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ASSESSING POTENTIAL SPILLOVERS FROM ECB MONETARY POLICY MEASURES IN THE NON-EURO AREA COUNTRIES: A BAYESIAN VAR APPROACH

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ABSTRACT

Assessing potential spillovers from monetary policy measures implemented by the European Central Bank has become an important concern in a globalized world. The interest in studying the impact of monetary policies adopted by the ECB on the non-Euro area countries has grown over time, and this crisis caused by the COVID-19 pandemic is a suitable moment to continue the analysis of other authors. The research focuses on the four CEE countries that are European Union members, but not EMU participants - Czech Republic, Hungary, Poland and Romania.

The paper sheds light on the impact of the monetary policy implemented by the ECB on the emerging economies from the non-Euro area.

The empirical analysis has been carried out on monthly data between 2010 and 2021. The econometric model includes five endogenous variables such as industrial production, inflation rate, real effective exchange rate, unemployment rate and 3-month interest rate, and three exogenous variables including 3-month EURIBOR rate, total assets of the European Central Bank and VSTOXX index. The paper applies a Bayesian VAR model to estimate the spillover effects from the ECB's monetary policy and to demonstrate the efficiency of the contractionary monetary policy implemented by the national central banks in each country, using a consistent set of endogenous and exogenous variables. To confirm the obtained results in the estimation of the impact of the monetary policy adopted by each national central bank, a Panel VAR model was estimated.

Extant results showed that the responses to an exogenous shock from the monetary policy adopted by the ECB are weak and statistically insignificant. This outcome led the analysis to a further estimation of the impact of the monetary policy implemented by the national central banks from each country, in order to make a comparison between the monetary policy of the Eurozone and the monetary policy adopted by the four emerging countries.

1. INTRODUCTION

The fundamental goal of the monetary policy is represented by price stability. In order to support this goal, monetary policy is usually divided into two categories: conventional monetary policy and unconventional monetary policy.

The conventional monetary policy entails setting the monetary policy interest rate, which influences the aggregate demand, as well as implementing money market operations, standing facilities and the provision of minimum reserves, all of which are considered traditional instruments that central banks frequently employ to achieve their objectives. In addition, in contrast to traditional monetary policy, unconventional monetary policy is represented by forward-looking prospective, long-term refinancing operations, and asset purchase programs, such as quantitative easing methods.

Many central banks in advanced economies responded to the recent financial global crisis in 2007 by implementing several unconventional monetary policy measures. The development of the following major difficulties necessitated the adoption of such measures: short-term nominal interest rates have been dropped closer to zero, there were persistent deflationary pressures, and economies showed no indications of recovery. Since October 2008, the European Central Bank (ECB) has introduced several non-standard monetary policy measures for the purpose of supporting the economies of the European and Monetary Union that have adopted the euro since 1999. However, assessing the effects of these measures and their potential spillovers towards non-Euro countries has become an important concern in a globalized world. Hence, the interest in studying the impact of monetary policies adopted by the ECB on the non-Euro area countries has grown over time, and this crisis caused by the COVID-19 pandemic is a suitable moment to continue this analysis, particularly since the literature in the field is rather scarce.

The aim of this paper lies in identifying the potential spillovers of the ECB's monetary policy measures to European countries that are not Eurozone members and have not entered the Exchange Rate Mechanism II yet: Czech Republic, Hungary, Poland, and Romania. The economies were chosen not only because they are EU members, but also because they are potential candidates for the adoption of the euro currency, being more influenced by the changes in ECB's monetary policies.

The Czech Republic, Hungary, Poland, and Romania hold a distinctive status as EU members that maintain monetary autonomy outside the Eurozone. These countries have comparable experiences of post-communist transition and European Union membership (Czech Republic, Hungary, and Poland in 2004; Romania in 2007), while preserving their financial autonomy via their national currencies—the Czech koruna, Hungarian forint, Polish zloty, and Romanian leu. Furthermore, they are regarded as emerging economies with significant potential for economic growth owing largely to their strong economic and financial connections with the Euro region.

CEE countries characteristics include export-driven economies, a financial sector favourably impacted by ECB decisions, a banking sector comprising eurozone financial institutions, similar monetary policies, similar exchange rate regimes, and reliance on foreign direct investments, which make them a suitable group for analysing ECB monetary policy spillovers. (Pilinkienė, 2016, Kulbacki and Michalczuk, 2021). At the same time, their individual differences facilitate a significant comparative analysis of the manifestation of these spillovers across varying economic frameworks.

Recognizing the potential impacts of ECB monetary policy measures on non-euro area nations is essential due to their asymmetric integration within the EU. Examining them facilitates a more nuanced evaluation of the effects of ECB policies on non-EMU countries, and this research seeks to address a gap by assessing these varying implications.

Further, recent studies such as Pantovic et al. (2023) demonstrated that monetary policy outcomes differed significantly between EMU and non-EMU countries. The

European Central Bank's policies had negative spillover effects on non-EMU nations because of the asymmetric level of integration within the EU. These outcomes have a negative impact on growth and prices in CEE countries. But, according to Fedajev et al. (2023), improved coordination at the EU level is essential for overall macroeconomic stability, highlighting the necessity for the ECB to play a substantial role in ensuring alignment between monetary and fiscal policies. This is supported by Passamani et al. (2015) and Gruppe et al. (2017), who found that the ECB's involvement boosts sustainability perceptions and marks a milestone in European economic integration.

Also, the study of Goczek and Witkowski (2023) supports the idea that the spillover effects of the ECB's unconventional monetary policy on CEE countries are largely insignificant and comparable to those of conventional monetary spillovers. While CEE countries maintain a degree of monetary autonomy, they are also vulnerable to foreign financial disruptions and market volatility. This is particularly relevant given the high degree of trade integration in the EU.

Three main questions are addressed by the research in the paper, as follows: (i) Does the monetary policy adopted by ECB influence the economies of the countries that are not in the Euro area?; (ii) Through which economic channels are shocks transmitted to the macroeconomic variables?; and (iii) How do the monetary policies implemented by the national central banks differ in terms of efficiency from the monetary policy of the Eurozone? Our aim is to provide evidence that there exists a relationship between the Eurozone and the emerging countries that are not Euro area members. Moreover, the paper reveals that a contractionary monetary policy implemented by the national central banks affects in a different way the macroeconomic variables of each country taken into consideration.

The paper provides several important contributions to literature. First, it addresses an important gap by investigating ECB monetary policy spillover effects on EU members outside the Euro area, offering needed insights into how ECB decisions affect emerging economies that are potential future Euro adopters. Second, the paper offers a valuable comparative assessment of monetary policies by demonstrating that while spillover effects from ECB decisions exist, they are notably weaker than the impacts of domestic monetary policies implemented by national central banks. This is an important finding for monetary coordination as these countries consider Euro adoption. Third, the study employs sophisticated Bayesian Vector Autoregressive (BVAR) modelling alongside Panel BVAR frameworks with sign restrictions for shock identification. From this perspective, this enables more nuanced analysis of both conventional and unconventional monetary policies across multiple countries. Moreover, this dual approach reconciles the need for country-specific analysis with the power of panel data to identify more generalizable patterns in the transmission of contractionary monetary policy. Finally, by examining transmission channels during both the 2007-2008 financial crisis and the COVID-19 pandemic (through January 2021), the research is one of the first comparative analyses of how ECB monetary policy spillovers operate during different crisis types, as it identifies specific channels through

which exogenous shocks propagate from the Eurozone to non-Euro economies during turbulent times. Adding to these contributions, this study serves as support in the direction of analysing the impact of the European Central Bank's monetary policy on the non-Euro area economies, filling a gap in literature where little research has been done on the influence on macroeconomic factors, with most papers focusing on the response of financial markets to monetary policies.

The following is a breakdown of the paper's structure. The next part covers the most important contributions to the literature on the subject, followed by Section 3 which details the design of our empirical study. In Section 4, we highlight the most relevant findings and analyses their relevance considering previous research. The final section of the report summarizes the key findings and analyses research limitations as well as future research directions.

2. LITERATURE REVIEW

The 2007 financial crisis impacted the global economy. Macroeconomic data revealed erratic behaviour, a global economic downturn, and increased financial market risk and uncertainty. Despite central banks' unconventional strategies to mitigate global financial crises after Lehman Brothers' collapse, literature has focused on industrial output and price levels in relation to traditional monetary policies.

The research concerning ECB monetary policy is not extensively developed, with most articles concentrating on its effects on financial markets. The literature presents various methodologies for examining the macroeconomic impacts of the ECB's monetary policy, but because of the weak variables' responses to exogenous shocks, we can assume that there might be a possibility of false representation or an improvement of the economy based on the aid from the ECB that is too small to be taken into consideration. A recent paper by Nocoń (2021) used a BVAR model to evaluate the monetary policy transmission mechanism, identifying economic change drivers, and predicting reactions in uncertain situations.

But to fully understand the macroeconomic implications of the implemented monetary policy, it is essential to ascertain its measurement to later evaluate its influence on the factors in question. Thus, Gambacorta et al. (2014) proposed assessing unconventional monetary policy by examining central banks' balance sheets. In contrast, Wu and Xia (2014) suggested a "shadow rate" to quantify unconventional monetary policy when monetary policy rates are close to zero.

Before discussing further research on the spread of monetary policy effects, the mechanism of monetary transmission must be explained. Monetary decisions affect GDP, inflation, and other macroeconomic variables. Taylor (1995) argued that modelling the exchange rate, long-term interest rate, and short-term interest rate is necessary to explain how monetary policy affects GDP and inflation. Taylor's result

supports an internationalized framework prone to exchange rate changes, which is crucial in analysing monetary policy transmission.

Moving the discussion to the area of econometric models, Christiano (2012) discusses two impulse-response function problems in an essay on Sims and VAR-type models to provide an overview of econometric calculation. It is stated that VAR models are practicable and widely utilized. Thus, a structural VAR can be estimated to track the dynamic impacts of monetary policy shocks on macroeconomic variables including inflation, industrial production, and the exchange rate to demonstrate their importance in understanding economic downturns. Clarida (2001), along with Amato et al. (2002), Eggertsson and Woodford (2003) and Mohanty et al. (2004), examined how advanced economies' monetary policy was implemented and kept inflation low throughout economic crises. Starting with Taylor's "forward-looking" rule, the author proposes implementing the formula with different parameters for open economies or monetary unions with the same inflation-targeting monetary policy.

Since macroeconomics literature does not present an exact definition of a shock, Ramey (2016) believes that shocks are closely related to errors in a system of simultaneous equations, being uncorrelated with each other and having economic significance. At the same time, shocks must be exogenous to the model's endogenous variables, uncorrelated with previous disturbances, and regarded as unanticipated events.

Given the importance of monetary policy decisions that influence the economy, specialized literature identifies and explains monetary policy disruptions. Benkovskis et al. (2011) conducted one of the initial studies investigating the cross-border effects of Eurozone monetary policy, utilizing a Factor Augmented VAR model to incorporate numerous macroeconomic parameters and mitigate errors from omitting components. According to the research, an unexpected hike in the Eurozone interest rate caused the economies of the Czech Republic, Poland, and Hungary to contract. Bernanke et al. (2005) also revealed that Structural VAR models are commonly employed to evaluate monetary policy innovations, although they have drawbacks. The article tries to tackle the hypothesis's difficulty of having a limited number of variables and implicitly a decreased number of impulse-response functions. Thus, the FAVAR method permits macroeconomic model examination of many indicators, because central banks monitor hundreds of factors when making economic policy decisions.

The study by Kenourgios et al. (2019) evaluated the effects of the European Central Bank's four quantitative easing programs. The ECB employed unconventional measures to boost liquidity and maintain healthy lending to the economy, restoring monetary policy transmission channels. Few authors, notably Lenza et al. (2010), have addressed this issue. According to the authors' Bayesian VAR Model, the unconventional monetary policy has a positive effect on the financial channel, but GDP and unemployment have a delayed positive response, while inflation has an immediate adverse effect.

In a globalized world where the effects of economic changes in one country can be transmitted to other economic environments, it is inevitable for the ECB's monetary policy to be transmitted outside the Eurozone, especially in Central and Eastern European countries due to their commercial and financial ties with advanced economies. CEE countries' internal factors are heavily influenced by Eurozone monetary policy, according to Wierzbowska (2015). The study compares Eurozone monetary policy to domestic monetary policy and finds that industrial production and inflation decline dramatically when faced with external shocks. Domestic monetary policy shocks had the largest influence on the Czech Republic, Hungary, and Poland, however results varied. Halova and Hovarth (2015) found that ECB's total asset growth increased industrial production and inflation. Additionally, small adjustments of macroeconomic variables may reduce their reactions to external shocks. Several authors, including Anzuini and Levy (2007) defined the channel of transmission of monetary policy impulses as how national central bank monetary policy rates affect the economy. Thus, strong financial markets are essential for intercepting and conveying monetary shocks to the economy.

Even though the monetary policy rate rise boosted inflation expectations, Champagne and Sekkel (2018) discovered that GDP declined more than prices in the context of target policy rate adjustments. Theodoridis and Mumtaz (2019) explored how business cycle shifts and monetary policy shocks affect volatility. Further, the authors suggest that real labor market frictions and the monetary authorities' willingness for gradual policy adjustments affect the transmission of the policy shock. Černohorská (2021) examined the long-term relationship between monetary policy and economic variables like as GDP, inflation, and private non-financial sector bank loans. Transmission channels are important because central bank instruments do not directly alter monetary policy goals. Also, Benecka et al. (2020) utilize a GVAR model to demonstrate how the European Central Bank's unconventional monetary policy influenced Central, Eastern, and Southern Europe. The authors calculated a "shadow rate" for each country when the monetary policy rate approaches zero and showed that an increase in the "shadow rate" lowers GDP and prices, a topic not addressed in previous publications.

The literature on spillover effects is constantly evolving, and Hajek and Horvath (2018) by analyzing the ECB's and US Central Bank's "shadow rates" and Eurozone prices found that these monetary shocks indirectly affect the non-Euro zone with small but significant effects, taking into consideration that unconventional monetary policy initiatives are less effective than conventional ones. South-Eastern Europe's economies are less affected by the ECB's policies, reflecting their trade and financial integration with the Eurozone. Most imports come from the Eurozone and many foreign banks are in non-Eurozone countries, but their development level is crucial to interpreting the ECB's monetary policy shock responses. Another noteworthy study is Potjagailo (2017)'s investigation of Eurozone monetary policy transmission to 13 non-Eurozone nations. Wu and Xia (2014) "shadow rate" was used to analyse the ECB's

unconventional monetary policy, and the impulse-response functions showed that financial and commercial channels effectively transfer exogenous shocks.

In their research, Husted et al. (2020) created a monetary policy uncertainty index that encompasses conventional and unconventional policy and is preferable during zero lower bound periods. Market-based indicators fell faster and stayed lower than other indexes during ZLB. Additionally, Kucharcukova et al. (2016) suggested that unconventional monetary policy has grown in relevance and efficiency. The European Central Bank initially adopted strategies to boost banking liquidity and money market lending. Additional steps were taken to boost economies as the 2007 crisis worsened and monetary policy rates approached zero. The authors note that macroeconomic variables respond differently to ECB unconventional monetary policy shocks. Rapid and sustained inflation dynamics had little impact on industrial production. Also, the general condition of non-Euro area nations illustrates the importance of ECB monetary policy, describing a large and similar response to Eurozone countries. In contrast, Bluwstein and Canova (2016) found that non-eurozone nations did not respond to ECB monetary measures. The research shows that the ECB's unconventional and conventional monetary policy generated macroeconomic volatility, particularly in inflation and industrial production. Countries with a high level of financial integration have more lasting reactions than emerging countries, and their transmission path is the exchange rate channel, one of the most essential for developed countries.

ECB recent research by Moder (2017) indicated low spillover effects from unconventional monetary policy. The study showed that unconventional monetary policy raised prices in emerging economies that import a lot from the Eurozone. In Romania, the price level responded positively, confirming our results and revealing that the trade and interest rate channels may transmit spillover effects.

This section highlights that, although research exists on the consequences of monetary policies implemented by the ECB, there remains a significant gap in comprehending the transmission channels through which European policies influence countries beyond the euro zone region. Considering this research gap, the main hypothesis of the paper posits that the ECB monetary policy enacted will indirectly influence emerging nations through various monetary policy transmission channels. Alongside, we propose the subsequent hypotheses:

H1. The magnitude of ECB monetary policy spillover differs among the four CEE countries due to their unique economic characteristics.

H2. The transmission channels through which ECB monetary policy is propagated are similar in all four countries.

H3. Domestic monetary policy is more effective in managing the CEE economies than ECB monetary policy.

3. RESEARCH METHODS

Our empirical analysis is supported by the macroeconomic theory that provides numerous economic categories and models of variables that were identified as significant in the extant literature. In this way, our results on the impact of monetary policy implemented by the European Central Bank on emerging non-Euro economies can be explained not only theoretically but also empirically.

Based on the premise that the monetary policy of the ECB might directly affect the developed countries of the euro zone and indirectly affect the emerging countries, we wanted to develop a model that would demonstrate the existence of spillover effects. As a first hypothesis, we intended to highlight the notion that the monetary policy of the ECB generates spillover effects, and as a second hypothesis, we assumed that the monetary policies of emerging countries have stronger connections.

The econometric analysis of the research paper includes two empirical models. The first one is a Bayesian Autoregressive Vector (BVAR) model implemented to provide an individual analysis of the examined countries and to show how macroeconomic variables respond to a monetary policy shock from the policy adopted by the European Central Bank. We complement this approach with a Panel Bayesian VAR implemented to consider the overall situation of countries and to emphasize the importance of a contractionary monetary policy implemented by the national central banks in each emerging country under study country.

Following the contribution of Litterman (1986), the Bayesian Autoregressive Vector was chosen bearing in mind the advantages of using this methodology, such as offering a theoretical ground to impose a priori beliefs to improve the model, handling large cross-sections data, providing a framework for forecasting and the lack of need for stationary data in order to avoid losing important data and information from the times series.

Autoregressive models were introduced by Sims (1980) and represented a fundamental discovery in the study of economic phenomena, given their extraordinary utility for the understanding of mechanisms of propagation of the shocks. Starting from the classical VAR model, the exogenous variables were introduced to better explain the dynamic behavior of the endogenous variables and describe the relationship between them and the endogenous factors. Lutkepohl (2005) exposes the problem of exogenous variables in a VAR model and states that even though the exogenous factors are determined outside the system, they have a significant contribution within the implemented model.

Starting from the VAR model indicated by Lutkepohl (2005), the model can be written as:

$$Y_t = A_1 \cdot Y_{t-1} + A_2 \cdot Y_{t-2} + \dots + A_p \cdot Y_{t-p} + B \cdot X_t + \varepsilon_t \quad (1)$$

where \mathbf{z}_t is a size vector ($K \times 1$) including the endogenous variables in the model, \mathbf{A} are the coefficient matrices of dimension ($K \times K$), \mathbf{B} is a matrix of dimension ($K \times M$), \mathbf{x}_t is a size vector ($M \times 1$) including the exogenous variables of the model and $\boldsymbol{\varepsilon}_t$ is a vector of residuals of the model. K is the number of endogenous factors; M is the number of exogenous factors and p is the number of included lags.

The matrix of residuals has a multivariate normal distribution:

$$\boldsymbol{\varepsilon}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}) \quad (2)$$

The estimation of orthogonal shocks, specifically the impact of the shock of one variable on another variable, while the rest of the variables are kept at constant levels, is an important advantage of a VAR model. The impulse-response functions are used to describe the response of one variable to innovations in another variable in the system, while the rest of the shocks are zero. But to keep the other shocks at zero levels, it is necessary to apply a method of decomposition of the system's variance-covariance matrix of residuals. In the case of Bayesian Panel VAR, we implemented the Cholesky decomposition and in the Bayesian VAR was adopted the shock identification technique by imposing sign restrictions on the impulse-response functions, following Uhlig (2005).

As Ciccarelli and Rebucci (2003) have shown, the Bayesian technique was introduced by Litterman (1986) as a solution to the problem of overfitting, which is a frequent problem in classical VAR models. The Bayesian methods are recommended to be used in time series analysis because they consider the a priori distribution of the data, which provides a better estimate of the impulse-response functions, the historical decomposition and the variance decomposition of forecast errors.

In Bayesian econometrics, each parameter is treated as a random variable that is characterized by a certain probability distribution. In other words, these distribution probabilities must be identified to be able to implement and solve the model. The principle of Bayesian analysis combines a priori information with the information included in data, to obtain a distribution that considers both sets of information. The Bayesian estimation uses the probability density function of the data conditioned by the model parameters and a common distribution of the model parameters. Further on, by employing the Bayes' Rule, it forms the probability density function of data and parameters, always called the "a posteriori" distribution.

After implementing the Bayes' Theorem, the *a posteriori* density distribution of the parameters is obtained:

$$\pi(\boldsymbol{\theta}|y) \propto f(y|\boldsymbol{\theta}) \cdot \pi(\boldsymbol{\theta}) \quad (3)$$

where $\pi(\boldsymbol{\theta}|y)$ is called *a posteriori* distribution of the vector of parameters conditioned by the information contained in y , the vector of data, $f(y|\boldsymbol{\theta})$ is the likelihood function and is represented by the *a priori* distribution.

As presented in their article, Ocampo and Rodriguez (2012), argued that the marginal density of a model exposes the probability that the data series are generated

by a particular model that removes the uncertainty due to the estimated parameter values. Generally, the marginal density is used in choosing the best model.

The choice of a priori distribution is an important issue in the correct estimation of the model. In this research, the Normal-Wishart distribution was chosen:

$$f(y|\beta, \Sigma) \propto |\Sigma|^{-k/2} \exp \left[-\frac{1}{2}(\beta - \hat{\beta})' (\Sigma \otimes (X'X)^{-1})^{-1} (\beta - \hat{\beta}) \right] \times |\Sigma|^{-[(T-k-n-1)+n+1]/2} \exp \left[-\frac{1}{2}tr \left\{ \Sigma^{-1}(Y - X\hat{B})'(Y - X\hat{B}) \right\} \right] \quad (4)$$

Following the methodology performed by Moder (2017) and according to the technical guide of the Toolbox implemented by Dieppe et al. (2016), the advantage of the Normal-Wishart conjugate distribution is given by the presumption that the variance-covariance matrix is unknown, in contrast with the Minnesota Prior distribution.

In addition to this choice of a priori distribution for the implemented research, the choice of the best Bayesian VAR model is made after computing the Bayes Factor, which is represented by the ratio between the estimated marginal densities of two different estimated models. The methodology calculations that were used were implemented according Koop (2003).

We included only one lag in the estimation as specified by the Schwarz Bayesian Information Criterion, but also relative to the calculated value of the Bayes Factor. Also, the a posteriori distribution is derived by Gibbs sampling with a total number of 5,000 iterations and a burn-in sample of 1,000 iterations. The information provided by the Bayesian VAR model was further employed by the analysis of impulse-response functions (IRF), the historical decomposition of the endogenous series (HD) and the forecast error variance decomposition (FEVD).

The stationarity of the analysed data is a fundamental characteristic that must be examined, but following the technical guide adopted by Dieppe et al. (2016), the Bayesian technique allows the VAR models to use non-stationary data in order not to lose the information that can be neglected due to transformation into stationary data series. However, the permanent shocks can lead to the instability of the model. Even though the used data series are not stationary, the estimated model met the stability condition, such as no root of the characteristic polynomial is outside the unit circle. If the model would not have been stable, certain results such as the impulse-response function or the forecast error variance decomposition would not be valid. Likewise, the Schwarz Bayesian Information Criterion indicated one lag for the optimal number of lags of the Panel Bayesian VAR as in the case of Bayesian VAR. To generate impulse-response functions, the identification of shocks is carried out via sign restrictions, following the method proposed by Uhlig (2005).

The variables under observation were chosen in respect with the economic rationale and following mainly the papers of Halova and Horvath (2015), Potjagailo

(2017) and Moder (2017). The endogenous variables taken into consideration were represented by the industrial production, adjusted inflation rate without energy prices, 3-month interest rate, real effective exchange rate and unemployment rate, in each of the countries included in the analysis. The exogenous variables in the model include the 3-month EURIBOR rate, the total assets of the European Central Bank and the VSTOXX index. The monetary policy implemented by the ECB was classified into conventional monetary policy, measured by the 3-month EURIBOR rate and unconventional monetary policy, measured by the total assets of the European Central Bank.

The study focuses on the four European Union members and emerging economies according to the European Bank for Reconstruction and Development, which are not Eurozone members: Czech Republic, Hungary, Poland and Romania. The empirical analysis has been carried out on monthly data for the period January 2010 to January 2021, and the data was collected from Eurostat, ECB Data Warehouse, Investing.com and the Federal Reserve Economic Data St. Louis (FRED). The total assets of the European Central Bank were available only at weekly frequency, so in order to obtain monthly frequency data for this variable, the averages of the weekly data were computed and used as monthly data.

To achieve reliable results, all the variables, except for the 3-month interest rate, the unemployment rate and the VSTOXX index were transformed into their natural logarithm. Further, the other data series entered the model in levels. Moreover, all variables were seasonally adjusted by the Census X-12 seasonal adjustment procedure in EViews 11. The data processing was performed in EViews 11, while the entire estimation was carried out by employing the BEAR Toolbox developed by Dieppe et al. (2016), two economists from the European Central Bank. The procedure was performed in MATLAB 2013.

Following the Uhlig (2005) sign restrictions methodology, Table 1 presents the signs of each endogenous variable used to pursue the effect of monetary policy shocks of a contractionary monetary policy. The response to a contractionary monetary policy shock of industrial production, the inflation rate and the real effective exchange rate is negative, while the 3-month interest rate and the unemployment rate present positive responses.

Table 1. Sign restrictions

	Monetary policy shock
Industrial production	-
Inflation rate	-
3-month interest rate	+
Real effective exchange rate	-
Unemployment rate	+

Source: Uhlig (2005)

4. RESULTS

In this section, we present our most important results and contrast them against existing contributions. An important point to make is that the results obtained in the case of the Czech Republic, Hungary and Poland are not so conclusive and, in some cases, even statistically irrelevant. Overall, our results highlight the effectiveness of the monetary policy implemented by each CEE country and the response of macroeconomic variables to an exogenous shock from the monetary policy adopted by the ECB.

As mentioned earlier, we implemented the impulse-response function, the historical decomposition and the forecast error variance decomposition for the purpose of examining the ECB's monetary policy influence over the emerging economies that are members of the European Union, but not EMU members. Furthermore, impulse-response functions were implemented for the analysis of the contractionary monetary policy.

The results show that the responses to an exogenous monetary policy shock are weaker compared to the responses of the macroeconomic variables to a contractionary monetary policy shock. In the four emerging economies, the degree of intensity of the impact of a contractionary monetary policy is similar, as further presented. Moving on to the panel BVAR analysis, the results of each country are in line with the logic of the overall analysis, despite small differences between the four economies. The dynamic effects of an exogenous shock are limited, and the investigation highlights the effects of a contractionary monetary policy.

4.1. ECB's monetary policy

The impulse-response functions were used to measure and explain the response of macroeconomic variables to an external shock from the European Central Bank's monetary policy. As mentioned above, the ECB's monetary policy is classified in two categories, i.e., conventional monetary policy and unconventional monetary policy. A shock of unconventional monetary policy is represented by an increased level of ECB's total assets in the balance sheet, while a shock of conventional monetary policy is represented by a decline in the 3-month EURIBOR rate.

The responses of macroeconomic indicators in the Czech Republic, in the aftermath of a monetary policy shock imposed by the European Central Bank, are consistent with economic theory and similar to those of other economies, but they are not statistically significant. However, in this case the responses of macroeconomic variables are statistically significant only in the case of the influence of a conventional monetary policy.

In emerging economies, a monetary policy shock from the European Central Bank is indirectly transmitted, whereas in Poland, unconventional monetary policy

measures have no effect on the economic environment because there is no transmission channel. The Romanian economy, on the other hand, exhibits statistically significant responses to an unconventional monetary policy shock, with the highest responses seen in the inflation rate and the 3-month interest rate. Although the responses to conventional monetary policy are economically relevant, only the 3-month interest rate displays statistically significant behaviour.

Certainly, in Hungary, the responses of the inflation rate and the 3-month interest rate are statistically significant both in the case of a conventional monetary policy shock and in the case of unconventional monetary policy shock, being the only emerging country with these characteristics.

Therefore, in Poland, in the case of exogenous shocks, the most affected variables taken into account were the 3-month interest rate and the unemployment rate. The aforementioned variables recorded significant increases of more than 12% in response to the European Central Bank's conventional monetary policy.

When the level of total assets of the European Central Bank is high, industrial production decreases in 3 of the 4 economies studied, while industrial production in Romania shows a significant increase of 3.23% in the first analysed period. Also, in the Romanian case, we observe the highest increase in the inflation rate as a response to an exogenous shock.

In the case of the real effective exchange rate, we can observe the same increase of 0.36%, both in Romania and in the Czech Republic, in the other countries being insignificant increases. Poland saw the largest decline in industrial production in the wake of an unconventional monetary policy shock of 0.42%, while the Czech Republic and Hungary recorded decreases of 0.11% and 0.08%.

In comparison to the exogenous shock of a high level of total assets of the European Central Bank, the exogenous shock from a low 3-month EURIBOR rate affects differently the macroeconomic variables. If the 3-month interest rate showed a slight increase compared to the unemployment rate in the case of the unconventional monetary policy shock, in the face of a conventional monetary policy, the 3-month interest rate showed a rapid increase. In the case of Poland and Romania, the inflation rate recorded the same level of growth.

4.2. Contractionary monetary policy

In all CEE countries the industrial production, the inflation rate and the real effective exchange rate showed a negative response to an increase in the monetary policy interest rate of their national central banks. Another similar characteristic is the positive response of the unemployment rate.

The monetary policy implemented by the national central banks directly influences the dynamics of the economy. In the case of Czech Republic and Poland, the most persistent responses to a contractionary monetary policy shock occur in the

case of industrial production and unemployment rate. Hungary is the only country where the shocks in the national central bank monetary policy have persistent and statistically relevant effect on the real effective exchange rate for almost the entire analysed period.

Regarding the unemployment rate, it shows a statistically significant positive and growing answer to shocks in interest rates up to 12 periods in the case of Czech Republic, while in the case of Poland, the positive trend is relevant throughout the whole investigated period. The unemployment rate in Czech Republic has the highest and increasing over time response, with a value of 1.95%, because of a contractionary monetary policy shock, followed by Poland where the increase accounts for 1.77%. In Hungary and Romania, the increases are less than 1%.

Regarding industrial production, in the case of Hungary, the response is statistically significant over the 20 periods taken into consideration, while in the other three economies the response to a contractionary monetary policy shock is significant for only half of the investigated period.

In the case of Romania, the unemployment rate is impacted in a statistically significant manner by a shock in the monetary policy for only 6 periods, showing an increase of 0.66%, while the real effective exchange rate and the inflation rate are statistically significantly impacted for only 5 periods.

In addition to the analysis of impulse-response functions, the historical decomposition explains how the economic, monetary and financial developments are described in terms of shocks over time. Following the comparison between the 2007 financial crisis and the crisis generated by the COVID-19 pandemic, we can observe the particularities of each country.

Even though there was an important stimulus from the monetary policy decisions, the dynamics of industrial production in the Czech Republic and especially in Hungary experienced a negative evolution during the financial crisis, in contrast with Poland and Romania where the decreases in industrial production were smaller.

The consequences of the crisis were felt from mid-2008 when the inflation rate showed an upward trend, followed by a slowdown due to monetary policy shock. Moreover, Romania and Czech Republic were the only economies that exhibited small decreases in the level of unemployment rate due to their procyclical adopted monetary policy.

Moving on to the impact of the coronavirus pandemic, the four emerging economies showed similar dynamics from a macroeconomic point of view. The declared state of emergency, as well as the mobility restrictions, led to a dramatic decrease in industrial production caused by the supply and demand shocks, in the first two quarters of 2020. Following the gradual normalization of economic activity and the relaxation of restrictions, there has been a moderate increase in industrial production largely stimulated by the decisions of monetary policy adopted for economic recovery.

However, there was also an increase in the inflation rate due to excessive demand for essential goods and drugs. Contrary to the economic theory of the relationship

between inflation and unemployment, an increase in the unemployment rate was visible due to the mobility restrictions but also as a result of the bankruptcy of many fragile companies.

However, the uncertainty in the health sector continues to be high. Even if the improvements in the economic environment are observed, the pandemic may lead to a regression of economic consolidations at any time. Regarding the European Central Bank's monetary policy, there is a visible contribution of the European Union to the recovery of its members. The "NextGenerationEU" and the new ECB's Asset Purchase Programs aim at supporting all the EU members to fight the COVID-19 crisis and improve the economic resilience. The funds from "NextGenerationEU" will be used for investing in advanced technologies and environmentally friendly technologies, bearing in mind to become more integrated and powerful, and climate-neutral by 2050 (European Commission, 2021).

Because the forecast error variance decomposition aims to highlight the contribution of each shock to the volatility of a certain variable, the percentage size of the shock will determine the magnitude of the changes in each variable. Agreeing with existing literature, the results of the research take into account the idea that the industrial production and the inflation rate are the most exogenously influenced variables. Moreover, the study shows also an increased exogenous influence on the 3-month interest rate.

The percentages of each shock's contribution to the variable's volatility can be found in Table 2.

In the four emerging economies, the exogenous shock recorded a value of over 33% in explaining the inflation's volatility, with the highest level of 37.3% for Poland. Furthermore, the results show a high percentage of the exogenous shock in the variance decomposition of the real effective exchange rate, which reaches a level of 34.6% in the case of Czech Republic.

Table 2. Forecast Error Variance Decomposition – monetary policy and exogenous shock

	Monetary policy shock	Exogenous shock
Czech Republic		
Industrial production	10.7%	23.1%
Inflation rate	8.7%	36.9%
Unemployment	14.9%	33.8%
3-Month interest rate	3.8%	30.8%
REER	10.1%	34.6%
Hungary		
Industrial production	27.5%	24.8%
Inflation rate	6.6%	34.1%
Unemployment	25.0%	21.4%

3-Month interest rate	22.1%	28.9%
REER	10.4%	31.0%
Poland		
Industrial production	10.1%	29.5%
Inflation rate	11.1%	37.3%
Unemployment	33.4%	26.9%
3-Month interest rate	5.4%	31.9%
REER	9.0%	30.8%
Romania		
Industrial production	18.4%	29.4%
Inflation rate	7.6%	35.2%
Unemployment	13.5%	26.9%
3-Month interest rate	10.2%	25.1%
REER	11.4%	29.1%

Source: own calculations

In contrast with the exogenous shock is the monetary policy shock that contributes with higher values to the volatilities of the industrial production and the unemployment rate. In the case of Romania, the monetary policy shock contributes with 18.4% to the volatility of industrial production, while the exogenous shock contributes with a level of 29.4%.

As a conclusion of the forecast error variance decomposition, the analysis highlights the importance of the exogenous shocks which significantly contribute to the volatility of the macroeconomic variables.

In order to consolidate the results obtained from the BVAR implementation, a Panel BVAR was estimated. The results of the impulse-response functions mostly support the interpretations above; thus, shocks in contractionary monetary policies can lead to a decline in industrial production and a rise in the unemployment rate.

5. DISCUSSION

When comparing the responses of the variables to an exogenous shock caused by the European Central Bank's monetary policy, we can conclude that the industrial production and the unemployment rate do not react as quickly as in the event of a restrictive monetary policy shock. However, there are spillover effects due to the monetary policy of the European Central Bank, but they are especially visible in the case of the 3-month interest rate and in the case of the unemployment rate.

Our results are mostly in line with the work of Halova and Horvath (2015) that investigated the causal relationships between macroeconomic variables, such as industrial production, inflation rate, unemployment rate, real effective exchange rate and the 3-month interest rate, in Central and Eastern European countries. Moreover, their results highlighted that due to an increase in the total assets of the European Central Bank, industrial production and inflation rate increase over time. This conclusion is not consistent with our findings that show a small decline of industrial production as a response to an exogenous shock. Also, the Halova and Horvath (2015) paper suggests that the relevance of the variables' reactions is not so strong due to the small increases or decreases reported by the analysis. However, the study covers only the financial crisis of 2007, while our examination considers a longer period which might lead to slightly different results.

Another similar study is the one of Moder (2017) where the spillover effects given by the implementation of an unconventional monetary policy recorded low values. The results show that an increase in the price level in the emerging EU economies can be generated by an expansion of the unconventional monetary policy, taking into consideration the high level of Eurozone imports in the total of imports of a certain non-Euro area country.

Also, the paper of Moder (2017) argues that in the case of Romania, the response of the price level is positive, reaching a positive response after 11 periods, thus confirming our results. Similarly, the 3-month interest rate positive response to an exogenous shock in the long run is also confirmed. Moreover, the author suggests that the potential monetary policy transmission channels can be represented by the trade channel and the interest rate channel, which we also emphasize.

Other studies, such as Bluwstein and Canova (2016) have shown the existence of important spillover effects which are comparable to the conclusion of this research. Changes in the unconventional monetary policy can lead to fluctuations in industrial output, while changes in conventional monetary policy can lead to visible fluctuations in the inflation rate. Hence, a combination of conventional and unconventional measures to control the dynamics of inflation and industrial production is considered possible, which our results indicate.

Although there are many similarities between the studied countries, there is also a remarkable degree of heterogeneity between them, especially in their response to the monetary policy measures implemented by the national central banks in each country.

The examined CEE nations were selected for comparison due to common features such as the level of financial integration, trade, and monetary policy. However, owing to their connections to the eurozone and the status of their internal economies, including GDP, inflation, and exchange rates, each nation reacts distinctively to the shocks. Also, each country structural and institutional factors might explain the variations in responses. This systematic variation indicates that country-specific elements are attributable to spillover effects.

This outcome suggests that the restricted extent of spillovers may signify that non-euro area nations retain a level of insulation from euro area disruptions, attributable to characteristics such as reduced financial integration, varying trade values, and specific connections with euro area countries. The impact of developed countries on emerging nations varies based on their economic links. The results obtained are due to narrow transmission channels and the difficulty of properly capturing such dynamics, not evidence of minimal spillover effects. This dual interpretation emphasizes the need for more study using complementary methods, higher-frequency data and even more macroeconomic variables to be included.

One of the most important results of our investigation is that there is a relationship between the ECB's monetary policy and the non-Euro area countries, but the link between them is not as strong as the relationship between the macroeconomic variables and the monetary policy implemented by each national central bank. Moreover, the analysis highlights that the ECB's monetary policy indirectly affects non-Euro area countries, as the weak responses of the macroeconomic variables to exogenous shocks suggest.

The interest rate channel is a substantial external shock transmission channel, according to the results. Changes in ECB policy rates can affect domestic interest rates in countries with interconnected financial markets or euro-denominated liabilities, affecting capital flows, lending conditions, and even investment decisions. Another important exogenous shock transmission channel involves trade, as most imports in the Czech Republic, Hungary, Poland, and Romania originate from the Eurozone. Euro area demand fluctuations instantly affect export-oriented economies by reducing external demand or changing exchange rates, affecting competitiveness.

6. CONCLUSION

The study shed light on the influence of the monetary policy implemented by the European Central Bank on the emerging economies from the non-Euro area, specifically four EU member countries: Czech Republic, Hungary, Poland and Romania. The results showed that the responses to an exogenous shock from the monetary policy adopted by the European Central Bank are weak and statistically irrelevant. This outcome led the analysis to a further estimation of the impact of the monetary policy implemented by the national central banks from each country, to make a comparison between the impact of the monetary policy of the Eurozone and the monetary policy of the four emerging countries.

The impact of the monetary policy measures adopted by the European Central Bank and the efficiency of the contractionary monetary policy implemented by the national central banks in each country are analysed in a Bayesian VAR framework, implemented for each country. In order to consolidate the results obtained by the

estimation of the impact of the monetary policy adopted by the national central banks in each country, a Panel VAR analysis was also estimated.

The results highlight the existent relationship between the monetary policy of the European Central Bank and the countries from the non-Euro area, but this connection is not as strong as the one between the economies and the monetary policy implemented by each national central bank. As one of the main findings of the empirical study, the weak responses of macroeconomic variables to exogenous shocks from the Euro area monetary policy demonstrate that the European Central Bank's influences are indirectly transmitted to emerging non-Euro area economies, being considered spillover effects.

In the case of exogenous shocks, the most affected macroeconomic variables are the 3-month interest rate and the unemployment rate, but also the industrial production and the inflation rate show significant responses, especially in the case of Romania and Poland. The Czech Republic is the only country that reveals statistically insignificant responses throughout the analysed period.

With the help of the globalization process, in a society where the economic decisions of a country can affect other nations, it is impossible that the monetary policy shocks from the policy of the European Central Bank do not spread beyond the borders of the Eurozone, especially in the countries from the Central and Eastern Europe. Therefore, an important channel of transmission of the exogenous shocks from the Eurozone monetary policy is represented by the interest rate channel. Also, another important channel is the trade channel since most of the imports of the emerging countries are from the Eurozone.

Regarding the impact of a contractionary monetary policy adopted by the national central banks of each country, the industrial production, the inflation rate and the real effective exchange rate showed negative responses because of an increase in the monetary policy interest rate, while the unemployment rate shows a positive response. These findings are supported by the economic literature. Unlike the monetary policy of the European Central Bank, the monetary policy implemented by each national central bank directly influences the dynamics of the economy, which is a fact proved by the persistent and significant responses of the analysed macroeconomic variables.

This study serves as a support in the direction of analysing the impact of the European Central Bank's monetary policy on non-Euro area economies and helps to address a deficiency in the literature. These findings lead to improving domestic monetary policy frameworks through transparency and responsiveness to external shocks. The ECB's monetary policy has limited direct impact on non-euro adopting countries, but spillover effects persist; policymakers should use fiscal buffers, flexible labour markets, and varied trade alliances to mitigate indirect negative external shocks. Interest rate and trade are key transmission channels for ECB policy spillovers, thus national authorities should improve monitoring them. Non-Eurozone states should also diversify their trade to reduce their exposure to Eurozone shocks.

However, there are some limitations of the model, and one of them is represented by the impossibility of imposing sign restrictions in the case of Panel Bayesian VAR in estimating the impact of contractionary monetary policy in each country, which led to results that are in contradiction with economic theory. Under these circumstances, the inflation rate and the real effective exchange rate show increasing dynamics instead of decreasing evolution. Nevertheless, our results are in line with the economic theory due to the method of identifying shocks based on sign restrictions which is implemented in this case.

Another possible limitation is given by the counterintuitive results of the model, which are present in other works as well. The industrial production decreases in the case of an exogenous shock from the European Central Bank's monetary policy, while the inflation rate, the unemployment rate, the 3-month interest rate and the real effective exchange rate increase. Due to their weak responses, we can say that there might exist a possibility of a far too little improvement from the European Central Bank's monetary policy decisions in the emerging economies.

An investigation of the consequences of the European Central Bank's monetary policy decision mix against the crisis produced by the COVID-19 epidemic, in order to sustain the European Union's economies, would be a suitable avenue for future research. How have new monetary policy decisions affected non-Euro area emerging economies, and whether unconventional monetary policy decisions, particularly the implementation of the temporary financial instrument "NextGenerationEU," will aid in the recovery of emerging economies are just two of the main questions that could lead to new research.

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