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The Impact of Interest Rate Transmission Channel on the Prices Development in the Eurozone Countries

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ABSTRACT

The purpose of this article is to investigate the monetary policy interest rate channel capabilities to influence the inflation in individual Eurozone countries. As the differences among Eurozone countries still exist, the question is whether the common monetary policy can similarly control and influence the development of inflation and economic performance in the individual union's countries. The reaction of inflation, product and exchange rate on 1% positive interest rate shock is examined via vector autoregression (VAR) model. We implement recursive Cholesky decomposition of variance-covariance matrix of model residuals. To estimate the model, we employ monthly data for period 2000M1-2019M7 consisting of 235 observations. VAR model allows computing impulse-response functions for estimation of interest rate pass-through to macroeconomic variables. We verify the similarity of individual responses to interest rate shock of four different Eurozone countries (Austria, Germany, France and Slovakia). The results show that the interest rate channel did not reveal particularly a strong and stable effect on the observed variables. For a reaction of prices, the theory indicates that the increase of interest rate should slow down the increase of prices causing the inflation rate to drop down. Although, the reaction of inflation on the monetary policy interest rate shock is in line with economic assumption, its intensity is very weak. It could indicate the future complication of monetary policy and its interest rate channel in affecting inflation behavior in Eurozone countries..

INTRODUCTION

During the last two decades many important changes occurred in the monetary policy strategies as well as in the monetary policy instruments of the European central bank (ECB). This can be seen in the case of traditional transmission channels of monetary policy and their effectiveness, which have varied due to a number of structural changes as well as debt crisis, global slowdown and slow recovering in Eurozone countries. ECB had to review the use of the key interest rates in the implementation of monetary policy in order to influence and help to restart economic activity. However, persisting problems of low

economic growth and stagnant economies also forced the ECB to use less conventional monetary policy measures as quantitative easing. The impact of monetary policy on the real economy (i.e. GDP, employment, industrial production, etc.) in the Eurozone depends on a number of external factors (economic structure, competitiveness, presence of various shocks, etc.). The differences among Eurozone countries still exist so the question is whether the common monetary policy can similarly control and influence the development of inflation and economic performance in the individual union's countries as well as to eliminate cyclical differences. As mentioned above, the recent economic situation in Eurozone countries still required expansionist quantitative monetary policy. However, in the next future, this type of policy may worsen inflation behavior. Therefore, the aim of this paper is to investigate the interest rate channel capabilities to influence the inflation in individual Eurozone countries. The reaction of inflation on 1% positive interest rate shock will be examined via vector autoregression (VAR) model. VAR model allows computing impulse-response functions for estimation of interest rate pass-through to macroeconomic variables. We verify the similarity of individual responses to interest rate shock of four different Eurozone countries (Austria, Germany, France and Slovakia). The paper is divided into five sections. Following the introduction, the relevant empirical literature is reviewed in Section 1. In Section 2 we provide an overview of VAR model. Section 3 provides data and results of the test. Section 4 discuss the results of our analysis. Finally, concluding remarks are made in Section 5.

1. LITERATURE REVIEW

According to the Keynesian interest rate channel, the policy of short-term nominal interest rate growth leads primarily to an increase in long-term nominal interest rates. Changes in the short-term nominal interest rate will be transmitted into medium and long-term interest rates through a money market supply and demand equalization mechanism. Interest rates modification will affect the cost of capital and, consequently, capital and consumption expenditure (Mishkin, 1995). The mechanism of the interest rate and credit channel impact on the real economy is sometimes called as the "black box", because there is far less agreement about exactly how monetary policy exerts its influence and what happened in the interim of transmission channel (Bernanke and Gertler 1995). Monetary policy authorities use their influence through a short-term interest rate, to influence the cost of capital and consequently spending on durable goods such as fixed investment, housing, inventories and consumer durables. In turn, changes in aggregate demand affect the level of production. The monetary policy actions, in particular the monetary tightening have only a temporary effect on interest rates but are followed by movements in real output and price level that may last for two years or more (Bernanke and Gertler 1995).

Economic theory generally assumes that monetary tightening will be followed by a decline of the product and the price level, and shortly thereafter, by the appreciation of the exchange rate. However, some analyses showed that it is also possible to expect the opposite behavior of the prices and the exchange rate. The reaction of the exchange rate may depend on the monetary regime. The unusual behavior of exchange rates can also be caused by changes in the exchange rates regime or by currency crises when monetary tightening may lead to an immediate depreciation of the exchange rate instead of an appreciation. This atypical reaction is usually referred to as the "*exchange rate puzzle*" Arnostova and Hurnik (2005), Mirdala (2012). As for the behavior of prices, atypical reaction occurs quite often and it is described in a series of works dedicated to the analysis of the impact of monetary policy changes on the price level. Studies offered several explanations for this problem. One of them is the misidentification of monetary shocks associated with a weak reaction of the interest rate to a given inflation. In other words, what is considered to be a monetary policy shock is in fact a combination of an actual shock and endogenous responses of the monetary policy (Balke and Emery, 1994). Another approach explains the existence of a price puzzle and unexpected price response by a bad estimation of the model (Rusnak et al., 2013).

The effects of monetary policy in terms of its transmission and effectiveness in specific countries is a richly discussed topic in numerous empirical studies. The results of studies realized on data collected before financial and debt crises in 2008 showed that the interest rate channel is the most important for monetary policy transmission in the Eurozone as it enables the direct pass-through of monetary shocks (such as a monetary policy tightening or loosening) (Angeloni et al., 2003). According to their findings, the

effects of the monetary policy on the output and the prices of the Eurozone aggregate was consistent with the effects of monetary policy shocks identified within each country. The reaction of the output to an unexpected increase in the short-term interest rate was only temporal and the response of prices was delayed up to four quarters. In the case of V4 countries (Poland, Czechia, Hungaria and Slovakia), analyses confirmed the importance of the interest rate channel in comparison with other transmission channels. Egert et al. (2007) analyzed the process of interest rates transmission in the CEE-5 countries after their accession to the European Union in 2004. The aim of their analysis was also to determine whether, in the case of future enlargement of the Eurozone by one of these countries, the transmission mechanism through the interest rate channel would suffer of heterogeneity. Several monitored interest rates revealed a weaker response than the literature suggests, indicating a lower degree of cointegration between the monetary policy rate and long and short-term market interest rates. Moreover, in the long run, this process has been further weakened. However, they concluded that the interest rate channel is more effective in CEE-5 countries than in the so-called "core countries" of the Eurozone and is comparable to the so-called "catching-up countries" such as Spain. Thus, the accession of new members should not make the Eurozone more heterogeneous in terms of the interest rate transmission mechanism quality. E.g. Arnostova and Hurnik (2005) used vector autoregression approach in order to analyzed transmission mechanism in the case of Czech Republic over the period 1994-2004. Their results showed that the unexpected tightening of the monetary policy led to a fall in output, whereas the prices remained persistent for a certain time and started to fall after approximately two quarters. The exchange rate reacted by immediate appreciation.

The interest in analyzing transmission processes of monetary policy has increased with regards of crisis consequences even more. One of the most important findings revealed that the traditional, interest rate channel can be considered as the most affected. Effects of financial crisis on interest rates pass-through was also analyzed in IMF's Global Financial Stability report (IMF, 2012). The report compared the interest rate pass-through to the short-term interest rates as well as to the long-term interest rates in case of the Eurozone and the United States. According this report, the financial crisis marked the transition from the short-term interest rates to the long-term interest rates in both the United States and the Eurozone. Badarau and Levieuge (2011) analyzed the role played by the financial heterogeneity of the countries of the monetary union and its consequences in terms of cyclical economic development. They showed that the common monetary policy has contributed to the deterioration of cyclical differences of union's countries compared to the situation if these countries were hit with shocks and still had their independent monetary policies. Further work has shown that, due to the crisis, it is no longer possible to fully trust Taylor-type monetary rules (Sinicakova and Pavlickova, 2011). The main problem of the short-term interest rate is its effectiveness, notably during the crisis, when the rates were reduced to zero values. Consequently, the transmission to real macroeconomic variables was relatively weak. They point out that using a short-term interest rate under a fixed monetary rule may be less effective than managing it under inflation targeting.

Wieladek and Pascual (2016) used a Bayesian vector autoregressive model (VAR) to calculate the impact of the current quantitative easing in the Eurozone and used impulse response analysis to investigate the impact of the individual monetary transmission channels. They examined the impact of the ECB's quantitative easing on Eurozone real GDP and core CPI on monthly data from 2012M6 to 2016M4. They concluded that in absence of the first round of ECB quantitative easing, real GDP and core CPI would have been 1.3% and 0.9% lower, respectively. The effect is roughly 2/3 times smaller than in the UK and US. Impulse response analysis suggested that the policy is transmitted via the portfolio rebalancing, the signaling, credit easing and exchange rate channels. Spanish real GDP benefited the most and Italian the least.

Geis et al. (2020) investigated how a future tightening of the ECB's monetary policy may affect countries located in the vicinity of the Eurozone namely Bulgaria, Croatia, Czech Republic, Hungary, North Macedonia, Poland, Romania and Serbia i.e. CESEE region. They find that a Eurozone monetary tightening does trigger sizeable spillovers to the CESEE region. They showed that in the context of a demand shock-induced monetary tightening, which is more realistic than the usual approach taken in the literature, CESEE countries' output and prices actually respond positively. Spillovers on output and prices in CESEE countries are heterogeneous, and depend on the trajectory of Eurozone tightening. The recent

studies on effectiveness of negative interest rates ECB policy showed, that banks offering negative rates provide more credit than other banks suggesting that the transmission mechanism of monetary policy is not hampered. The negative interest rate policy provides further stimulus to the economy through firms' asset rebalancing. Firms with high current assets linked to banks offering negative rates appear to increase their investment in tangible and intangible assets and to decrease their cash holdings to avoid the costs associated with negative rates. The results challenge the commonly held view that conventional monetary policy becomes ineffective when policy rates reach the zero lower bound. Burlon and Holton (2019) Therefore, the aim of our investigation is to monitor the transmission process of monetary policy via an interest rate channel in the case of selected Eurozone countries. The vector autoregression approach will be applied and for the selected variables of the model we chose industrial product, inflation and exchange rate, i.e. the variables that central banks typically use within their monetary rules. The main objective is to verify the reaction of inflation and other variables, whether their reactions are lagged or even inverse.

2. OVERVIEW OF VAR MODEL

Monetary transmission processes are often analyzed using vector autoregression models (VAR models). The standard VAR approach assumes that the dynamics of the economy can be described by a set of macroeconomic variables. Even though some authors argue that this approach cannot be considered realistic, VAR model remains one of the most often used in modelling of monetary transmission processes. A vector autoregression approach enables to study the impact of monetary shocks on selected variables and allows a cross country comparison. VAR models represent dynamic systems of equations in which the current level of each variable depends on past movements of that variable and all other variables involved in the system. To identify structural shocks that affect endogenous variables of the model, we implement recursive Cholesky decomposition of variance-covariance matrix of model residuals. Cholesky decomposition of the residuals implies the contemporaneous interactions between exogenous shocks and the endogenous variables are characterized by a causal chain. Ordering of endogenous variables then reflects expected particular economy structure following general economic theory assumptions. Unrestricted VAR model can be represented by the following infinite moving average representation:

$$KY_t = AY_{t-1} + BX_t + \varepsilon_t \qquad (1)$$

where

$$Y_t = [y_t, p_t, i_t, e_t] \qquad (2)$$

is a *nx1* vector of endogenous variables of the model, where *yt*– real product (industrial production index), *pt* – domestic consumer price index (CPI), *it* –money market 3- month interest rate; *et*- nominal effective exchange rate (NEER). Selected ordering of the variables in the vector of endogenous variables takes into account the sequence of transmission of monetary policy from short-term interest rates to other variables. The matrix *A* is a polynomial of variance-covariance matrices in the form of *nxn* representing the relationship among variables on the lagged values, the matrix *B* includes all coefficients expressing the relationships between endogenous and exogenous variables and the matrix *K* contains all the coefficients describing the simultaneous relations between variables. $\mathcal{E}_t$ is *nx1* vector of structural shocks errors.

Vector of exogenous variables:

$$X_t = [p_{com}, y_t^F] \qquad (3)$$

consist of two variables: world commodity prices index p_{com} and product of Eurozone y_t^F (industrial production index). The reduced form of a VAR model is obtained by multiplying the equation (1) by inverse matrix C^{-1}. This operation is necessary because the model represented by equation (1) is not directly observable and structural shocks could not be identified properly. VAR model described by equation (1) can be modified as follows:

$$Y_t = K^{(-1)}AY_{t-1} + K^{(-1)}BX_t + K^{(-1)}\varepsilon_t = DY_{t-1} + e_t \qquad (4)$$

where *D* is matrix expresses relation between lagged values and e_t represents *nx1* vector of normally distributed errors (shocks in reduced form). Relationship between reduced-form VAR residuals (e_t) and structural shocks ($\mathcal{E}_t$) can be expressed as follows:

$$K^{-1}C\varepsilon_t = e_t \; or \; C\varepsilon_t = Ke_t \tag{5}$$

After implementation of Cholesky recursive scheme for identifying structural shocks of the VAR model, the equation (5) can be rewritten as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{y,t} \\ \varepsilon_{p,t} \\ \varepsilon_{i,t} \\ \varepsilon_{e,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ k_{21} & 1 & 0 & 0 \\ k_{31} & k_{32} & 1 & 0 \\ k_{41} & k_{42} & k_{43} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{y,t} \\ \varepsilon_{p,t} \\ \varepsilon_{i,t} \\ \varepsilon_{e,t} \end{bmatrix} \tag{6}$$

From relation (6) it is clear that the matrix K is a lower triangular matrix (all elements above the diagonal are zero) and the matrix C is a unit matrix (all elements outside the main diagonal are zero). The presented VAR model allows us to calculate the impulse-response functions (IRF) of individual endogenous variables of the model (focusing on the interpretation of IRF inflation results) to assess the extent and nature of the impact of monetary policy shock in individual EU member states. Ordering of variables is based on the considered channels of the monetary policy shock transmission, represented in model by unexpected interest rate growth. To capture the effects in demand, we included the real product, expressed through the industrial production index (data available in monthly frequency while data on real output are reported only quarterly) like many other authors such as Creel and Levasseur (2005), Kapuscinski et al. (2014). For price variable the domestic price indices (consumer price index) was selected. To assess the impact of monetary policy on the inflation and real economy, the money market interest rate will be used similarly, as in the studies of Arnostová and Hurnik (2005), Kapuscinski et al. (2014) and Babecka-Kucharcukova et al. (2013). They pointed out a close link between the main monetary policy rate and money market rates. Moreover, the monetary policy rate of central banks does not change regularly, therefore the three-month money market rate will be used. Similar to Creel and Levasseur (2005), Babecka-Kucharcukova et al. (2013), Dabla-Norris and Floerkemeier (2006) the exchange rate will be expressed by nominal effective exchange rate (NEER). To eliminate the problem of the price puzzle, we took 6 lags (6 months) when estimating the model, similar as Arnostova and Hurnik (2005), Babecka-Kucharcukova et al. (2013) or Kapuczinski et al. (2014). The test of information criteria also confirmed 6 lags as to be most suitable.

To estimate the model, we employ monthly data for period 2000M1-2019M7 consisting of 235 observations. The data are retrieved from IMF statistics (International Financial Statistics), ECB and Eurostat. Our analysis is focused on four Eurozone countries such as Austria, Germany and France so called "old or core" Eurozone countries and Slovakia "new" Eurozone country. The data for other Eurozone countries were not fully available for whole observed period and variables. All variables except interest rates are in the form of indices (2010=100) and are seasonally adjusted. It is necessary to test the variables for the stationarity of the time series, as well as for the existence of a long-term equilibrium before the applying the model. It is also necessary to check the model for the autocorrelation, the residual heteroscedasticity and the normality. To save the space, the next part of the paper presents only selected test results. Other results are available from the authors upon request.

3. EVOLUTION OF VARIABLES AND RESULTS OF THE TESTS

When constructing the model, we assume that monetary policy decisions of the central bank and changes of its key interest rates are transmitted to the interest rates on the money market. This suggests that changes in setting of 2-week interest rate for the main refinancing operations (CBIR) are later closely copied by the development of 3-month EURIBOR (Figure 1). In other words, the evolution of the EURIBOR reflects the changing stance of the ECB. The central bank's key interest rate and the money market interest rate present a high degree of correlation; thus money market interest rates can be used for estimating changes in monetary policy stance.

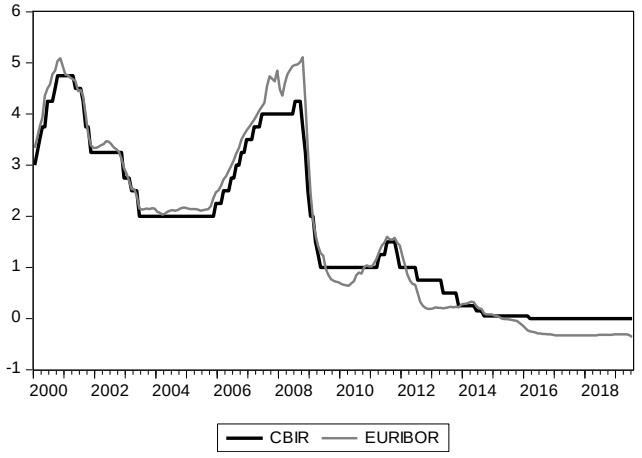

Figure 1. Interest rates

Source: Data from ECB

The evolution of interest rates in Eurozone countries indicate that base interest rates reached the highest level right before the economic crisis. Year 2009 brought about the reversal in the character of monetary policy, changing the focus of the European Central Bank from decelerating inflation rates to stimulation of the economy of the Eurozone countries. That is why the ECB adopted rather expansionary policies with interest rates close to zero and even negative.

Behavior of inflation in the Eurozone over the period 2000 - 2007 was relatively stable (Figure 2). Since the end of 2007 to the end of the reporting period the development of inflation has been more volatile with sharp decrease connected to the crisis as well as a significant increase that followed up. Since 2014, the inflation has increased too slowly, so the ECB had to implement unconventional instruments in order to avoid the danger of deflation.

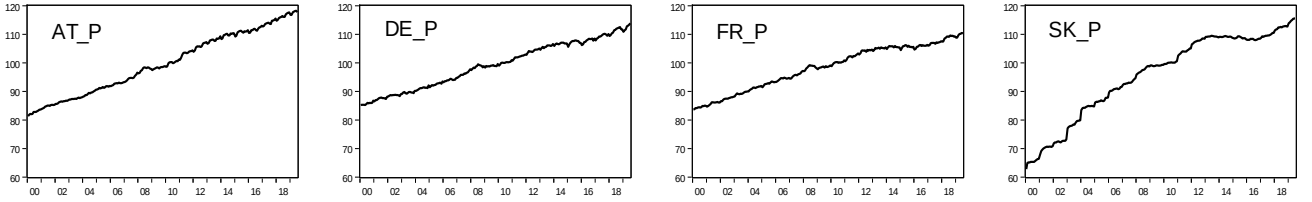

Figure 2. The evolution of prices in individual Eurozone countries (Index 2010=100; Austria (AT); Germany (DE); France (FR); Slovakia (SK))

Source: Data from IMF

The inflation behavior in Slovakia can be described as much more volatile as in the case of "old" Eurozone countries. Moreover, Slovakia belonged to the part of Eurozone countries characterized by a higher rate of inflation. Price volatility in Slovakia was associated with the deregulation process and various administrative measures, especially at the beginning of the monitored period. However, the economic crisis has also significantly affected the development of prices in the "new" member states, and the post-crisis development is already marked by slow growth (NBS, 2020). The industrial production index (IPI) is a business cycle indicator which measures monthly changes in the price-adjusted output of industry. Since 2000 total industrial output had been on a relatively steady growth path in the Eurozone countries as well as in Slovakia. The production level reached its highest value in 2008 and afterwards fell continuously for one year. Afterwards the indicator steadily increased again and regained over 90 % of its pre-crisis value in 2011. The 2009 decline in production was particularly strong for the production of basic metals, machinery and equipment, and for motor vehicles which together account for more than

one fifth of total EU industrial production. The only sector that did not register a decline in production levels during the crisis years was the pharmaceutical industry. In the second half of 2011 and in 2012, industrial production was on a slow downward trend. Since early 2013 the index value slightly but steadily increased and almost regained its pre-crisis level by the end of 2017. In 2018 and 2019 industrial production stagnated. During the last four years particularly strong increases in industrial production were recorded in Austria and Slovakia (Figure 3) (Eurostat, 2020).

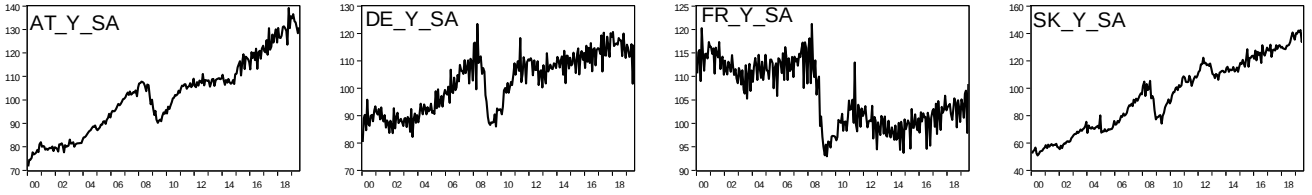

Figure 3. The evolution of IPI (Index 2010=100%; Austria (AT); Germany (DE); France (FR); Slovakia (SK))

Source**:** Data from IMF

The last surveyed variable is a nominal effective exchange rate. It represents the exchange rate in the model. NEER is the weighted average of the bilateral exchange rates of the domestic currency against the currencies of the relevant country´s trading partners. Based on the Figure 4, we can follow the evolution of NEER. Generally, we can observe a trend of gradual appreciation with the shorter periods when NEER depreciated, then resumed its previous course. As expected, the years of economic crisis are marked with the most prominent depreciation of the surveyed period. In the case of Slovakia, NEER appreciated continually until 2008. Since then, the evolution of NEER can be described as a rather volatile. Nevertheless, the appreciation that appeared after 2008 was not as strong as before 2008 and the exchange rate did not surpass its levels from before crisis period.

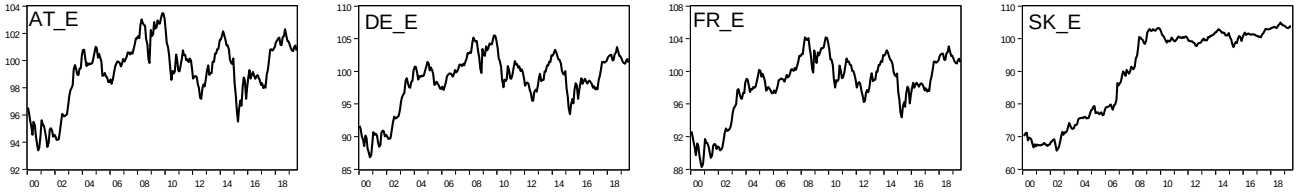

Figure 4. The evolution of NEER (index 2010=100; Austria (AT); Germany (DE); France (FR); Slovakia (SK))

Source: Data from IMF

Before the model estimation, it is necessary to test time series of variables for stationarity and cointegration. In order to verify the stationarity of time series we use unit roots test - Augmented Dickey-Fuller Test (ADF) and Phillips – Perron (PP). Both tests verify the null hypothesis of the existence of a unit root. If the hypothesis were confirmed, it would mean that the time series are non-stationary. Observed time series were mostly non-stationary at values, therefore it was necessary to test them for the stationarity also at their first differences. Here, the stationarity was confirmed and the null hypothesis of the unit root presence was rejected (Table 1).

Testing for the cointegration verifies the existence of stable long-term relations between endogenous variables of the model. For this purpose, Johansen test was used with a number of delays equal to 6 (determined according to AIC, LR and FPE information criteria). The results of both test statistics (trace test and maximum eigenvalue statistics) did not confirm the presence of cointegrating equation (Table 2) and thus a VAR approach can be applied.

Table 1. Results of the unit root tests, Austria (AT); Germany (DE); France (FR); Slovakia (SK)

		I - ADF	*I - PP*	*Y - ADF*	*Y - PP*
AT	level	-1.556225	-1.167542	-0.456875	-0.875137
	1st diff.	-6.371254*	-6.371254 *	-17.21372*	-31.25148*
DE	level	-1.556225	-1.167542	-1.533591	-3.197901**
	1st diff.	-6.371254*	-6.371254 *	-7.680223*	-37.89180*
FR	level	-1.556225	-1.167542	-1.584063	-3.979004**
	1st diff.	-6.371254*	-6.371254 *	-27.16568*	-44.23122*
SK	level	-2.490172	-2.320346	-0.588979	-0.604878
	1st diff.	-10.98549*	-11.28195*	-23.70285*	-23.81041*
		E - ADF	*E - PP*	*P- ADF*	*P - PP*
AT	level	-2.204158	-2.058807	-0.143886	-0.163689
	1st diff.	-12.48580*	-12.46429*	-13.97747*	-14.10861*
DE	level	-2.223206	-2.065302	-0.048452	-0.048452
	1st diff.	-12.25953	-12.23532*	-9.836888*	-17.35178*
FR	level	-2.059146	-1.910190	-1.779973	-1.541459
	1st diff.	-12.39969*	-12.36786*	-13.52277*	-13.75847*
SK	level	-1.192742	-1.174173	-5.162404*	-3.820139*
	1st diff.	-12.36100*	-12.36100*	-7.967995*	-14.55822*

Note: Data represent results of t-statistics. Null hypothesis can be rejected at 1% significance level (*), at 5% significance level (**), at 10% significance level (***).Y = product (industrial production index); I = interest rate (money market 3-month interest rate); E = nominal effective exchange rate (NEER); P = consumer price index

Source: own calculations

Table 2. Results of the cointegration tests

	Number of equations	*Trace Statistics*	*0.05 Critical Value*	*Eigenvalue*	*0.05 Critical Value*
AT	none	86.29902	95.75366	26.01031	40.07757
DE	none	82.17367	95.75366	33.22389	40.07757
FR	none	83.84902	95.75366	38.28338	40.07757
SK	none	93.30449	95.75366	43.85942	40.07757
	at most 1	49.44507	69.81889	16.76510	33.87687

Source: own calculations

In order to verify the stability of the model we used the AR roots test. The graphs (Figure 5) show that none of the points exceeds the circle, thus the estimated VAR models for each countries were considered stable.

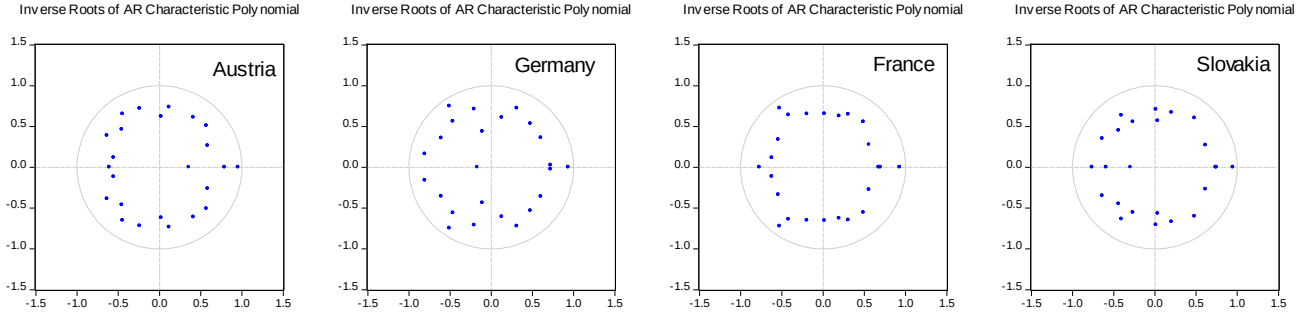

Figure 5. AR root tests

Source: own calculations

4. DISCUSSION OF RESULTS

Estimated vector autoregression models enable to analyze impulse response functions for selected endogenous variables. The results are grouped by variables in order to simplify the comparison of the responses for each country. We focus solely on the response of endogenous variables to changes in interest rates. The estimated response of variables to a monetary policy shock is observed over the period of 18 quarters after initial shocks. As mentioned previously, in the case of an unexpected monetary tightening (monetary policy shock in the form of sudden increase of interest rate) the theory suggests: a production decline, a price level decline (with possible time lags) and the appreciation of the country's exchange rate. For a reaction of prices, the theory indicates that the increase of interest rate should slow down the increase of prices causing the inflation rate to drop down. However, as explained previously, sometimes an unusual behavior in the form of sluggish or even positive response of prices can appear after an unexpected monetary tightening ("price puzzle"). The Figure 6 depicts the impulse-response function for price levels in analyzed Eurozone countries over the period of 2000- 2019. We can see that the expected downward trend appears, but not immediately. In most cases, the reaction is lagged by 2 quarters. When comparing the reactions in the so called "old" Eurozone countries (Austria. Germany and France) with Slovakia it can be seen, that the reaction of Slovak price level is more pronounced. Finally, it can be stated, that the interest rate channel of ECB monetary policy is functioning and that reaction of inflation on interest rate shock is in line with theoretical assumptions.

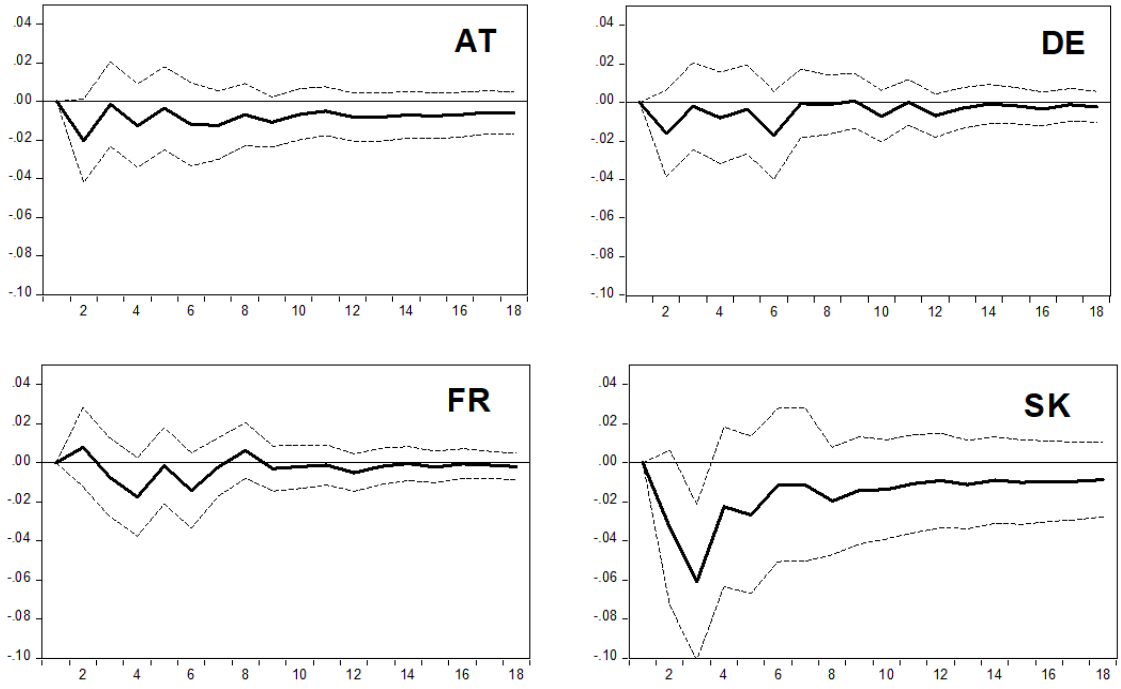

Figure 6. IRF functions – reaction of prices on 1% positive interest rate shock

Source: own calculations

Note: Response of d(P_SA) to d(I); AT = Austria; DE = Germany; FR = France; SK= Slovak republic

Our analysis is extended on reaction of production and exchange rate as well. The reaction of industrial production on 1% positive interest rate can be seen in the Figure 7. Here, the theoretic suggestion about the Eurozone production decline cannot be generally confirmed. Despite positive shock in interest rate, the initial reaction of production is slightly positive. This behavior may be related to the fact that production growth is largely determined by other factors as domestic demand, fiscal policy and external trade development. As a result, transmission of monetary policy measures to variables such as industrial production might have been weakened.

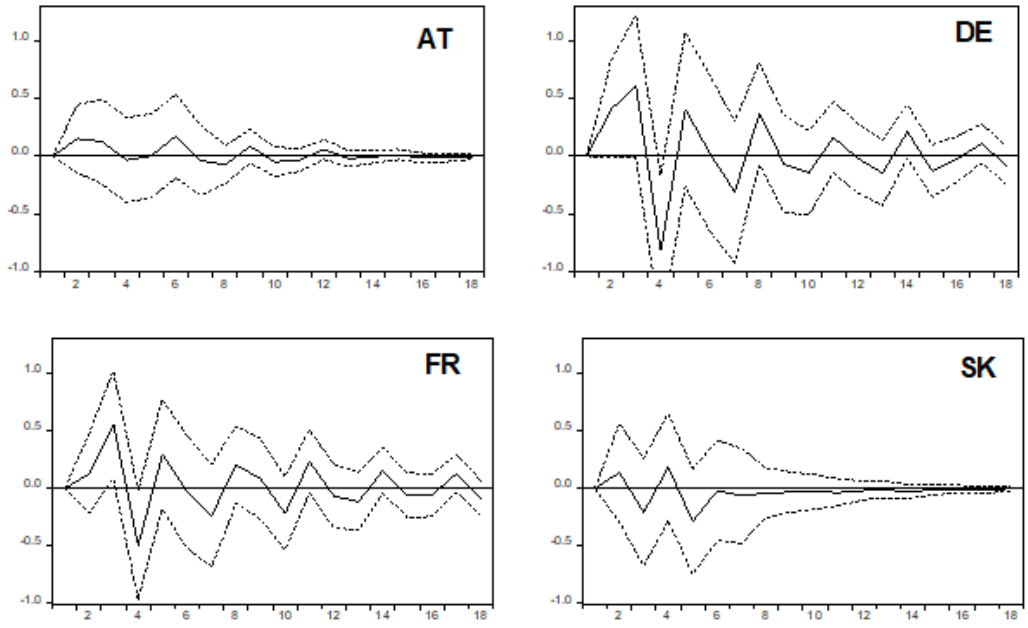

Figure 7. IRF functions – reaction of product on 1% positive interest rate shock

Source: own calculation

Note: Response of d(Y_SA) to d(I); AT = Austria; DE = Germany; FR = France; SK= Slovak republic

The exchange rate was the last variable tested for impulse-response functions. Here the theory indicates that the increase of interest rate should be accompanied by the inflows of foreign capital, causing the appreciation of a country's exchange rate. Based on the Figure 8, we can follow the evolution of NEER after the positive interest rate shock. In all cases the appreciation of the exchange rate is lagged by several quarters. What is more, the reactions differ in their volume. The most intense reaction can be observed for Slovak Republic. Moreover, the responses of NEER in all analyzed countries can be considered very similar.

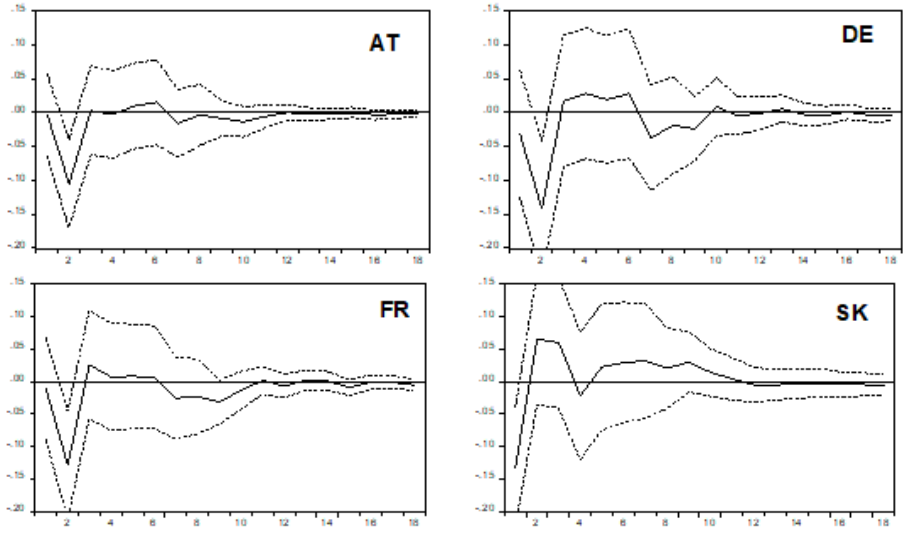

Figure 8. IRF functions – reaction of NEER on 1% positive interest rate shock

Source: own calculation

Based on the estimated model it is possible to continue with a decomposition of variance of endogenous variables. Table 3 shows the contributions of changing the interest rate to the variability of the price level in Austria, Germany, France and Slovak Republic. The results indicate that variations of interbank interest rates had a similar very weak impact on the variability of inflation in Austria (3.61%), France (2.46%), and Germany (1.78%) as well as in Slovakia (5.68%). The sensibility of the reaction of the price level in Eurozone countries can be explained by the relatively stable behavior and low rate of inflation in the Eurozone over the analyzed period. Based on the results for other variables (not presented here) – production and NEER we could conclude that the contributions of the changing interest rate to their variability were also low. We could therefore assume that there are other channels that play an important role in the transmission of monetary policy measures and that the transmission via the interest rate is weakened.

Table 3. Decomposition of variation of endogenous variables (2002-2012)

P	AT		FR		DE		SK
1	0.000000	1	0.000000	1	0.000000	1	0.000000
6	2.243872	6	2.467708	6	1.706406	6	5.638543
12	3.131935	12	2.508427	12	1.773038	12	5.732415
18	3.613024	18	2.468031	18	1.780703	18	5.687465
Cholesky ordering: d(y_sa) d(p_sa) d(i_sa) d(e_sa)							

Source: own calculation

Many authors noticed that the crisis affected mostly the traditional interest rate channel (e.g. Horvath, Franta and Rusnak, 2013; IMF, 2012). The crisis has also renewed debate of the joining the Eurozone and the advantages of the single monetary policy as a tool for the macro-economic regulation and mitigation of shocks. Unfavorable developments after 2008 still verify the ability of monetary policy to mitigate negative impacts. This can be seen in the context of common monetary policy effects and asymmetries between member countries. Based on our results we can conclude that the interest rate channel did not reveal, particularly a strong and stable effect on the observed variables. Although, the reaction of inflation on interest rate shock is in line with economic theory its intensity is very weak. The comparison of "old" and "new" member country of Eurozone revealed that the inflation, product as well as exchange rate responses to the positive interest rate shock in the Eurozone and in the Slovak Republic are very similar. Our previous study concluded, that there exist asymmetries of reactions as between Eurozone member state (Germany, Austria vs. Portugal, Spain) as between EMU 12 and V4 countries. However, we had stated that due to crises, the responses of variables on interest rate shock in EMU12 and CEE countries have become more similar (Bartokova and Durcova, 2015).

CONCLUSION

The European central bank had to change the monetary policy strategy as well as instruments during the last ten years due to crisis and economic circumstances. Persisting problems of low economic growth and stagnant Eurozone economies forced the ECB to use less conventional monetary policy measures as quantitative easing. Therefore, the question of traditional interest rate channel effectiveness in influencing the inflation and real economic performance is raising. Many empirical studies had concluded that the interest rate channel of ECB monetary policy was considered as the most affected by the crisis. Moreover, the differences among Eurozone countries still exist. Therefore, the aim of this paper was to investigate the interest rate channel capabilities to influence the inflation behavior in different Eurozone countries such as Austria, Germany, France and Slovakia.

The reaction of inflation on 1% positive interest rate shock was examined via the vector autoregression model. VAR model allowed to compute impulse-response functions for estimation of interest rate pass-through to inflation and other macroeconomic variables. We have verified the similarity of individual responses to interest rate shock of four Eurozone countries. The basic variables of the model were mon-

ey market interest rate, inflation, product and exchange rate, i.e. variables that are generally used in the central bank monetary rules. The aim of the analysis was to evaluate the efficiency of the interest rate channel. Our analysis was based on several expectations. We assumed that negative developments related to the crisis can distort the transmission of monetary policy effects on macroeconomic variables and that the impact of monetary policy changes are transmitted to the economic variables only partially or significantly lagged. To identify structural shocks that affect endogenous variables of the model, we implemented recursive Cholesky decomposition of a variance-covariance matrix of model residuals. We employed monthly data for period 2000M1-2019M7. Comparison of the reactions of variables in the "old" Eurozone countries with Slovak Republic revealed that the effects of positive interest rate shock are very similar. Another important outcome is a fact, that the interest rate channel did not reveal particularly a strong and stable effect on the observed variables. Although, the reaction of inflation on interest rate shock is in line with economic theory, its intensity is very weak. It could indicate the future complication of monetary policy and its interest rate channel in affecting inflation behavior.

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