1962; Dornbusch 1976). The main channel of spillover here is the international trade and the exchange rate. The initial situation is a monetary restriction abroad and the subsequent spillover of this exogenous shock to the domestic country's economy. After the monetary restriction, the decline in output and aggregate expenditures abroad is relatively flexible. The demand for imports, which is an induced quantity, also cools down – the open domestic economy is affected, and net exports and overall output in that country are declining (Dornbusch 1980). Subsequently, however, it is necessary to distinguish between open economies with flexible and fixed exchange rates. The decline in net exports is putting downward pressure on the domestic currency. In the case of a floating exchange rate, nothing prevents this weakening. Thus, competitiveness is growing, and the trade balance is improving again. However, Potjagailo (2017) adds that the overall effect of the foreign shock spillover in the case of a floating exchange rate is not apparent. An important factor is the economy's overall openness and substitution elasticity between domestic and foreign goods.¹

However, if a monetary shock recipient has decided to maintain a fixed exchange rate, the domestic central bank also responds by tightening monetary policy to prevent the currency from weakening (Dornbusch 1980). Therefore, the decline in output is permanent, and the domestic economy moves in the same way as the foreign countries. Dornbusch et al. (2011) add, however, that in the long-run, the domestic country will, in both cases, return to its potential output regardless of the magnitude of the foreign exogenous shock.

2.2. Can the ECB beggar its neighbours?

According to Potjagailo (2017), another possibility of a spillover of foreign monetary policy is its financial channel. This exogenous shock affects all world economies, regardless of their business activities. Svensson – van Wijnbergen (1989) state that the money supply's growth in a foreign economy leads to an outflow of capital from this country to the domestic economy, whose

¹According to Svensson – van Wijnbergen (1989), the overall effect of international spillovers can be positive or negative. It will depend primarily on the intertemporal elasticity of consumption substitution for substitutes and also the intratemporal elasticity of consumption substitution for complements.



currency will strengthen. The trade balance of the domestic country is deteriorating, and the demand for its goods is declining. Thus, its competitiveness is declining. Also, the expansion of monetary policy in the foreign economy leads to a decline in world interest rates. Given the Mundell-Flemming-Dornbusch model's assumption that domestic and global interest rates are equal (perfect mobility of capital), domestic interest rates will also fall. In the new equilibrium, the domestic money market requires a decline in output. After easing monetary policy in a foreign country, domestic output and employment decline. The spillover of foreign monetary expansion is leading to the impoverishment of the domestic country. This phenomenon is referred to in economic theory as *beggar-thy-neighbour*. The easing of monetary policy in the large monetary area should lead to growth in exports, employment, and real output at the neighbouring countries' expense.

The purpose of this article is to answer the question whether the ECB is begging its neighbours or not. If beggar-thy-neighbour is to occur, it would mean that the ECB's expansionary (restrictive) policy would lead to a decline (growth) in output in countries outside the eurozone. In trying to answer this question, the situation is further complicated by the fact that the ECB also pursued unconventional monetary policy during the period under review. If we were only looking at how the output of neighbouring countries responds to the ECB interest rates, this fact would remain hidden.

2.3. Literature review

The EA is a major monetary area, where there may be a significant spillover of monetary policy to the neighbouring countries. Also, these countries outside the EA are often members of the EU, and there is cooperation of economic policies among them. However, many studies focus on the ECB's internal transmission mechanism only in the common monetary area.² The reason for greater interest may be that the EA consists of many diverse countries and that it is very challenging for the ECB to choose a monetary policy that suits all member states. It is therefore essential to first identify the effects of internal transmission.

Nevertheless, there has been a growing interest in analysing the cross-border transmission mechanism and the ECB's monetary shocks spillover effect in recent years. The study of specific channels is getting attention. For example, [Moder \(2019\)](#) focuses on the countries of Southeast Europe. The results show that the transmission of monetary shocks occurs mainly through mutual trade and export activity. Interest rates play a more significant role in only a small number of the countries surveyed. According to [Potjagailo \(2017\)](#), a more significant spillover of interest rates occurs mainly in the Central and Eastern European countries. The ECB's expansionary monetary policy boosts the output of these countries' economies and lowers interest rates.

[Kucharcukova et al. \(2016\)](#) divide the ECB's initial monetary shock into conventional and unconventional parts by constructing monetary condition index. Conventional policies affect inflation and the output of economies in the same way as the EA member states. The spillover of the unconventional monetary policy shock is significant and rapid, especially at exchange rates. The impact on the real economy is slower and limited. Inflation is not affected by the ECB's

²[Peersman \(2004\)](#) debates on the monetary policy processes within the EA. In recent years, there has been a growing interest in analyzing the impact of the ECB's unconventional monetary policy and its penetration in the EA.



unconventional monetary policy. Hajek – Horvath (2018) add that price shocks' effect is generally limited within the EA. These results suggest that the law of one price is not valid, at least in the short-term. Besides, the transmission of conventionally conducted monetary policy is more pronounced than the shock of the ECB's unconventional monetary policy.

3. METHODS AND DATA

3.1. Sign restricted vector autoregression models (SRVARs)

Research in the field of macroeconomic dynamics is based on many econometric procedures and models. However, in assessing the monetary policy's impact, the vector autoregression (VAR) model, which has become the basis for several studies in various economic fields, cannot be overlooked (Blanchard – Quah 1989; Kim 2001; Sims – Zha 2006). The VAR model's construction and its modifications are based on Sims' pioneering work (1980). The application and the econometric method itself, therefore, lie on the shoulders of economic giants. However, it is still alive and popular because of constant modifications and improvements (Sims et al. 1990; Doan et al. 1984), especially in terms of more convincing interpretation, elimination of some shortcomings and conjectures. Stock and Watson (2001) state that the VAR models remain a powerful tool for data description and economic policy analysis. They also claim that the main advantage is flexibility, simplicity of use, and relatively easy interpretation of results. Christiano (2012) adds that this econometric approach has undoubtedly stood the test of time and still plays a key role.

Due to the disadvantages of VAR analysis and the possibilities for solving the price puzzle, the research uses a sign-restricted VAR model (Canova – De Nicolo 2002; Uhlig 2005³). The sign-restricted VAR (SRVAR) model became essential for macroeconomic analysis relatively quickly after its creation. This model can also be applied very appropriately to the issue of monetary policy spillovers. The advantage of sign restriction is that it only provides guidelines for the impulse response function. These barriers are then relatively easy to defend based on economic theory and knowledge of individual quantities' operation.

The algorithm, proposed by Uhlig (2005), is followed in the paper. We characterize the basic VAR model:

$$Y_t = BY_{t-1} + u_t \quad (1)$$

where Y_t is $m \times 1$ vector of data at time $t = 1 - l, \dots, T$; B_i are matrices of coefficients of size $m \times m$; and u_t is one step ahead prediction error with variance-covariance matrix Σ . The equation (1) can also contain a time trend and constant.

According to Uhlig (2017), the goal of any structural vector autoregression is to map the forecast errors in the reduced form u_t to the structural shock ε_t . This process should have a clear economic interpretation, and the relationship between u_t and ε_t is orthogonal.

³Uhlig (2005) used two different approaches in the construction and estimation of SRVAR: the rejection method (we use this in our paper) and the penalty function method. The rejection method is used, for example, by Rubio-Ramírez et al. (2005).



However, it is also necessary to define the response function for the application of sign restrictions. According to Uhlig (2017), in the case of the horizon $k = 0, 1, \dots, K$, j -th shock of the size of one standard deviation and a positive sign, the response function is as follows:

$$\tilde{r}_k = \tilde{B}^k \tilde{A} e_j \quad (2)$$

where e_j is a vector of the same length as ε is with only zero entries, except 1 in entry j . From $\tilde{r}_k$ the response functions for individual time series are extracted. Sign constraints for equation (2) are commonly set for entries in $\tilde{r}_k$ at different horizons k .

We can estimate equation (1) by the method used in Uhlig (2005, 2017).⁴ This is the Bayesian approach (BVAR),⁵ a computationally simple and pure method of creating a tolerance band for the analysis of response functions (Sims – Zha 1999). According to Uhlig (2005), equation (1) is then estimated using the maximum likelihood method (ML).

3.2. Model description

We use a two-country approach in the construction of the model. First, it is necessary to define the two countries under review. We divide these countries into a domestic economy, which is the recipient of the exogenous shock, and a foreign economy (centre country), which emits this exogenous shock. In the case of an exogenous shock, it is a change (shock) to foreign monetary policy that the domestic country cannot control. Individual domestic economies are only exposed to these exogenous shocks and have to face them. Thus, we create a total of two blocks of variables. It is critical to assess the impact of an exogenous monetary shock on the domestic economy and the policy response. The empirical model based on the defined theoretical model (1) is as follows:

$$\begin{bmatrix} Foreign_t \\ Domestic_t \end{bmatrix} = B \begin{bmatrix} Foreign_{t-1} \\ Domestic_{t-1} \end{bmatrix} + \begin{bmatrix} u_{Foreign,t} \\ u_{Domestic,t} \end{bmatrix}. \quad (3)$$

The empirical model (3) is the unlimited VAR (p) model without an intercept and one lag $p = 1$. $[Foreign_t]$ is a 3×1 vector and contains $[y_{ea_t}, p_{ea_t}, i_{ea_t}]$ variables. $[Domestic_t]$ is a 4×1 vector and contains the same variables of domestic economy $[y_{dom_t}, p_{dom_t}, i_{dom_t}, e_t]$. B is a 7×7 coefficient matrix. $u_{Foreign,t}$ and $u_{Domestic,t}$ are the estimation errors. Also, i_{ea_t} (conventional monetary policy) is replaced by sr_{ea_t} (shadow rate) for models dealing with unconventional policy.

First, we create a block of variables for the foreign country $[Foreign_t]$, and then the variables for the domestic country $[Domestic_t]$ are included. The variables for both the domestic and foreign countries are thus endogenous variables of the empirical model (3). Thus, the model

⁴Uhlig (2005, 2017) uses a sign-restricted VAR method, referred to as the rejection method. Within BVAR, the procedure can be defined as follows: a) First, take many draws b_i and Σ_i . b) Subsequently, Cholesky decomposition $\Sigma_i = L_i L_i'$ is performed. c) Any other decomposition $\Sigma_i = A_i A_i'$ satisfies $A_i = L_i R_i$, where $R_i R_i' = I$ d) Subsequently, R_i is further drawn. A_i is also checked to see if it satisfies the sign restriction. e) The last step is to verify the sign restriction.

⁵According to Wu – Xia (2016), the shadow rate is an excellent instrument for describing unconventional monetary policy development. The shadow rate replaces short-term interest rates and complements them with the implementation of unconventional monetary policy.



does not contain any purely exogenous variables. The aim is neither to further complicate the system and nor to create theoretical difficulty to defend the links. Besides, the degrees of freedom are quickly disturbed when additional variables are added.

Implementing a restrictive monetary policy in a centre country is the starting point. Thus, we assume the monetary restriction and growth of the interest rate variable (+) i_{-ea} at first. Subsequently, we apply only one sign restriction (–) to the output response (y_{-ea}). According to theoretical, generally accepted assumptions, output in the EA should decline after tightening the ECB's monetary policy and rising interest rates. Other variables are not restricted, and the system is depicted in equation (3). For better clarity, the vector *Domestic* includes the domestic country's variables. The domestic country's reaction, which receives a monetary shock, is not restricted, and we allow a free impact on the domestic variables. The reason is the need to evaluate possible heterogeneous reactions across the monitored countries. It does not have to be a price puzzle in the case of a different response from the theoretical basis, but rather an effect necessary to argue.

Moreover, the theory suggests that the reaction may not always be unambiguous. We apply sign restrictions without the desire to anticipate the result. Within the output in the EA, we make only a weak sign assumption. Besides, this design makes it possible to avoid the price puzzle problem in the ECB's internal transmission mechanism, which would significantly misrepresent the exogenous monetary policy results. We select the lags of the model (3) based on information criteria. We verify the models by an overall stability test precisely due to non-stationary time series entry.

3.3. Data

Our time series cover the period from January 2000 to February 2020.⁶ Monthly data contain a total of 242 observations.⁷

The dataset contains variables for eight non-EA EU countries and the United Kingdom, which is already not a member of the EU, but it was a member of the EU for most of the period under our interest.

We consider the EA as a single entity from a monetary policy perspective because the member states of the single monetary area cannot conduct monetary policy independently according to national preferences. We aggregate all variables for the EA, the whole dataset,

⁶We are not interested in observations before 2000 since we assess the ECB's monetary policy spillover, which began in January 1999. Potjagailo (2017) also did not use observations during the emerging euro area due to many structural changes. Furthermore, it is not just the eurozone formatting problem. Hajek – Horvath (2016) state that it is appropriate to avoid data from the 1990s for Central, Eastern and South-Eastern Europe due to the turbulent period with many structural breaks. On the other hand, more recent data (since February 2020) are affected by the global economy in a global pandemic, which is not the subject of this article. These periods, therefore, create time constraints in which the research will move. However, for a smaller number of variables and delays, the number of observations is sufficient.

⁷For the assessed spillover of exogenous monetary policy into the Bulgarian economy, the period under review is from January 2000 to June 2018 due to the lack of observations in the time series for the 3M interbank interest rate. The total number of observations is 222. The model for Bulgaria covers 91.74% of the whole period.



therefore, contains a total of 10 politically independent currency areas. We consider the currency area as a zone with a common currency and a single monetary policy. The monitored countries are divided according to their division into three groups (Table 1 and Supplementary Table S1⁸).

We investigate two other characteristics: exchange rate volatility and financial integration. Since all nine countries use different exchange rate regimes, we evaluate their exchange rate volatility. Countries with a fixed (low volatility) exchange rate may experience a more substantial spillover to the price level. Therefore, we calculate exchange rate volatility as a coefficient of variation in percentage terms over the whole period. As the euro circulates through different dimensions in some of the countries surveyed (loans, flows, transactions, etc.), we also measure financial integration *vis-à-vis* the euro. The International Investment Position (IIP) by IMF is used to calculate financial integration. We then measure financial integration using the net international investment position (difference between the assets and liabilities) to GDP. This position then shows a net claim on or a net liability to the rest of the world. The methodology of summing gross foreign assets and liabilities relative to GDP is then used by Lane – Milesi-Ferretti (2007), Georgiadis (2015), and Potjagailo (2017). Based on whether countries are above or below average in each indicator, we divide them into high (H) and low (L) levels (see Supplementary Table S1).

The analysis uses the basic macroeconomic variables for the given currency areas. These are the real output of the economy (y – approximated by the industrial production index – 2015 = 100, Eurostat), the harmonized index of consumer prices (p – 2015 = 100, Eurostat), the short-term interest rate (i – 3M interbank interest rate, Eurostat), and the real exchange rate (e – nominal exchange rate domestic/EUR, deflated by HICP, Eurostat). We use the industrial production index⁹ primarily because of enough observations, as this index is published monthly. The monthly periodicity then significantly increases the number of observations.

Table 1 List of analysed countries

Euro area (EA) (19)	AT, BE, CY, EE, FI, FR, DE, GR, IE, IT, LT, LV, LU, MT, NL, PT, SK, SI, ES
Old member economies (OME) (3)	DK, UK, SE
New member open economies (NMOE) (3)	BG, CZ, HU
New member closed economies (NMCE) (3)	HR, PL, RO

Notes: Abbreviations are the two-digit ISO country code; EA indicates the Euro Area. Economic openness is measured by the share of exports to GDP in 2019 according to Eurostat: EA (19) (48.2%), DK (58.3%), UK (31.1%), SE (47.7%), BG (64.2%), CZ (74.4%), HU (82.2%), HR (52.0%), PL (55.5%) and RO (40.4%).

⁸All tables and figures marked S are available in the Supplementary material of this article at <https://doi.org/10.1556/032.2023.00005>.

⁹Ravazzolo – Vespignani (2015) claim that industrial production has been widely used as a measure of real economic activity. Kim (2001) and Kim – Roubini (2000) have used industrial production as a proxy for real economic activity. Moreover, IPI is quite common in VAR models and research on monetary policy spillover (Potjagailo 2017; Kucharukova et al. 2016).



On the other hand, industrial production may require imports in a small open economy. In a closed economy, it might be less dependent on imports, so there is a risk of overrepresenting the role of imports in GDP in the small open economies. Therefore, we perform a correlation analysis between quarterly GDP and quarterly IPI time series computed from monthly data. The results, reported in [Supplementary Table S3](#), show that the correlation is high and statistically significant at the 1% significance level in all studied countries. Moreover, there is no systematic bias between the results for open and closed economies. Hence, we believe that we can use IPI as an approximation of GDP.

We try to estimate both conventional and unconventional monetary policy spillovers. We measure the exogenous shock of conventional monetary policy using the short-term interest rate (i_{ea}) for the EA. To measure the shock of unconventional monetary policy, we use shadow interest rate (sr_{ea} , based on [Wu – Xia 2016](#)). The shadow interest rate makes it possible to include information on the ECB's unconventional monetary policy, especially in recent years. Thus, a comprehensive view of the spillover of monetary policy into individual countries' analysis is possible. [Wu and Xia \(2016\)](#) state that when economies operate close to their zero-lower bound, it is difficult to assess the impact of unconventional monetary¹⁰ policy on these economies. Thus, we cannot use short-term interest rates since unconventional monetary policy escapes the analyses. We can use the shadow rate for all central banks that operate at their technical zeros and use unconventional monetary policy instruments. If possible, time series are obtained seasonally, and calendar adjusted. However, this was not possible in the case of the price level, and additional seasonal adjustment¹¹ was necessary. The interest rate, the real exchange rate, and the shadow interest rate are not adjusted.

We use the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski – Phillips – Schmidt – Shin (KPSS) test to test for stationarity of all variables at levels. The unit root tests for the variables in the levels are in the [Supplementary Table S4](#). The price level and output are considerably non-stationary variables in all countries. This is valid for the interest rate and the real exchange rate. However, for Croatia, Poland and Romania, the interest rate at levels is already stationary. To ensure the models' stability, we adjust the variables to year-on-year changes ([Supplementary Table S5](#)). Interest rates and shadow interest rates for the EA are at the level. The reason is a problematic interpretation because these are *per annum*. Thus, using the year-on-year change, the result was improved, and most of the variables become stationary. Problems occur mainly in the price level, where the month-on-month change ([Supplementary Table S6](#)) seems to be a more appropriate adjustment to remove the unit root. Nevertheless, adjusting for month-on-month changes would not provide long-term information in time series. For this reason, partially non-stationary time series and interest rates at levels enter the individual models for the monitored countries. If the models as a whole are stable, then the econometric framework is not destabilized. The models' stability is verified using the inverse values of the roots of the autoregressive polynomial in [Supplementary Table S7](#).

¹⁰According to [Wu – Xia \(2016\)](#), the shadow rate is an excellent instrument for describing unconventional monetary policy development. The shadow rate replaces short-term interest rates and complements them with the implementation of unconventional monetary policy.

¹¹We use Census X-13 available in the EViews10 software package from U.S. Census Bureau.



4. RESULTS AND DISCUSSION

We evaluate the spillover effect by constructing the SRVAR model (3) and its interpretation using impulse-response function analysis (IRF).¹² Thus, the Bayesian VAR model is analysed by obtaining the median selections of impulses and responses and plotting them using specified confidence intervals.

The critical period for evaluating the IRF is the monetary policy horizon (12–18 months). However, the maximum horizon for the IRF is set at up to 60 months. The main advantage is the ability to monitor the overall gradual disappearance of the response, which indicates that the models are *de facto* stable (Figures 1–4). Only statistically significant responses of specific variables to the interest rate shock will be evaluated, that is, primarily to the peaks of the response. SRVAR models for individual countries are constructed with the shortest possible delay (p). This is mainly due to the shorter analysis period and the lower number of observations. The individual information criteria are presented in Supplementary Table S8. SRVAR models are constructed with a delay ($p = 2$). The models' stability is verified not only graphically by the disappearance of the response to the monetary shock but also by the inverse values of the autoregressive polynomial (Supplementary Table S7). All models have passed this test, and the IRF is stable. Interest rates at levels and their alternative in the form of a shadow interest rate did not impact the overall stability of the models. We use 68% confidence intervals around the median responses when plotting IRF.

Specifically, we analyse the spillover effect of the ECB's conventional monetary policy, approximated by the short-term interbank interest rate, and the ECB's unconventional monetary policy, which is assessed using the shadow interest rate for the EA. Subsequently, we discuss the impact of the monetary shock and its spillover to the monitored countries. We focus on responding to the economy's output, the price level, the interest rate and the exchange rate. We assume that conventional monetary policy is the primary policy of every central bank and, if possible, these banks will always prefer it to the unconventional one. Unconventional monetary policy is included mainly to increase the results' robustness and cover a broader range of monetary policies. Moreover, we split the whole period into two parts and report these results in Section 4.6 as the robustness check.

4.1. Output

Statement A: *Monetary restrictions in the EA will increase interest rates in the single currency area and strengthen the euro against the trading partners. EA production and exports are gradually losing competitiveness. Imports are growing, and the output of foreign trading partners is growing.*

The trade channel's strength depends on international trade's importance from the country's receiving a monetary shock point of view. It is, therefore, beneficial to segment the sample of countries into individual, often heterogeneous, states. In addition to the openness of the economy,

¹²The procedure is based on the rejection method (Uhlig 2005, 2017) defined in subchapter 3.1. Bayesian SRVAR models are then constructed with two delays, no constant, and the IRF is estimated at 60 periods with 68% confidence intervals. 200 posterior selections and 200 sub-selections from each posterior selection are used to create an impulse vector and a possible candidate impulse response to which the rejection method will be applied. The total number of accepted selections is 1,000. Sign restrictions are applied for 3 periods ($K = 3$), starting with the first.



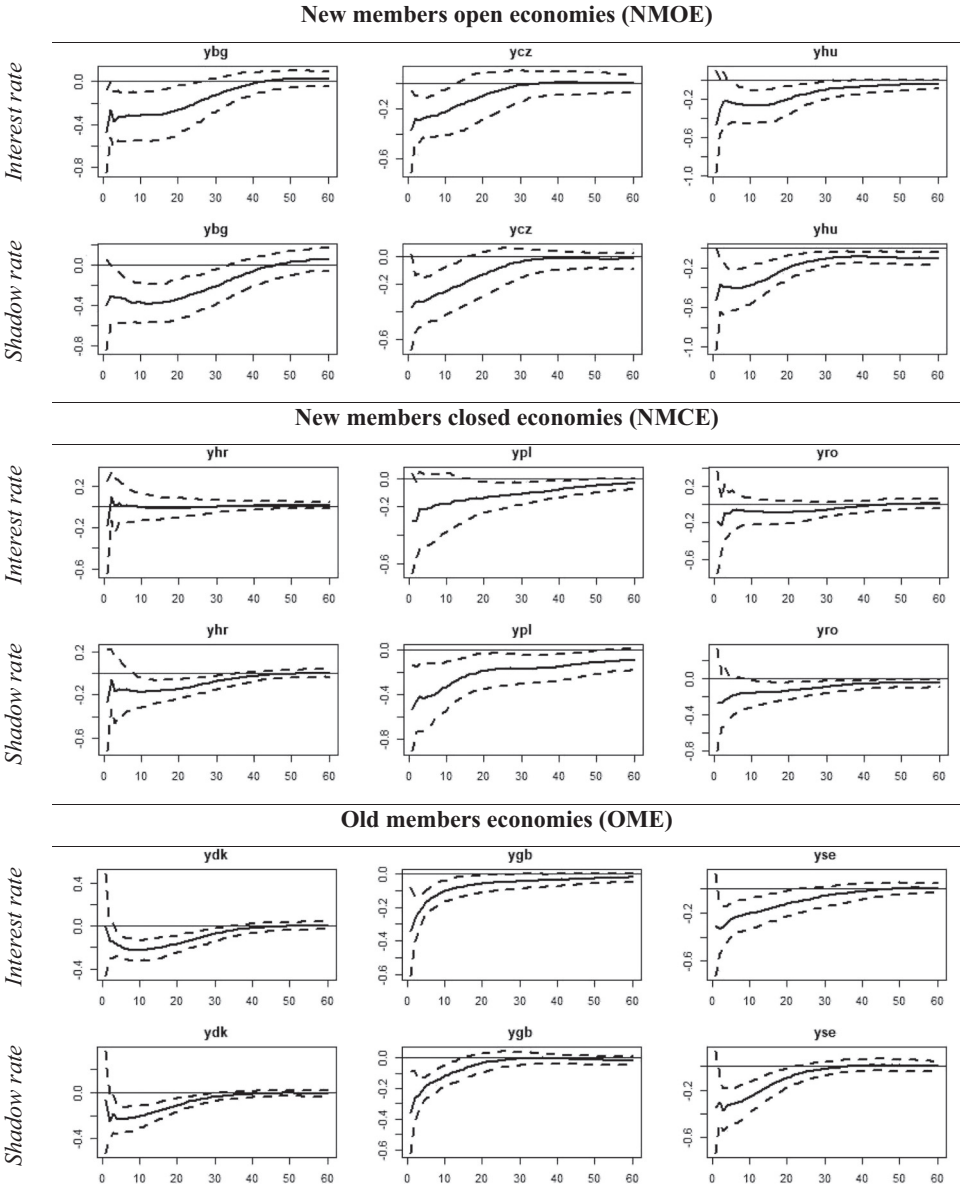


Fig. 1. The response of economic output in the NMOE, NMCE and OME countries to the tightening of the ECB's conventional and unconventional monetary policy

Note: Analysis of the countries' response to the ECB's restrictive monetary policy of one standard deviation using the sign restriction method ($K = 3$). The short-term interest rate shock in the EA refers to the conventional monetary policy, and the shadow interest rate shock refers to the unconventional monetary policy. We use 68% confidence intervals when plotting IRF, and report the median responses.



the development of the exchange rate is also essential. Statement A is based on the theoretical definition and presume dependence of countries according to [Dornbusch et al. \(2011\)](#). This problem is crucial to address because, in the event of a monetary expansion of the ECB, there would be an effect known as the *beggar-thy-neighbour*. From the EU institution's position, this is entirely at odds with the integration unit's policy. Also, we must realize that these are mainly countries with a lower economic level compared to the member states of the EA.

The monetary restriction in the EA leads to a decrease in output in NMOEs. Moreover, this effect seems to be long-lasting, especially in the case of Hungary and Bulgaria. However, the situation is different in NMCEs. Although we can see a negative impact in Poland, the same is not valid in Romania and Croatia.

Generally, the EA's policy tightening is more substantial in the open economies than in the closed ones. [Benecka et al. \(2020\)](#) find out similar results. In their analyses, ECB's tightening impact is lower in the closed economies (Poland and Romania) than in the open ones (Czechia, Hungary and Bulgaria). Similarly, [Potjagailo \(2017\)](#) claims that industrial production reacts significantly in all countries, however the reactions are stronger in countries with high degree of trade openness. Surprisingly, we can see a significant impact on OMEs as well. This impact is even more significant than in the case of NMCEs, even though the level of openness is similar. On the other hand, [Potjagailo \(2017\)](#) claims that there is a significant spillover between the EA and these countries (only marginally significant in Denmark). One can argue that OMEs are more connected with the EA due to historical reasons or geographical location.

4.2. Price level

Statement B: *Central banks should include monetary policy spillovers in their decision-making processes due to their significant influence.*

If the central bank wants to achieve price stability, it must face the exogenous monetary shock and mitigate its effects. Strong trade and financial integration in Europe causes monetary policy and shocks to spillover from the single monetary area into countries outside the monetary union ([Hajek – Horvath 2016, 2018](#)). [Potjagailo \(2017\)](#) emphasizes that the central banks of the non-EA countries must first and foremost respond to the ECB's highly expansionary monetary policy since the financial and economic crisis. If central banks pursued a purely counter-cyclical economic policy, we could agree with statement B. The impact of the ECB's monetary restraint spilling over on output is clear from the previous part. However, in the case of the price level reaction, the situation is relatively different. Furthermore, the stability of the price level is crucial from the point of view of monetary policy and internal transmission mechanisms. The impact on the price level is generally less significant than in the case of production ([Figure 2](#)). This is in line with the conclusions of other works. [Horvath – Voslarova \(2017\)](#) note that the peak response of an unconventional monetary policy shock to output is about twice as large as the effect on Central and Eastern European countries' price levels. [Benecka et al. \(2020\)](#) state that, relative to output, the price effects tend to be less accurately estimated and smaller in magnitude, because prices are related to the exchange rate movements. However, monetary restrictions in the EA lead to lower price levels in all countries and are significant in most of them. They observe a negative and significant impact in 4 of the ten NMS. Our conclusions are similar in this regard.



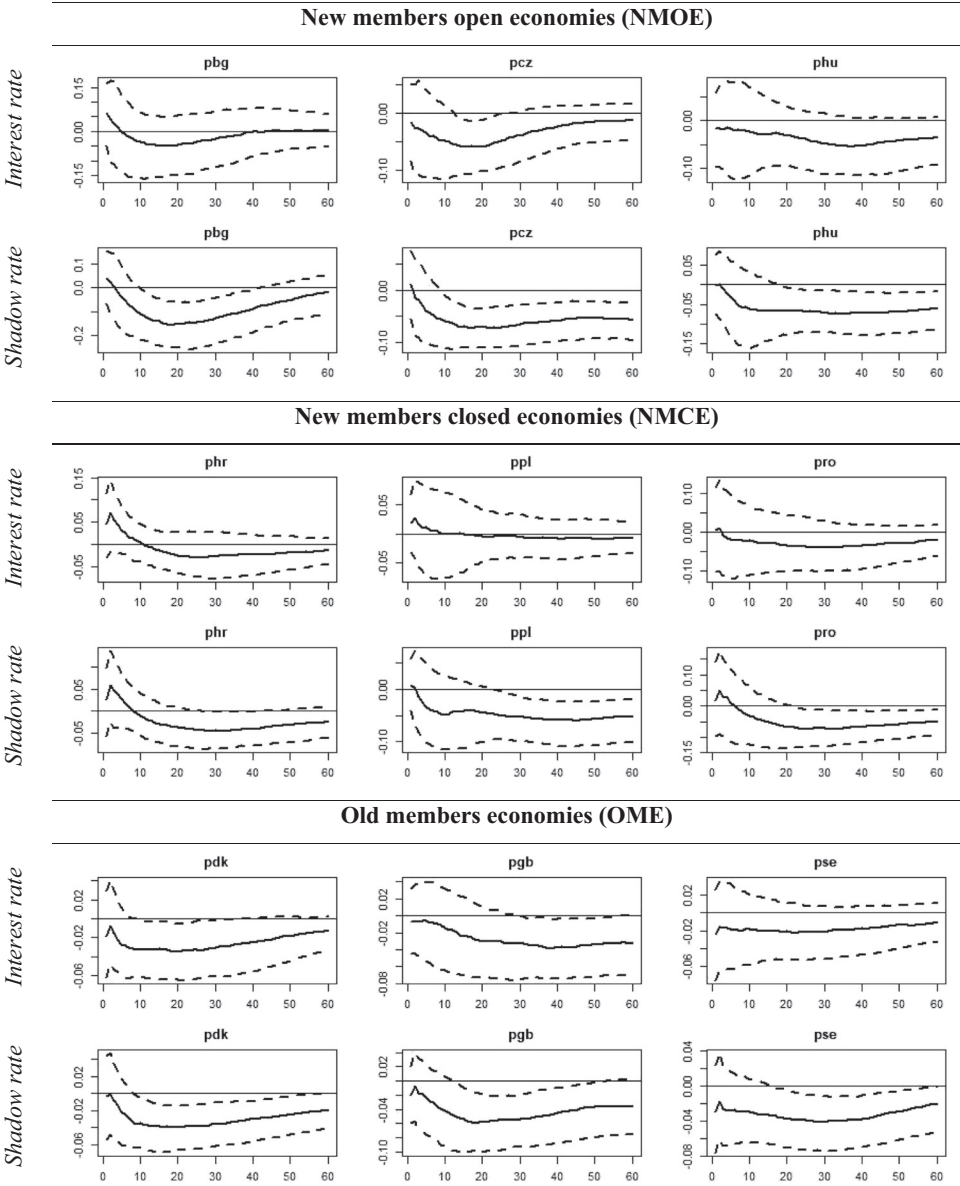


Fig. 2. The response of price levels in the NMOE, NMCE and OME countries to the tightening of the ECB's conventional and unconventional monetary policy
Note: See Figure 1.

Interestingly, when using shadow interest rates, the decline in the price level appears to be more pronounced than in the case of standard interest rates. The decline in the price level occurs in all countries with a specific time lag (usually longer than one year). This is also in line with the



theory due to the monetary transmission mechanism's functioning and the monetary policy horizon. Changes in the interest rate settings affect inflation only with a delay of about a year to a year and a half. [Kucharcukova et al. \(2016\)](#) point to a relatively strong price puzzle in consumer prices' response to the spillover of the conventional monetary policy. Similarly, [Potjagailo \(2017\)](#) finds the consumer price index's problematic results for the price level. From [Figure 2](#), we can see that the response of the price level in individual countries is negative or statistically insignificant. Therefore, there is no problem with the price puzzle, but the reactions are feeble. Only the price levels in the Czech Republic, Denmark and the United Kingdom respond to the spillover of the conventional monetary policy. For these countries, the response is around -0.05% .

The spillover of the unconventional monetary policy then again hits the NMOE countries most significantly. The most significant influence is to Bulgaria (with a peak of -0.15%) and the Czech Republic (-0.08%). [Benecka et al. \(2020\)](#) or [Hajek – Horvath \(2016, 2018\)](#) find similar results. Closed economies then react to unconventional monetary policy with a peak at -0.05% . [Hajek and Horvath \(2016\)](#) conclude that the price level's response in Poland and Romania to the spillover of the unconventional monetary policy is statistically insignificant, which is acceptable because, in this study, the response becomes significant only with a longer delay. The old member economies react very similarly to the spillover of conventional monetary policy, but the effect is more pronounced. In the case of Sweden, it is statistically significant. The results suggest that the monetary policy spillovers may affect the ability to achieve price stability in countries receiving this exogenous shock. From this point of view, it is possible to agree with statement B. However, a key finding is that central banks need to pay attention to the implementation of the ECB's unconventional monetary policy. Furthermore, it can therefore undermine the achievement of the goal of monetary policy. However, it is undoubtedly essential to monitor monetary conditions abroad, especially for countries such as the Czech Republic, Hungary, and the OME countries.

4.3. Interest rate

Statement C: *There is a close link between the EU's central banks and ECB, so the EU countries outside the EA will follow the ECB in conducting monetary policy.*

[Kucharcukova et al. \(2016\)](#) claim that the tightening of ECBs monetary policy is associated with a corresponding domestic policy's tightening. Moreover, they state the response of the domestic rate is almost immediate, occurring within a few months following the change in the ECB policy. [Potjagailo \(2017\)](#) adds that interest rates move the same way as in the EA immediately in Bulgaria, Latvia and the Western European economies outside the EA, whereas they react with a delay in the remaining economies.

However, our results ([Figure 3](#)) do not fully confirm this. The response of interest rates in most countries is relatively insignificant. Also, interest rates in OME react more than in NME. This may be related to more experience in conducting monetary policy in OME. Also, central banks react even less to monetary tightening by the unconventional instruments (shadow rate) than the conventional ones. It can be challenging for central banks to recognize that this is a monetary restriction, as they monitor the interest rate differential by default, but it does not change in this case. For this reason, central banks do not fundamentally respond to the ECB's unconventional monetary policy and its spillover.



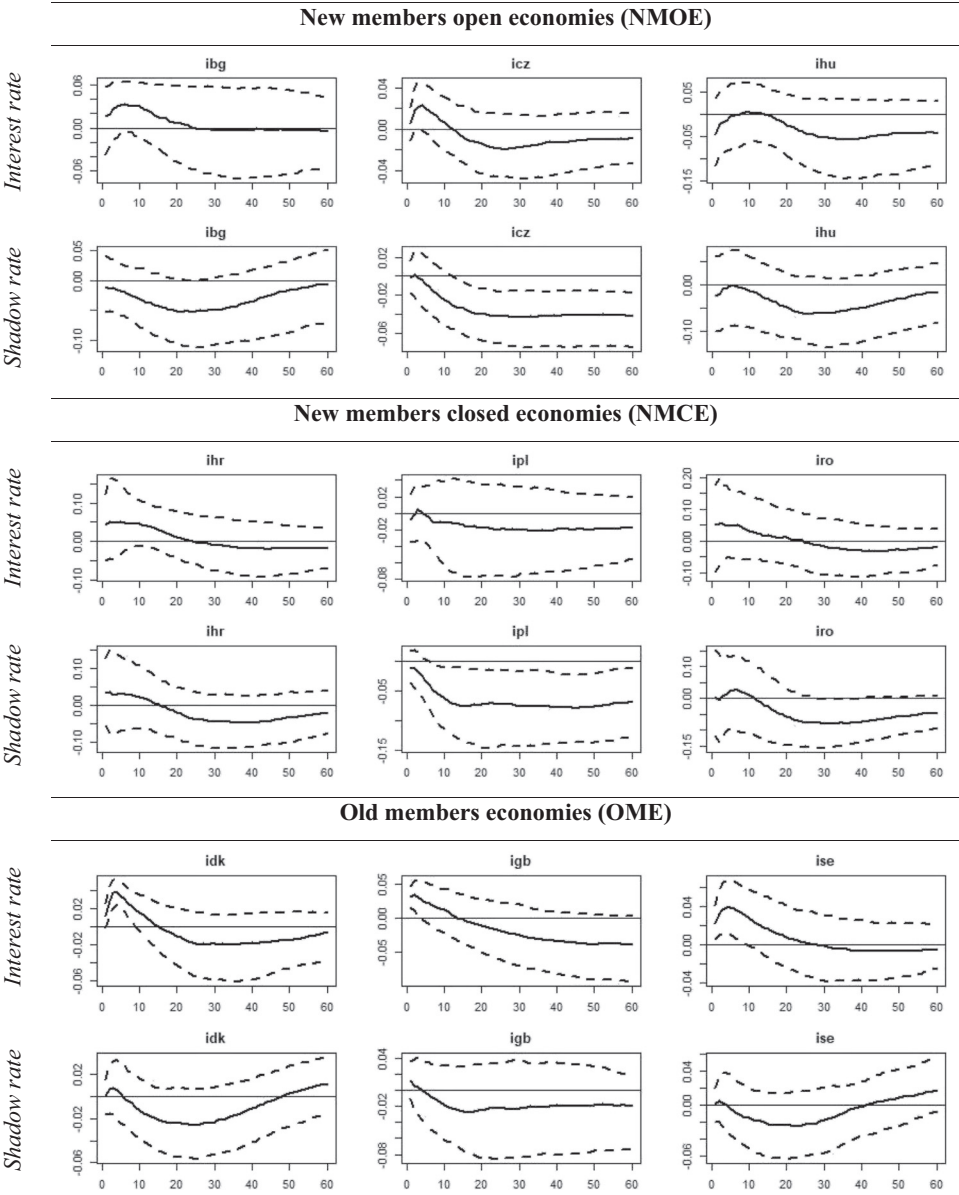


Fig. 3. The response of interest rates in the NMOE, NMCE and OME countries to the tightening of the ECB's conventional and unconventional monetary policy
Note: See [Figure 1](#).

The surprising finding is that if shadow interest rates rise in the EA, NMEs respond by lowering their rates. It is confusing for the central banks of the NME, where the economic downturn is coming from, and they try to offset this by lowering the interest rates. One can say



that the ECB forces the NME central banks to pursue a conflicting monetary policy. Interestingly, this does not happen in OME, or at least not to such an extent. [Benecka et al. \(2020\)](#) find the same effect for NME – domestic policymakers respond to compensating for production or inflation changes. However, this impact appears to be negligible for both NMOE and NMCE. Production and inflation rate behave the same regardless of whether central banks pursue the monetary policy. These changes are due to the ECB's effect and spillovers on output and inflation. Before concluding on statement C, it is necessary to make a deeper connection to the results. It seems that the OMEs indeed follow the ECB in the implementation of conventional monetary policy.

From this perspective, we cannot talk about a completely independent monetary policy for these countries. The results also show that the more countries are integrated and linked to the monetary area's core, the more they lose their independent monetary policy. This is not just the case of a trade channel, as in the case of the NMOE, but especially a financial channel and the interconnection of financial markets. [Dornbusch et al. \(2011\)](#) confirm that the spillover effect is closely linked to the overall interdependence. The impact of monetary policy spillovers on the NMCE economy is weaker in both output and price levels, and also to a large extent statistically insignificant.

Therefore, even domestic monetary policy does not respond to the ECB's conventional monetary policy. Monetary policy is independent, but independence is still due to the ongoing integration within the framework of monetary policy spillovers. Surprisingly, Poland, the Czech Republic, Romania, and, partly, Bulgaria reacted more to the ECB's unconventional monetary policy and its spillover. The international transmission of unconventional monetary policy shock to the price level ([Figure 2](#)) seeks to balance the central banks of the NME states with the conflicting monetary policy. The effort to offset the ECB's monetary shocks then leads to a decline in the overall effectiveness of monetary policy in the NME countries. Besides, [Georgiadis \(2015\)](#) argues that states' efforts to prevent international transmission of monetary policy may harm long-term economic growth. Overall, the countries' monetary policy under review also appears to be dependent on the conduct of the ECB's monetary policy. Non-EA central banks' reaction to monetary policy spillovers is heterogeneous, but the conclusion leads to the same result.

This heterogeneity is a fundamental reason for studying the spillover effect of monetary policy, in general. Subsequently, it is only necessary to make the verdict itself over statement C. Therefore, we could declare statement C to be true, albeit with different interpretations in the individual monitored states. For the OME countries, we can say unequivocally that deepening integration into the single monetary area can be beneficial. According to the results, these countries are already following the ECB's monetary policy, so joining the EA is a logical step. Political feasibility remains an issue. On the other hand, for the NME countries, involvement in the single monetary area could prevent the destabilizing impact of international transmission shock. Also, if these countries' central banks want to fight the monetary shock (they even fight the shock of unconventional monetary policy), long-term economic growth may be adversely affected ([Georgiadis 2015](#)). Moreover, it may reduce the overall effectiveness of the monetary policy. From the point of view of the spillover effect, it is more advantageous, especially for small economies, to integrate more.

4.4. Exchange rate

[Potjagailo \(2017\)](#) finds that real effective exchange rates appreciate in most countries which allow their currency to fluctuate against the euro. On the other hand, [Benecka et al. \(2020\)](#) find



significant appreciation of domestic currencies only in Romania and some euro countries (Slovakia and Slovenia). Our results suggest that monetary policy changes in the EA do not have much effect on developments in the real exchange rate. It is reasonable to assume that the development of the real exchange rate is influenced more by the theory of purchasing power parity (in the case of OMEs) or the catching-up process (in the case of NMEs) (Figure 4).

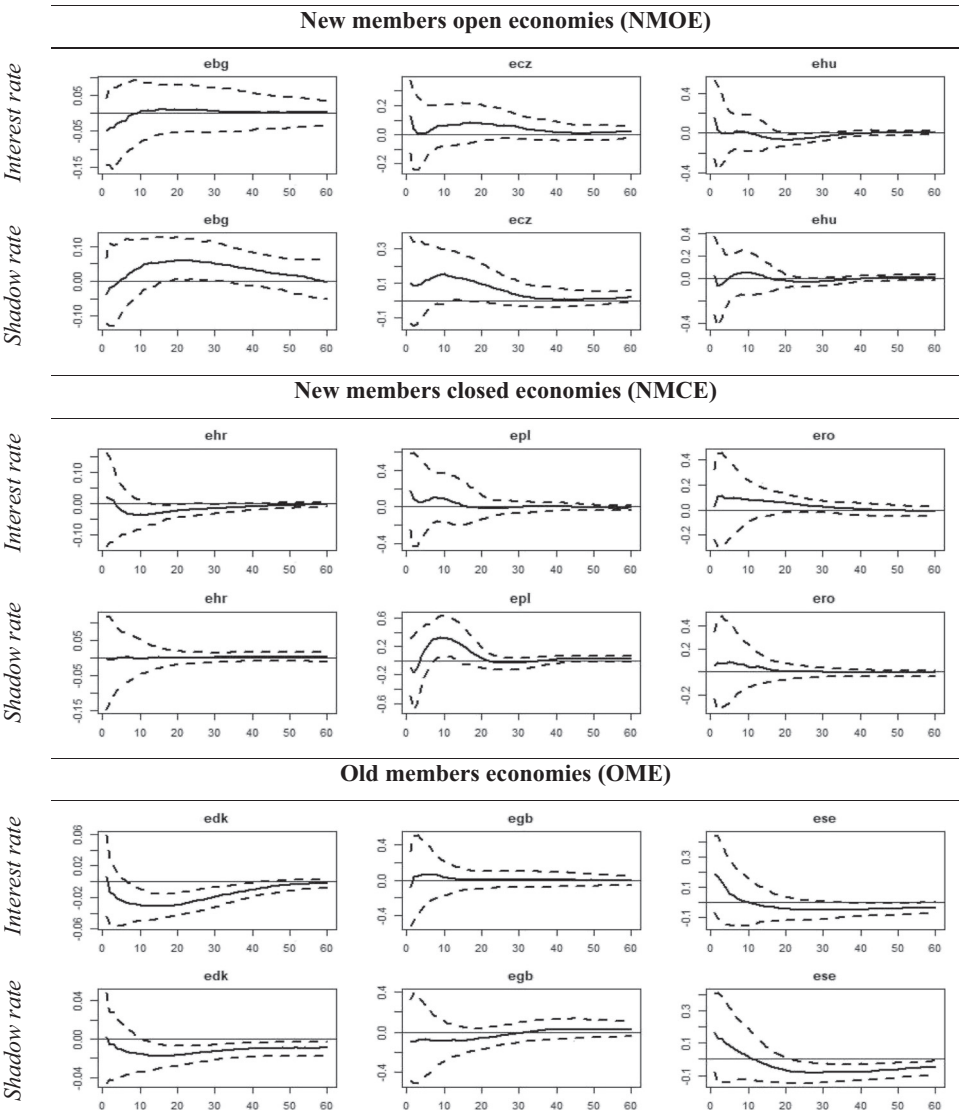


Fig. 4. The response of real exchange rate in the NMOE, NMCE and OME countries to the tightening of the ECB's conventional and unconventional monetary policy

Note: See Figure 1.



The results show that the tightening of the ECB's conventional monetary policy leads to a strengthening of Denmark and Croatia's real exchange rate. The spillover of conventional monetary policy in these countries leads to increased purchasing power with a peak after ten months. In Denmark, the results are statistically significant, and the response rate is 0.03%. Similar results occur in [Potjagailo \(2017\)](#). Denmark is only one of the few countries where the real exchange rate strengthens after the monetary shock. For the remaining countries, the impact on the exchange rate is relatively insignificant. We can still observe a feeble effect in Sweden (-0.05%) and partly in Hungary (-0.01%), but only in the longer term up to 20 months. We can see that the growth of the shadow interest rate in the EA leads to a weakening of the real exchange rate in the NME, specifically in Bulgaria (0.06%), the Czech Republic (0.13%), and Poland (0.25%). The spillover of unconventional monetary policy is leading to a decline in purchasing power in the NME. This effect is mainly due to the more pronounced impact of unconventional monetary policy on the price level in these countries and probably to the non-adjustment of the nominal exchange rate. The conventional monetary policy did not have such a significant effect on the NME prices, and the real exchange rate in these countries was not affected by the spillover of the tightening of conventional monetary policy.

On the contrary, the OME countries react oppositely. The tightening of the ECB's unconventional monetary policy then leads to a strengthening of the real exchange rate and an increase in the population's purchasing power, especially in Denmark (-0.01%) and Sweden (-0.05%). However, Sweden reacts with a considerable delay. In Denmark, the response is relatively flexible. On the other side, these results are generally not unexpected. The real exchange rate should be influenced primarily by fundamental processes, and monetary policy spillovers should not significantly impact. Some papers assess the impact on the nominal exchange rate ([Kucharcukova et al. 2016](#)). The weak impact of monetary policy spillover on the real exchange rate, which we find in the article, is mainly due to secondary factors and real output development.

4.5. Exchange rate volatility and financial integration

In the case of countries with a fixed (low volatility) exchange rate, their price levels can be expected to respond more than those of countries with a floating (high volatility) exchange rate. However, this expectation is only observed for Denmark among the five low volatility countries. In contrast, countries such as the Czech Republic and the UK have price levels that are responsive despite being countries with a volatile exchange rate. As regards the effect of financial integration, the situation is complicated by the fact that of the four countries with low financial integration, three are also OME. Thus, the Czech Republic is the only new member state with low financial integration. However, the Czech Republic does not seem to show any different behaviour than Hungary or Bulgaria, which are also NMOEs. In terms of the observed characteristics, the only difference between Hungary and the Czech Republic is the degree of financial integration. However, the results for both countries are virtually identical. Hence, we conclude from the above that neither exchange rate volatility nor the degree of financial integration has a significant impact in the case of the spillover effect.



4.6. Robustness check

For the robustness analysis, we split the whole period into two parts – before the collapse of Lehman Brothers, i.e., until August 2008¹³ (92 observations) and after it (138 observations). Also, the results in the period 2001M1 – 2008M8 for most countries show a price puzzle (monetary restriction leads to an increase in price levels). For this reason, we have additionally estimated all models with a restriction on the price level in the EA for the analysed period (the price levels of the countries under study are not restricted to avoid biasing the results). [Supplementary Table S9](#) shows the results of all estimations in a simplified form.

First, we show the results for the whole period using the traditional interest rates (a) and the shadow rate (b) from the previous subsection. We then show results before the collapse of Lehman Brothers using traditional interest rates (c). This is followed by the crisis and post-crisis period using the shadow rate (d), as it was only during this period that unconventional monetary policy was implemented in the EA. In the last rows, we then report results for the pre-crisis period using a second restrictive rate on the EA price level (c*). If we wanted to present the results for models (c), (d) and (c*) here in the same form as results (a) and (b) in the previous section, it would be confusing. However, these results are available upon request. Only statistically significant results are captured in [Supplementary Table S9](#). If a monetary restriction in the EA leads to an increase in the variable in the domestic economy, this is indicated by (+), otherwise (–).

We find that the price level and output are becoming statistically significant after halving the period under consideration to the periods before the global financial and economic crisis. In the case of output, this effect is substantial, and the sensitivity of output to spillovers is more pronounced. When trade linkages are weaker, international monetary policy transmission is dampened. Nonetheless, the robustness test reveals that monetary shocks induced by the European Central Bank permeate the EU, and the economies are strongly linked. However, we point to the positive fact that the EA does not generate exploitative effects despite implementing monetary policy tightening and loosening. The *beggar-thy-neighbour* situation does not induce integration barriers. The robustness test establishes our conclusions.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

The paper deals with the spillover effect of ECB's monetary restriction on four economic variables: the economy's output, price level, interest rates and real exchange rate in the non-EA countries. It is reasonable to think that the role of the spillover effect grows with higher interconnection in the EU. If so, there are two possible consequences. First, the non-EA countries may face the so-called *beggar-thy-neighbour* situation. This means that monetary policy shock leads to the opposite impact (monetary expansion leads to a decrease in output and vice versa) in other countries. If this were true, the central banks of the non-EA countries would face negative consequences, and it could endanger the integration process in the EU. The second scenario is that monetary policy shock influences both the EA and other EU countries the same

¹³We should note that this reduced the number of observations, and the first period may be biased.



way (monetary expansion leads to an increase in output and vice versa). Such a situation is then more convenient for the non-EA central banks and can lead to a greater integration.

Using the Bayesian sign-restricted VAR model, we find that the later solution is true. ECB's monetary policy shock influences the non-EA countries' output in the same direction as in the EA. This effect is particularly significant in the case of NMOEs and OMEs. The reaction in NMCEs is somewhat weaker. We claim that the level of openness and the level of economic integration play a crucial role here. Moreover, we suggest that even higher economic integration and/or openness of the economy would be beneficial for the countries outside the EA.

Generally, we state that central banks of other EU must consider monetary policy spillover in their decision-making process, and they need to care about the role of unconventional monetary policy instruments. However, there is no need to fight the spillover effect since it works in the same direction as expected. Moreover, a more profound integration process should be beneficial for these countries.

SUPPLEMENTARY MATERIAL

Supplementary data to this article can be found online at <https://doi.org/10.1556/032.2023.00005>.

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