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**The Effectiveness of Conventional and Unconventional Monetary Policy in  
CEE countries using TVP-FAVAR models**

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**Abstract**

The paper analyses the role of monetary policy in economic activity and studies the responses of the economic growth rate and inflation rate to conventional and unconventional monetary shocks in three Central and Eastern European countries: Romania, Hungary, and the Czech Republic. The research focuses on the recent evolution of the economy affected by the health crisis, military conflict in Ukraine, and high inflation. The study offers a high degree of novelty using Vector Autoregressive models with Time-Varying Parameters and common factors (TVP-FAVAR). The results of the estimation are consistent with expectations and economic theory, and the models could provide clear view of the impact of monetary policy measures applied, depending on the phase of the economic cycle. The TVP-FAVAR models could give assistance to policymakers in the formulation of the most suitable monetary policy measures in the economic recovery process and maintenance of price stability.

**Keywords:** monetary policy, conventional, unconventional, economic growth, inflation.

**1. Introduction**

As a result of the financial crisis, health crisis and the beginning of the military conflict in Ukraine, Central and Eastern European countries faced an unfavorable evolution of economic growth and inflation, followed by a slow process of economic recovery. The COVID-19 crisis has generated the implementation of unprecedented unconventional monetary policy measures consisting of asset purchase programs (APPs) carried out by emerging market economies to reduce long-term interest rates and to support productivity. Later, with the outbreak of the military conflict in Ukraine, they were faced with record levels of inflation rate generated by the increase in the price of energy and its effects at the international level.

Thus, the European Central Bank (ECB) and the other central banks have applied conventional and unconventional monetary policy actions to effectively respond to economic and financial

shocks, which include the increase of monetary policy interest rates and interventions on the asset market. It is well known that during the financial crisis, central banks focused on adopting unconventional monetary policy measures, such as increasing the balance sheet by purchasing financial assets from the market to lower the long-term interest rate, subsequently selling them in the goal of reducing the inflation rate.

In Europe, some central banks, including Hungary and Romania, adopted APPs during the COVID-19 pandemic (Arenas et al., 2021). The same authors mentioned that the scale of assets purchased during this period varies widely, while Romania implemented smaller-scale APPs, Hungary experienced these strategies at a higher level.

Lane (2024) points out that while Europe's economies have seen a broad-based increase in inflation in the post-pandemic period, the outbreak of the military conflict in Ukraine in February 2022 was an additional shock that increased the inflation in 2022, particularly in Europe. The author mentioned that for the Eurozone, the energy sector is characterized by a high net import content, so that the military conflict in Ukraine generated an increase in energy prices that pushed up inflation. The evolution of inflation determined the adjustment of the monetary policy strategy by reducing quantitative easing and begin raising the policy rate, thus focusing especially on conventional monetary policy measures.

There is a substantial body of literature that examines the effectiveness of monetary policy actions in managing economic crises, a topic of great interest due to the current economic dynamics. Moreover, because of the diversity of the recent events in Central and Eastern Europe, the study presents the effects of military conflicts and health crises, in addition to those of the financial crisis. Thus, we can analyze the effectiveness of monetary policy measures in managing several types of events that lead to economic decline and rising inflation.

Gertler and Karadi (2011) developed a quantitative macroeconomic model to analyze the effects of unconventional monetary policy through central bank interventions in the credit market. They used the model to analyze the effects of the unconventional monetary policy measures to combat a simulated financial crisis and concluded that these measures could be efficient and should be used only in crisis situations.

The effectiveness of monetary policy in the Eurozone was also analyzed by Fiorelli and Meliciani (2019) by performing a VAR model to estimate the effects of conventional and unconventional tools on industrial production and inflation. The study supports the effectiveness of these measures in the economic recovery process and reduction of inflation and highlights that unconventional policy has played a key role on economic and financial stabilization. Likewise, Hanisch (2017) found that unconventional monetary policy measures can stimulate the economic activity, but its effect is limited compared to the effect of short-term interest rates reduction, while goods and stock prices are more influenced by conventional monetary policy measures.

Besides the applicability of unconventional monetary policy during the economic crises, the most common measure of conventional monetary policy is based on the fact that higher interest rates lead to lower inflation in the post-crisis periods (Mishkin, 1996). Gocer and Ongan (2020) recently concluded that there is a negative relationship between inflation rates and the nominal interest rates and emphasized the effectiveness of using interest rates as an operational target in inflation targeting policy. Benkovskis et al. (2011) analyzed the effects of conventional monetary policy on three Central and Eastern European countries and found that economic activity variables are primarily affected through the impact of increased interest rates and reduced foreign demand, thus leading to a contraction of GDP.

The specialized literature concluded that it is necessary to apply a monetary policy that involves the complementary implementation of conventional and unconventional measures, since the effects of the latter are considered stronger in periods of financial crisis and less effective in periods of inflationary pressure (Dell'Ariccia et al., 2018).

Weale and Wieladek (2016), Churm et al. (2015), Baumeister et al. (2013) have found sizable positive effects using vector auto regression models that analyzed the economy's responses to asset purchases measures and observed direct relationship between unconventional monetary policies and both GDP and inflation. Regarding the response of the economy to an epidemic shock, Vasconez et al. (2023) were one of the first that incorporated disease dynamics into a DSGE-SIR model and found that no measure of unconventional monetary policy can completely remove the negative effects of an epidemic crisis but there are significant benefits of it.

The aim of this paper is to analyze the role of monetary policy in economic activity and study the responses of the economic growth rate and the inflation rate to conventional and unconventional monetary shocks in three Central and Eastern European countries: Romania, Hungary, and Czech Republic. The three countries were selected due to the similarities regarding the evolution of the economic growth rate and inflation over time. Moreover, the selection was also supported by the different monetary policy measures applied in these countries, which can provide important information about their effect over time. The research focuses on the recent evolution of the economy affected by the health crisis, military conflict, and inflation and aims to identify optimal statistical methods to emphasize the effectiveness of monetary policy measures over time. Considering the diversity of recent events, the aim of the paper is to provide a clearer understanding of the effects of shocks over time considering the changing economic conditions. The study offers a high degree of novelty using Vector Autoregressive models with Time-Varying Parameters using common factors (TVP-FAVAR). Thus, TVP-VAR models were applied to estimate the shock effects of conventional and unconventional monetary policy measures on economic growth and inflation, but the results must be interpreted with caution and expert opinion is also recommended, given the limitations of the models in terms of data size, complexity of parameter estimation and interpretability. However, TVP-FAVAR models are preferred in the extant scientific literature because they offer the advantage of the assumption that most macroeconomic time series exhibit a certain form of non-linearity.

To summarize economic developments, several relevant indicators were compressed into common factors and used in the estimation of VAR models (FAVAR), first proposed by Bernanke et al. (2005). In this model, the factors jointly follow a vector autoregressive process, which captured the comovement of many observable variables (Bai et al., 2014). In addition, the TVP-FAVAR model can be successfully used to identify monetary policy shocks and their transmission to the economy considering the volatility of monetary shocks over time (Amiri and Gang, 2018; Eickmeier, 2011).

## 2. Method

The purpose of applying Vector Autoregressive (VAR) models is to determine the dynamic responses of economic growth and inflation to monetary policy shocks for three Central and Eastern European (CEE) countries, namely Romania, the Czech Republic and Hungary. The data used were seasonally adjusted and were downloaded from both the Eurostat database and the databases of the central banks involved, with a quarterly frequency, from January 2007 to December 2023. Following an assessment of the evolution of the macroeconomic time series and the correlation with the historical events, but also taking into account the reputable sources, the data used for the three countries are considered reliable and consistent. The models are run using the BEAR toolbox for MATLAB, which was developed by Dieppe et al. (2016).

The data used to fulfill the research objective includes the seasonally adjusted quarterly series of the real Gross Domestic Product (GDP) to analyze the evolution of economic growth, the inflation rate which is directly influenced by monetary policy (INFL), indicators specific to unconventional monetary policy measures, namely total assets and liabilities from the balance sheet of central banks (BS), monetary aggregates M1, M2 and M3, as well as indicators specific to conventional monetary policy measures: the monetary policy interest rate, the interest rate on loans, the interest rate on deposits, the interest rate on new mortgage loans with maturity up to 1 year, the interest rate for new consumer loans with maturity up to 1 year and the interest rate for lending to non-financial companies with maturity up to 1 year. Seasonally unadjusted time series were adjusted using the X-13 algorithm, which generated robust results regarding the evolution of the analyzed time series, and indicators were tested for unit root using the ADF test. The ADF results suggested that all variables have the same degree of integration, namely I (1). Therefore, the first difference was applied to ensure the stationarity of the time series.

Vector Autoregressive (VAR) models represent a multivariate generalization of autoregressive models and are generally applied to time series that have multiple dynamic equations, being the most common method of monetary policy analysis. Given the widespread use of these models in monetary policy studies and taking into account the specific economic conditions of the three CEE countries, VAR models are preferred because they offer versatility by extending the model settings depending on the purpose of the study. In addition, the time period considered covers multiple economic crises when the aggregate series exhibits changes in persistence and volatility, but these structural shifts may be captured by the time-varying parameters of the TVP-VAR models. First, VAR models were identified using both the Cholesky decomposition and the Triangular factorization method and no significantly different results were observed between the

two methods (Carvelli et al, 2024; Ciminelli et al., 2022; Lopez-Buenache, 2019). To estimate the models, a time lag was chosen using the Schwarz Bayesian information criterion. Since VAR models are sensitive to estimates performed on small datasets, similar to Murarasu et al. (2023) and Lenza et al. (2010), we estimate a Bayesian VAR (BVAR) model based on Independent Normal Wishart prior to analyze the effect of interest rate shocks and balance sheet changes on economic growth and inflation rate.

As presented in the previous section, the monetary policy measures are applied depending on economic cycle phase. Thus, we extend the analysis by applying Autoregressive Vector with Time-Varying Parameters (TVP-VAR) models to capture the effects of monetary policy measures on the real economy over time (Amiri and Gang, 2018). Moreover, we extend the study by using a larger number of indicators due to the limitation of standard VAR models in terms of the low degree of information included in the estimation. The model combines a standard VAR model with the output of a factor analysis (FAVAR) and captures the response of the economic growth and inflation rate to the conventional and unconventional monetary policy through common factors. To capture the evolution of conventional and unconventional monetary policy, the following variables will be included in the factor analysis: total assets and liabilities from the balance sheet of central banks (BS), monetary aggregates M1, M2 and M3, the monetary policy interest rate, the interest rate on loans, the interest rate on deposits, the interest rate on new mortgage loans with maturity up to 1 year, the interest rate for new consumer loans with maturity up to 1 year and the interest rate for lending to non-financial companies with maturity up to 1 year. The results of the factor analysis will be analyzed from an economic point of view and the final factors will be chosen to describe the conventional and non-conventional monetary policy. In the following sections, we first estimate BVAR and FAVAR models and evaluate the ability of these models to produce plausible impulse responses (Fiorelli et al., 2019). In addition, TVP-VAR and TVP-FAVAR models will be estimated to identify monetary policy shocks and their transmission to the economy over time (Eickmeier et al., 2011). The performance of these models could provide clear guidance on the impact of monetary policy measures applied depending on the phase of the economic cycle.

### 3. Results

The evolution of the economy for the three countries has faced two great challenges over time, the financial crisis and the health crisis, their effects on the economic growth rate and the inflation rate being observed in Figures 1 and 2. During the financial crisis, the yearly economic growth rate recorded negative values of approximately -5% for each of the 3 CEE countries, while the health crisis generated up to 10% decrease in economic activity, followed by a fast recovery of economic activity.

Regarding the inflation rate, the post-crisis period is significantly affected by economic instability. Thus, the economic decline identified in the evolution of economic growth rate in 2009 had negative effects in the following years in terms of the inflation rate. In Romania and Czech Republic, the financial crisis generated an increase in inflation from 0% in 2010 Q2 to 2% in 2011 Q4, while in Hungary inflation increases from 2% in 2010 Q2 to 5% in 2011 Q2. The

impact of the COVID-19 pandemic on inflation is also observed, exacerbated by the outbreak of the military conflict in Ukraine, reaching values of up to 16% in 2023 Q1. The inflation rate in Romania in 2016 showed significant fluctuations due to the changes made to the VAT level in June 2015 and January 2016.

Monetary policy measures were applied differently in the three countries. During the financial crisis, central banks focused on unconventional monetary policy measures, such as increasing the balance sheet by purchasing financial assets from the market to lower the long-term interest rate, then selling them to reduce the inflation rate. In the recent period, the main monetary policy measure taken against high inflation is the interest rate increase. Thus, we estimate statistical models and evaluate the ability of these models to produce plausible impulse responses to identify the effectiveness of monetary policy measures in the process of economic recovery and reduction of inflation.

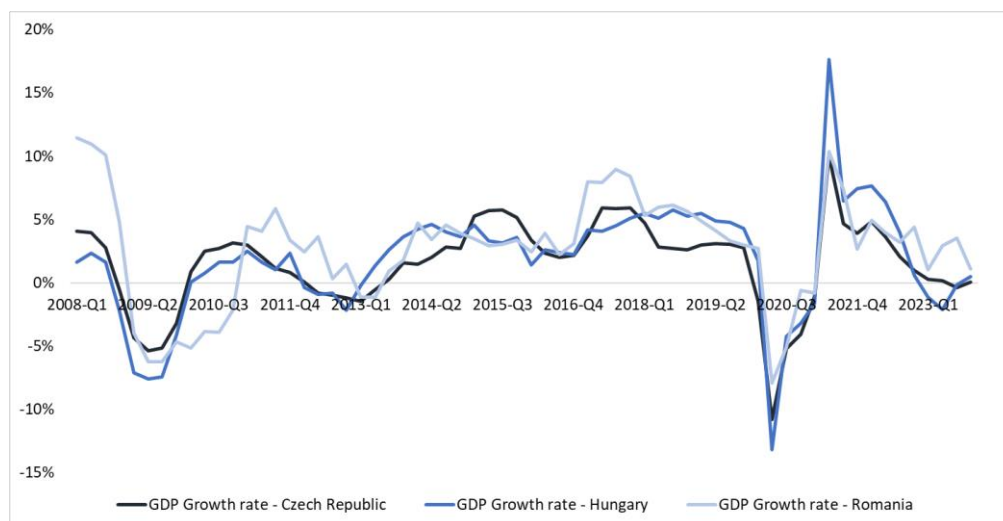


Figure 1. Evolution of Gross Domestic Product growth rate for three CEE countries  
*Note.* The data for the three CEE countries are from Eurostat ([Statistics | Eurostat \(europa.eu\)](https://ec.europa.eu/eurostat))

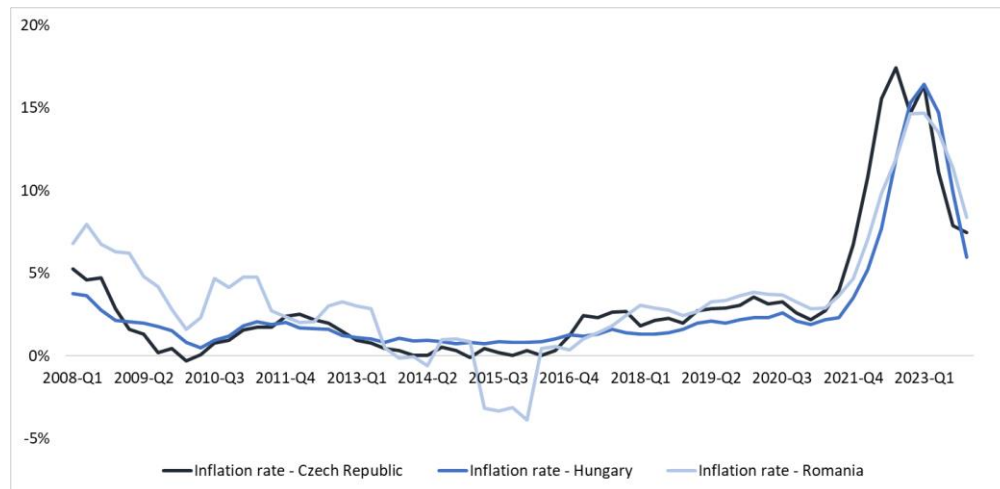


Figure 2. Evolution of Core inflation rate for three CEE countries

*Note.* The data for the three CEE countries are from central banks websites, as follows: Czech National Bank (<https://www.cnb.cz/en/monetary-policy/>), Magyar Nemzeti Bank (<https://www.mnb.hu/en/publications/>), National Bank of Romania ([Banca Națională a României - Inflation Reports \(bnr.ro\)](https://www.bnr.ro/)).

### 3.1. Estimation of BVAR and FAVAR models

The study focuses on two types of monetary policy measures, namely conventional and non-conventional, and the results are consistent with earlier research. Conventional monetary policy measures are mainly represented by changes in the interest rate, while unconventional measures are characterized by changes in central banks' balance sheets generated by the purchase or sale of financial assets in the market. The Figure 3 illustrates the impulse response functions of economic growth and inflation in Romania, the Czech Republic and Hungary to positive shocks in monetary policy measures.

Thus, the estimation of the BVAR models, presented on the left side of Figure 3, shows a negative response of the economic growth in Romania (i.e. GDP\_RO) to the increase in interest rate (i.e. INT\_RATE\_RO) and balance sheet level (i.e. BS\_RO). Similar to [Fiorelli et al. \(2019\)](#), the effect of the balance sheet extension is not statistically significant and does not determine the expected response of the economic growth rate and inflation for the historical data. According to economic theory and the applicability of monetary policy measures, the expansion of the balance sheet should cause a decrease in the long-term interest rate, which would generate an increase in GDP and inflation rate. However, considering that the measures dedicated to the expansion of the balance sheet are not consistently applied by the central banks of the three analyzed countries, the results of the study are in line with authors expectations.

Figure 3. BVAR and FAVAR impulse response functions for the three CEE countries

*Note.* The graphs are created by the author and the data for the three CEE countries are from Eurostat ([Statistics | Eurostat \(europa.eu\)](https://ec.europa.eu/eurostat/)) and from central banks websites, as follows: Czech National Bank (<https://www.cnb.cz/en/monetary-policy/>), Magyar Nemzeti Bank

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(<https://www.mnb.hu/en/publications/>), National Bank of Romania ([Banca Națională a României - Inflation Reports \(bnr.ro\)](#)).

Regarding the inflation rate, the historical evolution of the economy determined a positive correlation with the interest rate for Romania and Czech Republic, mainly triggered by the recent conventional monetary policy measures and their lagged effect. However, to support these assumptions, the authors re-estimated the models using a database up to December 2020, and the results showed negative correlation between interest and inflation rates, in line with economic expectations. Thus, we can conclude that BVAR models are sensitive to recent developments in the economy and may cause biased results if the effects of the monetary policy measures are not observed. This temporal effect can be handled by two ways of estimation described in the following.

First, we avoid concentrating the monetary policy strategy in a single variable, by constructing common factors across multiple variables and using them to estimate FAVAR models, presented on the right side of Figure 3. Following the application of the common factor extraction method, we obtained two common factors, considering the weights and evolution of explanatory variables. Thus, the first common factor (i.e. F\_CONV) is characterized by the evolution of the monetary policy interest rate, the interest rate on loans, the interest rate on deposits, the interest rate on new mortgage loans with maturity up to 1 year, the interest rate for new consumer loans with maturity up to 1 year and the interest rate for lending to non-financial companies with maturity up to 1 year. The second common factor (i.e. F\_UNCONV) is constructed using data on the central bank's balance sheet and monetary aggregates.

The results of the estimation of the FAVAR models for the three countries, as opposed to the BVAR models, show that a positive shock in the unconventional factor (F\_UNCONV) has a positive impact on economic growth in Romania and Hungary. Regarding the Czech Republic, the implementation of the new monetary policy measure based on exchange rate (i.e. exchange rate commitment) led to an increase in the balance sheet of the Central Bank of the Czech Republic in the 2013 - 2017 period, without a significant impact on inflation rate or economic growth. This measure directly influences the FAVAR model results, leading to a negative response of economic growth and inflation. Likewise, an increase in the conventional factor (F\_CONV) leads to a decrease in economic growth and inflation rate, in line with economic theory regarding the use of monetary policy measures to ensure and maintain price stability.

Therefore, it can be concluded that the use of FAVAR models is a good alternative for quantifying the impact of monetary policy measures, because it offers a higher degree of accuracy by expanding the data set used in the estimation.

### *3.2. Estimation of TVP-FAVAR models*

Given the sensitivity of standard VAR models to recent economic developments and to the concentration of the monetary policy in a single variable, we can evaluate the effect of monetary



policy measures over time by estimating VAR models with common factors and time-varying parameters (TVP-FAVAR).

The estimation of the TVP-FAVAR models for the three countries generates similar results to the FAVAR models and are presented in Figure 4. Therefore, a positive shock in the unconventional factor has a positive impact on economic growth in Romania and Hungary, due to APPs (Arenu et al., 2021). In Czech Republic, the impulse response is still negative, because of the implementation of the new monetary policy measure based on exchange rate, observed in the 2013 – 2017 period.

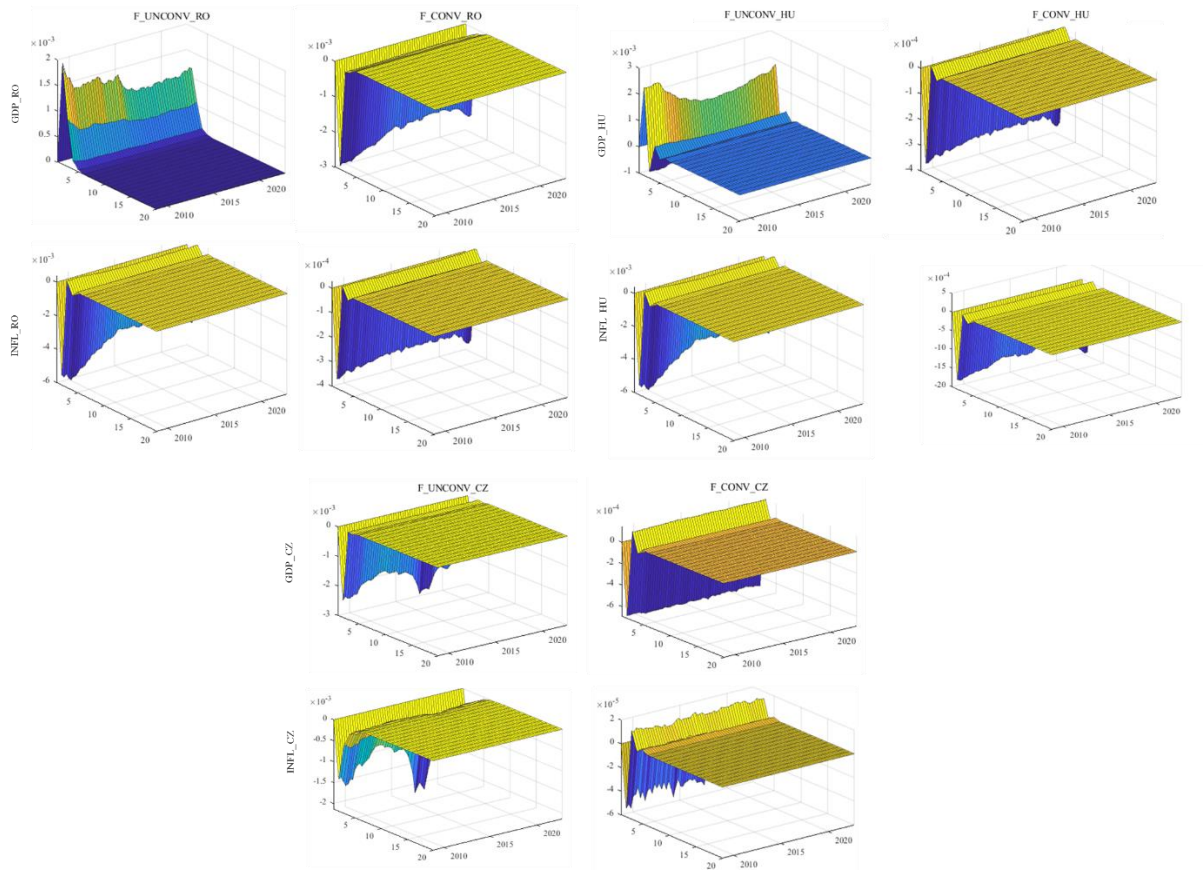


Figure 4. TVP-FAVAR impulse response functions for the three CEE countries

*Note.* The graphs are created by the author and the data for the three CEE countries are from Eurostat ([Statistics | Eurostat \(europa.eu\)](https://ec.europa.eu/eurostat)) and from central banks websites, as follows: Czech National Bank (<https://www.cnb.cz/en/monetary-policy/>), Magyar Nemzeti Bank (<https://www.mnb.hu/en/publications/>), National Bank of Romania ([Banca Națională a României - Inflation Reports \(bnr.ro\)](https://www.bnr.ro/)).

Figure 4 shows that a positive shock in the conventional factor leads to a decrease in economic growth and inflation rate, for all the analyzed countries. Furthermore, we note that the impact is

significantly higher during the 2009 financial crisis and 2021-2022 due to high inflation rates, health crisis and military conflict in Ukraine.

We emphasize that the response of economic growth and inflation rate to a positive conventional monetary policy shock is immediate, but with a relatively low impact, while subsequently the effect of the shock tends to zero. So, we can argue that depending on the level of economic growth or the inflation rate, which the policymakers want to achieve, cumulative and consecutive shocks can be applied to ensure a significant change in the indicators, depending on the moment of implementation.

Therefore, it can be concluded that the use of TVP-FAVAR models represents a good alternative in the process of quantifying the impact of monetary policy measures over time, depending on the phase of the economic cycle. The TVP-FAVAR models bring an important contribution to the study of the effectiveness of monetary policy measures in ensuring and maintaining price stability, both in periods of expansion and economic decline.

#### **4. Discussion**

As found by [Arena et al. \(2021\)](#), the European Central Bank (ECB) and the other central banks have applied conventional and unconventional monetary policy actions to effectively respond to economic and financial shocks, which include the increase of monetary policy interest rates and interventions on the asset market. In this direction, the paper proposed the analysis of the role of monetary policy in economic activity by studying the responses of the economic growth rate and the inflation rate to positive conventional and unconventional monetary policy shocks.

Several types of autoregressive vector models were estimated to study the effects of monetary policy in three EU member states in Central and Eastern Europe – the Czech Republic, Hungary, and Romania. First, the study focused on the estimation of BVAR and FAVAR models to assess the ability of these models to produce plausible impulse responses, in line with authors' expectation and economic theory.

A first limitation of the BVAR models was highlighted, namely the use of a single variable to define conventional, respectively unconventional monetary policy measures. By concentrating the monetary policy in a single variable, we emphasized that important information can be lost, and in the case of the three analyzed countries, the interest rate and the balance sheet level were not the only channels used by the central banks to apply the monetary policy. To summarize economic developments and further develop the study, we compress several relevant indicators into common factors, later used in the estimation of FAVAR models. We concluded that the use of FAVAR models is a good alternative for quantifying the impact of monetary policy measures, because its results are in line with expectations and offer a higher degree of accuracy by expanding the data set used in the estimation.

Another limitation of the BVAR and FAVAR models is that they are sensitive to recent developments in the economy and may generate biased results if the effects of monetary policy measures are not yet observed. Thus, the use of FAVAR models with time-varying parameters

(TVP-FAVAR) provides important information related to the impact of monetary policy measures over time, thus constituting a support for economic policymakers in the formulation of the most suitable measures in the economic recovery process and maintenance of price stability. The results of TVP-FAVAR models' estimation are in line with expectations and economic theory. A positive shock in the conventional factor leads to a decrease in economic growth and inflation rate, for all the analyzed countries. Similar results were obtained by Fiorelli and Meliciani (2019) and Hanisch (2017). Moreover, as found by Amiri and Gang (2018), a positive shock in the unconventional factor has a positive impact on economic growth in Romania and Hungary, while in Czech Republic, the impulse response is still negative, because of the implementation of the new monetary policy measure based on exchange rate, observed in the 2013 – 2017 period. In addition, TVP-FAVAR models helped us to notice that the impact of shocks is significantly higher during the 2009 financial crisis and 2021-2022 due to high inflation rates, the health crisis, and the military conflict in Ukraine.

We conclude that the study highlights both limitations and important benefits of statistical models and can be an important tool in analyzing the effectiveness of monetary policy measures in the economy.

## 5. Conclusion

The main finding of the study is that the BVAR and FAVAR models without time-varying parameters are not flexible enough to account for different phases of the economic cycle, such as expansion, recession, or recovery periods. This limitation of the standard VAR models reduces their utility in guiding policy recommendations that adjust according to changing economic conditions. As we have shown in previous sections, the results of TVP-FAVAR models' estimation are consistent with expectations and economic theory, so the possible underestimation of the long-term effects of policy interventions generated by standard VAR models can be corrected by estimating VAR models with time-varying parameters.

Although TVP-FAVAR models were successfully applied to estimate the effects of conventional and unconventional monetary policy measures on economic growth and inflation, the results must be interpreted with caution and expert opinion should also be considered, given the limitations of the models in terms of data size, complexity of parameter estimation and interpretability. In order to expand future research, the use of a larger data set by integrating Bayesian settings can be an advantage in the estimation of TVP-FAVAR models. However, the complexity of the parameters estimated in this case could decrease the accuracy of the models.

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