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The importance of demand, uncertainty and monetary policy shocks from the euro area for the Romanian economy

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Abstract. *This paper is evaluating the impact of external shocks that are affecting the Romanian economy by employing a Bayesian approach. By employing three Bayesian VAR models this paper provides an answer on the importance of external shocks using the impulse response functions, variance and historical decompositions. The relevance of the study is a major one as it quantifies the intensity of external shocks coming from the euro area that have the potential to affect the Romanian economy in terms of external demand, uncertainty and monetary policy, aspects which are of high interest especially in the new economic context of the COVID-19 health crisis.*

Keywords: external demand, uncertainty, monetary policy, Bayesian VAR, variance, impulse response.

JEL Classification: C11, D81, E52, O47.

1. Introduction

The great recession highlighted close links between developed economies and emerging ones, in particular through the considerable impact of external shocks on emerging economies, the same is the case of Romania in relation to the euro area. For an economy in close connection with the euro area such as Romania, it is essential to define how much of the fluctuations of key macroeconomic variables, such as economic growth or the unemployment rate are due to external shocks.

The objective of this paper is to quantify the importance of three key external shocks coming from the euro area that are affecting the Romanian economy. This paper aims to evaluate the impact of the demand, uncertainty and monetary policy shocks coming through the main trading and financial partner of the Romanian economy. The motivation for quantifying the importance of external shocks comes from the major impact that the great recession had on Romania and on top from the interest on developing a very important perspective of the economic outlook going forward.

Therefore, this paper becomes relevant both for the present and future perspectives for the Romanian economy as it will highlight to what extent Romania is affected by the euro area in terms of output growth, uncertainty, and monetary policy level.

2. Literature review

The relationship between external economic activity from developed countries to emerging economies is a topic of interest for many studies, the most notable papers in this area have grown since 2005, when the shocks from the US to emerging economies in Latin America were studied by Canova (2005) or by Mackowiak (2007) which studied the impact external shocks from US to Asian emerging economies. Other recent approaches are still focused on the external shocks coming from US impacting emerging economies such as Turkey, South Africa, Argentina, Brazil, Peru or Mexico (Akinci, 2013) or even for Eastern European countries such as Hungary or Poland (Horvath and Zhong, 2019; Andrle et al., 2013).

One approach that seeks to emphasize the importance of euro area demand shocks to emerging Asian countries is the one developed by Erten in the paper “Macroeconomic Transmission of Eurozone Shocks to Emerging Economies”, where the results highlight the major importance of demand shocks that could severely impact the economic growth capacity of emerging countries (Erten, 2012; Gruss et al., 2019). Also, an important study is the one developed by Andrle et al. (2013), which focuses on the shocks coming from the euro area to Poland, this study is closely related to the approach in the current paper and concludes using similar econometric techniques that up to 50% of the variance in the output growth rate is given by external shocks coming from the euro area to Poland. Almansour et al. (2015) is as well supporting the high degree of vulnerability of emerging economies to external shocks stating that external shocks can contribute to half or maybe even more in some cases in terms of the output growth variance for the emerging economies.

The study developed by Erten (2012) is evaluating the impact of external demand shocks on output growth performance for emerging economies by employing Bayesian VAR model. This study is using quarterly data from 1993 to 2011 in order to capture the effects of the shocks created by proxy variables for global financial conditions and external demand. Erten (2012) is studying the extent of the external shocks from the euro area on emerging economies from Asia and Latin America. This article finds out that more than 50% of the output growth rate for emerging economies in Latin America and emerging economies in Asia is explained by external factors. Conditional forecasts of the various scenarios indicate that a deepening recession in the euro area could create a severe and persistent contraction for emerging economies.

The working paper developed by Andrle et al. (2013) at the International Monetary Fund is of great relevance in terms of certifying the robustness of the results for the current paper, as the it highlights the links between Poland and the euro area, using a simple econometric approach. The authors estimate a VAR model, using data for real and nominal variables, imposing robust hypotheses that allow them to identify how external factors affect the evolution of output growth in Poland between 1999 and 2012. The results of this paper suggest that external shocks in the euro area can be able to explain about 50% of Poland's output growth variance and up to 25% on interest rates and inflation.

The VAR models estimated by Mackowiak (2007) show that external shocks lead to macroeconomic fluctuations for emerging economies. In addition, US monetary policy shocks are rapidly and strongly affecting the exchange rate of emerging economies. It is important to note that US monetary policy shocks affect the real economic activity of emerging economies in a much stronger manner than it affects its own real economic activity.

The current study will focus on an approach similar to the one developed by Horvath and Zhong (2019) in terms of variable selection. This paper is taking as main subject the external shocks of demand, uncertainty and monetary policy coming from the euro area (the main financial and trade partner of Romania). Horvath and Zhong (2019) are combining these perspectives in a fascinating way and aggregate in a single study all these three types of external shocks employing Panel VAR model and using classical methods to identify these effects such as impulse response functions and variance decomposition. The ordering of the variables in the VAR model developed by Horvath and Zhong (2019) is essential to obtain a correct empirical estimate. The authors are ordering the variables in the model in such a way that macroeconomic variables like inflation or output growth lead to immediate changes in financial variables in emerging economies, such as stock returns, monetary policy interest rates or the real exchange rate, while financial variables will affect macroeconomic variables with a lag. The same variable ordering approach will be employed also in the current paper.

3. Model specification

In this section I will summarize the form of the general VAR model for the particular case of this paper and afterwards I am exposing the three different Bayesian approaches highlighting also the main economic implications of each one of them.

3.1. Formulation of the general VAR model

The VAR models estimated in this paper contain 8 endogenous variables, 4 lags, and one vector of exogenous regressors. In a compact form the general model can be summarized in the following equation:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + A_3 Y_{t-3} + A_4 Y_{t-4} + C X_t + \varepsilon_t \quad (1)$$

Where:

Y is a matrix of dimension $n \times 1$ (8×1 in this particular case) and it represents the vector of endogenous variables.

$A_1, A_2, ..., A_p$ are $p(4)$ matrices of parameters with dimensions $n \times n$ (8×8 in this particular case).

C is a matrix of dimension $n \times m$ (8×8 in this particular case) and X_t is a vector of constant exogenous regressors (constant terms).

ε_t is the vector of residuals, where: $\varepsilon_t = (\varepsilon_{1,t}, \varepsilon_{2,t}, ..., \varepsilon_{n,t})$ with $\varepsilon : N(0, \sum)$

In a more compact notation, the model can be summarized as exposed in equation (2):

$$Y = XB + \varepsilon \quad (2)$$

3.2. Bayesian VAR with Minnesota prior

One of the widely used prior distributions in macroeconomic research is the Minnesota prior (Giannone et al., 2017; Fuleky, 2020). Reflecting the fact that the variance-covariance matrix is known and the only thing that remains to be estimated is the vector of parameters (Dieppe et al., 2018). This implies the prior belief that the variables in the model cannot be predicted, as they follow an unobservable trend. Therefore, in order to calculate the shape of this posterior distribution I will follow the computational steps developed in Dieppe et al. (2018). To obtain the posterior distribution for β two elements will be necessary: the likelihood function $f(Y \mid \beta)$ for the data and the prior distribution for $\beta : \pi(\beta)$.

One should start from the likelihood function, this formulation implies that the residuals follow a normal multivariate distribution of mean equal to 0 and a variance-covariance matrix $\overline{\sum}$. In this case the data would follow as well a normal multivariate distribution of mean $\overline{X}\beta$ and a variance-covariance matrix $\overline{\sum}$. Therefore, the likelihood function for Y will have the following form:

$$f(Y|\beta, \overline{\sum}) = (2\pi)^{-nT/2} |\overline{\sum}|^{-1/2} \exp\left[-\frac{1}{2}(Y - \bar{X}\beta)' \overline{\sum}^{-1} (Y - \bar{X}\beta)\right] \quad (3)$$

Ignoring the constant terms, equation (3) will be simplified and will take the following form:

$$f(Y|\beta,\bar{\sum}) \propto \exp\left[-\frac{1}{2}(Y-\bar{X}\beta)'\bar{\sum}^{-1}(Y-\bar{X}\beta)\right] \quad (4)$$

The prior β will follow as well a normal multivariate distribution of mean β_0 and variance covariance matrix Ω_0:

$$\pi(\beta) \sim N(\beta_0,\Omega_0) \quad (5)$$

Similar to the previous approach the constant terms will be excluded and the simplified equation will take the following form:

$$\pi(\beta) \propto \exp\left[-\frac{1}{2}(\beta-\beta_0)'{\Omega_0}^{-1}(\beta-\beta_0)\right] \quad (6)$$

By combining the likelihood with the prior, the posterior distribution will take the form of a multivariate normal distribution:

$$\pi(\beta|Y) \propto \exp\left[-\frac{1}{2}\left(\beta-\bar{\beta}\right)'\bar{\Omega}^{-1}\left(\beta-\bar{\beta}\right)\right] \quad (7)$$

$$\pi(\beta|Y) \sim N\left(\bar{\beta},\bar{\Omega}\right) \quad (8)$$

3.3. Bayesian VAR with normal-diffuse prior

A possible alternative to the Minnesota prior can be represented by the normal-diffuse prior and it can be used when one wants to remain agnostic about the value of $\sum$. Thus, the main change will be the distribution for $\sum$ which will be now defined by the *"Jeffrey's"* distribution or diffuse prior:

$$\pi(\Sigma) \propto |\sum|^{-(n+1)/2} \quad (9)$$

The peculiarity related to this prior distribution would be that it is a non-informative distribution, which means that the data will bring the biggest contribution when it comes to the estimated results.

Following the same steps as exposed in the previous section and by starting from the likelihood function and the prior distribution this will lead again the posterior to take the form of a normal multivariate distribution:

$$\pi(\beta|Y) \propto \exp\left[-\frac{1}{2}\left(\beta-\bar{\beta}\right)'\bar{\Omega}^{-1}\left(\beta-\bar{\beta}\right)\right] \quad (10)$$

$$\pi(\beta|Y) \sim N\left(\bar{\beta},\bar{\Omega}\right) \quad (11)$$

3.4. Mean-adjusted Bayesian VAR

A reformulation compared to the classical Bayesian VAR is the one in which prior information about the trend of the steady-state values can be introduced in the model, meaning that the steady state values will not represented constant terms (Villani, 2009) which was the case for the last two sections.

In this case, the steady state parameters will become variable in time. The vector $\overline{Z}\Delta$ introduces this property for the steady state values. The compact form of the VAR model of section 3.1 will change and it can be formulated as follows:

$$Y = \bar{X}\beta + \bar{Z}\Delta + \varepsilon \tag{12}$$

4. Database and variable selection

4.1. Variable selection

In order to evaluate the impact of external shocks of demand, uncertainty and monetary policy from the euro area on the Romanian economy, the current paper is following the approach developed by Horvath and Zhong (2019) regarding the variable selection process and data transformation. On top of that I will approach the empirical study by using two vectors instead of one in order to certify the robustness of one critical proxy variable, and as exposed in the previous section I will employ three different Bayesian estimations instead of the classical OLS approach used in Horvath and Zhong (2019). The vectors that I will use in my estimations will contain three external variables and five domestic variables. More specifically:

$$Y_t = [D_t, \pi_t, D_t^E, r_t^E, U_t^E, r_t, s_t, x_t] \tag{13}$$

$$Z_t = [u_t, \pi_t, D_t^E, r_t^E, U_t^E, r_t, s_t, x_t] \tag{14}$$

In the case of the vector Y_t the domestic variables are the following: D_t which denotes the year-on-year output growth, π_t represents the year-on-year CPI inflation rate, r_t captures the 3M Romanian Interbank Offer Rate (ROBOR3M), s_t measures the year-on-year stock return, and x_t stands for real effective exchange rate.

In the case of Z_t: u_t denotes the unemployment rate which serves as a proxy for real economic activity (the same significance as D_t) while the rest of the variables are the same as in the case of Y_t. The purpose of the second vector is to evaluate the effects of external shocks on unemployment dynamics in order to see if they are different compared to the output growth.

The external block of variables contains measures for external demand D_t^E proxied by the euro area output growth rate, r_t^E proxied by the Euro Interbank Offered Rate (EURIBOR3M), and a measure of external uncertainty U_t^E, proxied by the VSTOXX index (Bonciani and Van Roye, 2016) which represents the stock market expectations in terms of volatility for the euro area.

4.2. Database

The current paper is using monthly data starting from January 2002 to March 2020 (2002M1 – 2020M3). The data used in the models was transformed according to Horvath and Zhong (2019). Transformations were performed as follows:

π_t – denotes the year-on-year domestic CPI inflation rate excluding energy, food, alcohol and tobacco. For this case the overall index has been extracted from Eurostat and year-on-year inflation has been calculated using monthly data.

D_t – the domestic output growth has been calculated using seasonally adjusted data for the GDP at market prices from the Eurostat database. In order to transform the data from quarterly to monthly series a quadratic temporal disaggregation was necessary, this one has been performed using Eviews 10. Afterwards the year-on-year growth rates have been calculated.

r_t – the proxy used for the domestic interest rate was ROBOR3M for which I used the monthly average of the daily series extracted from the interactive database of the National Bank of Romania.

S_t – for the year-on-year stock return the BET index has been used. The BET index is known as the representative index for the Romanian stock market, the market quotes have been extracted from the Bloomberg database and year-on-year returns have been calculated.

x_t – the real effective exchange rate for Romania vs the euro area has been extracted from the European Commission database and it is used in logarithm following the approach from Horvath and Zhong (2019).

The external group of variables is constructed in a similar way. External Demand D_t^E has been extracted from Eurostat and transformed exactly like the domestic output growth (D_t), the external interest rate r_t^E (EURIBOR3M) is used as monthly average of the daily series in the same manner I transformed the domestic interest rate. In the case of external uncertainty (U_t^E) the VSTOXX index has been extracted from the Reuters Eikon database and is used in logarithm following the approach of Horvath and Zhong (2019).

5. Results

As mentioned before, three models are simulated for the two vectors of variables in order to ensure additional robustness checks. As the obtained results are fairly similar in all the 6 developed models, I will take a parsimonious approach and present in this section the results obtained for the vector Y_t using the Minnesota prior. As previously mentioned, the impulse response functions, variance decomposition and historical decomposition will be used for interpretation purposes.

It is very important to mention that the simulated models contain 4 lags and the identification method used was the Cholesky decomposition following the approach used

in Erten (2012). The method of identification is also in line with Horvath and Zhong (2019), the authors of the article using a recursive ordering approach with the contemporaneous matrix being lower triangular and with the elements on the diagonal normalized to one. Following the approach of Erten (2012) and Horvath and Zhong (2019), the block-exogeneity restriction will be used for the current paper as well, the main reason is that domestic variables in Romania will be restricted so that they do not produce any impacts on the variables from euro area. The GDP of Romania relative to the euro area GDP represents at the moment of writing this paper about 1.6%. Therefore, the hypothesis that the domestic variables will have a negligible impact on the euro area variables is a reasonable one.

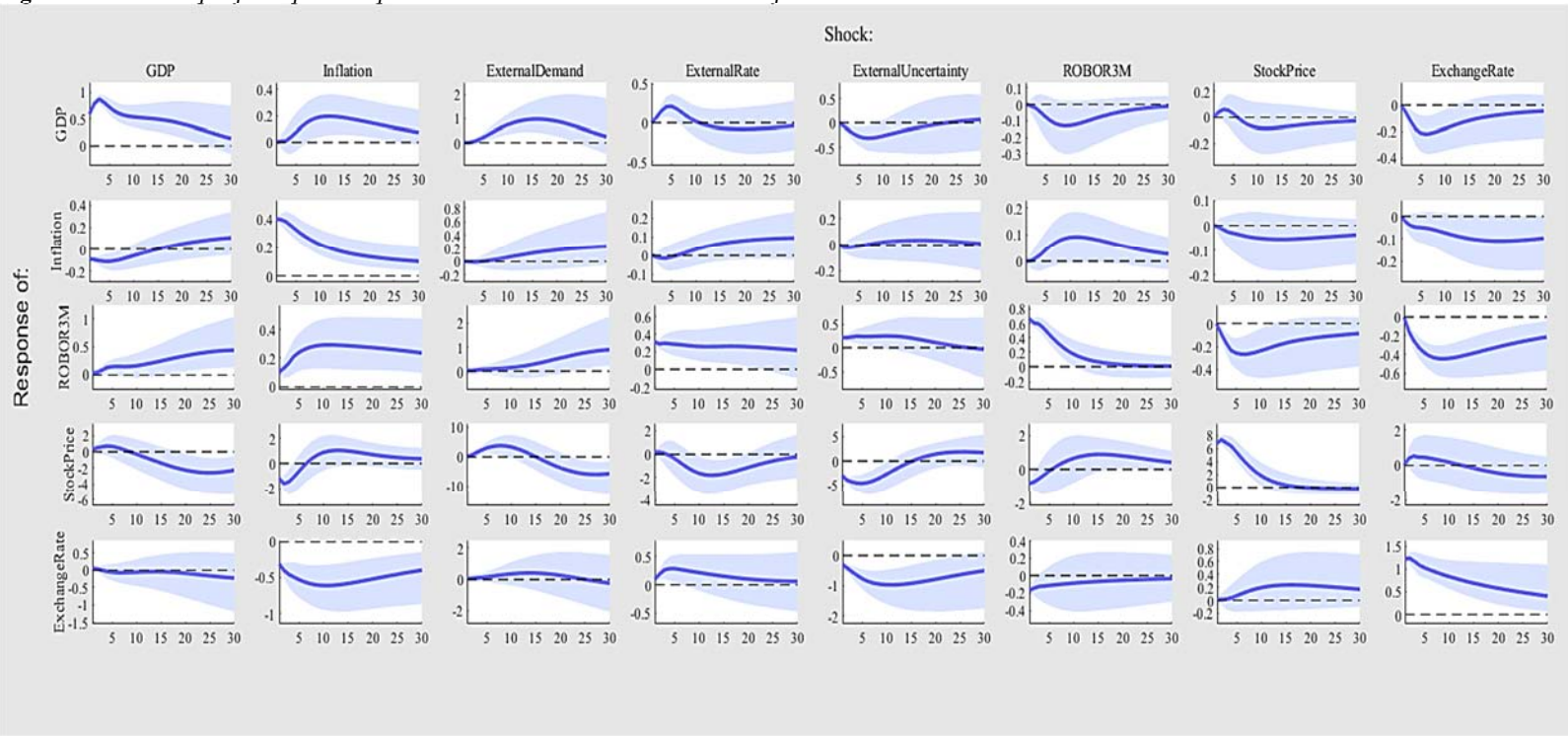
5.1. Impulse response functions

It can be observed in Figure 1 that the external variables in the euro area have a significant influence on the macroeconomic and financial variables of Romania.

Shocks generated by external demand affect in a positive and persistent way the domestic output growth, the shock begins to be significant, with a confidence level of 95% starting with month 5 and it lasts until month 24 when the lower bound of the 95% confidence interval is reaching 0. The euro area interest rate generates a positive impact on the domestic interest rate, the shock is statistically significant and persists until period 22. The external monetary policy instrument does not create significant shocks in connection to output growth and inflation for Romania.

Bayesian VAR with Minnesota prior

Figure 1. *Matlab output for impulse responses to a one standard deviation shock for the domestic variables*



External uncertainty mostly affects the real exchange rate and stock market return, the effects being statistically significant until periods 24 and 10. No significant impacts can be found generated by external financial uncertainty on variables that express the real economic activity of Romania.

These impulse response functions confirm that the Romanian economy is in close connection with the euro area in terms of real economic activity but also financial activity. A negative shock of external demand can generate a negative impact on Romania's economic growth over a horizon of up to 2 years, however, the external financial variables at the level of the euro area do not significantly affect real economic activity of Romania but they do affect domestic financial variables like the stock market return or the exchange rate.

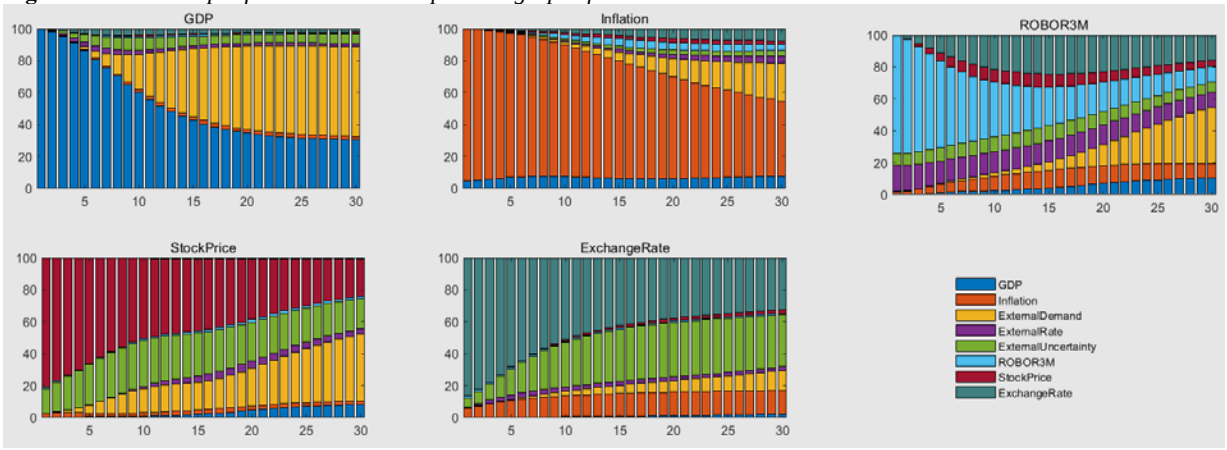
5.2. Variance and historical decomposition

The variance decomposition highlights how much each shock contributes to the variance of each endogenous variable in the model. With this technique I aim to quantify the expected importance of each type of external shock in relation to the domestic macroeconomic and financial variables. One of the most important findings of this paper can be found in the graphs from Figure 2 where it can be seen very easy that the external demand is the most important influencing factor for the output growth variance.

The historical decomposition is exposed below in Figure 3 in order to measure the contribution of historical shocks by decomposing the series into the contribution of each variable and summing up the impact in order to explain the past values of each component in the model. The purpose of the historical decomposition here is to measure the impact of the external shocks during the great recession and the first year of recovery.

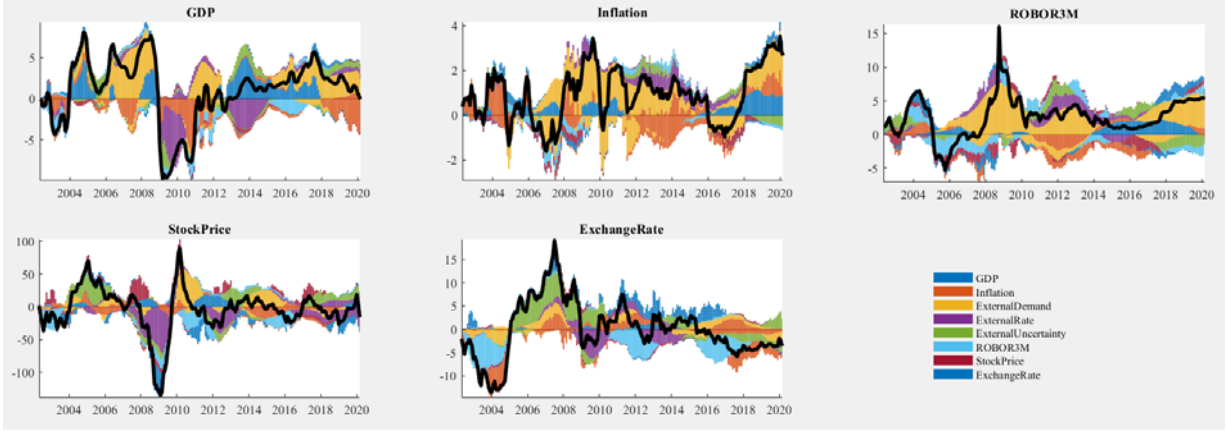
Bayesian VAR with Minnesota prior

Figure 2. *Matlab output for variance decomposition graphs for the domestic variable*



Bayesian VAR with Minnesota prior

Figure 3. *Matlab output for historical decomposition graphs for the domestic variables*



6. Main findings

After exposing the variance decomposition, it can be observed that the shocks coming from the external demand can represent 30% of the variance of the output growth on a horizon of 12 months. At the same time, these shocks can explain 50% of the variance in output growth and the unemployment rate over a time horizon of 2 years. For a more detailed overview Table 1 is presenting the median of the variance decomposition for GDP growth and unemployment rate. The results are in line with Erten (2012) which concludes that a severe external demand shock will create a deterioration in the economic growth of emerging economies. The conclusions of Andrle et al. (2013) are also in line with the current paper showing that 50% of the output variance in Poland is due to external shocks from the euro area.

Table 1. *Variance decomposition for the output growth and unemployment rate*

Variance Decomposition (Median in %) GDP:								
Period	D_t	π_t	$\boldsymbol{D_t^E}$	r_t^E	U_t^E	r_t	s_t	x_t
1	100	0	0	0	0	0	0	0
6	79	0.5	4.2	3.4	5.8	0.5	0.4	3.5
12	49.7	2.1	30.3	2	6.8	1.1	0.7	3.4
18	35.6	2.2	47.5	1.7	5.1	0.9	0.6	2.4
24	30.7	2.1	53	1.7	5.1	0.7	0.6	2
30	29	2.1	53.9	1.9	5.7	0.7	0.6	1.9
Variance Decomposition (Median in %) Unemployment:								
Period	u_t	π_t	$\boldsymbol{D_t^E}$	r_t^E	U_t^E	r_t	s_t	x_t
1	100	0	0	0	0	0	0	0
6	91.1	0.3	3.7	0.59	0.7	0.7	0.3	0.3
12	69.2	0.4	21.8	0.98	1.3	1	0.5	0.6
18	49.4	0.4	39.9	1.13	1.8	0.8	0.6	0.9
24	39.1	0.4	49.1	1.28	2.3	0.7	0.5	1
30	34.8	0.4	51.9	1.49	2.8	0.7	0.5	1.2

The domestic monetary policy instrument (ROBOR3M) is more responsive to Exchange Rate shocks (20.8%) rather than Inflation (11.8%) over a period of 18 months.

The stock market return is mainly affected by external demand, external uncertainty and domestic output growth. External uncertainty has an immediate impact on the return on stock market returns (12.5% since the first month), while external demand has a much stronger long-term effect (up to 32% over a 24-month horizon). This may suggest that foreign investors have a developed capacity to create volatility in the Romanian stock market. According to the degree of fast and significant reaction it is reasonable to believe that the foreign investors play the most important role in the Romanian stock market.

The real effective exchange rate is mainly affected by external uncertainty in the Eurozone (up to 30% in the long run), Inflation (14%) and External Demand (11%).

The dynamics of the unemployment rate is also governed to a significant extent by external demand, with 50% of the variance in the unemployment rate also being explained by the shocks coming from external demand. The variance decomposition is almost identical when the models were simulated both for output growth and unemployment.

7. Conclusions

The most important external shock from the euro area that is affecting the Romanian economy is the external demand which affects both macroeconomic and financial variables. External demand can represent 50% of the variance of the output growth and unemployment rate in the long run. External uncertainty mainly affects the stock market return and the real exchange rate (variations are up to 30% and 25% in the long run) while not having a significant impact on the real economic activity. The foreign monetary policy instrument (euro area interest rate) mainly affects the interest rate in the Romanian money market, with variations of up to 16.7% from the first month, while the domestic monetary policy instrument (ROBOR3M) is more sensitive to the shocks created by the real exchange rate (20.8%) rather than to the inflation shocks (11%). The stock market return does not significantly affect economic growth in Romania, but can be instantly affected by external uncertainty (12.5% from the first month) and in the long run being in a more material way by the external demand (31.9% on a 2 year timeline).

Taking into account the belief that half of the economic growth or contraction can be explained in the long run by external demand, and in the short run by the negative effects generated by real economic activity, the Romanian economy should follow a trend which is in line with the euro area in terms of economic decline and recovery.

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