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КАТЕДРА „СТАТИСТИКА И ПРИЛОЖНА МАТЕМАТИКА“

КРЪГЛА МАСА
С МЕЖДУНАРОДНО УЧАСТИЕ

СТАТИСТИЧЕСКИ ИЗМЕРЕНИЯ НА РЕГИОНАЛНИТЕ РАЗЛИЧИЯ И НЕРАВЕНСТВА МЕЖДУ СЕВЕРНА И ЮЖНА БЪЛГАРИЯ

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С МЕЖДУНАРОДНО УЧАСТИЕ

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Abstract: *The paper presents a framework for practically modelling the growth rate of gross domestic product and unemployment as two key macroeconomic indicators. Empirical research on the movement of these two macroeconomic indicators in the Republic of Serbia relates to the period I quarter 2011 - IV quarter of 2019. For the purposes of modelling GDP growth rates and unemployment rates in the Republic of Serbia, an appropriate VAR model has been developed, stability has been studied, and the evaluation of prognostic capabilities of the given model has been carried out. In the paper we investigate the relationship between GDP growth rate and unemployment rates. Also, we analysed the existence of causality between the observed variables. The main goal of the work is to create a model that will be used for analytical and prognostic purposes. The basic conclusion in the paper is that there is a clear presence of causation between GDP growth rates and unemployment rates.*

Key words: *GDP growth rate, unemployment rate, time series, VAR, stationary.*

JEL: *C53.*

Iintroduction

Increasing need for macroeconomic indicators monitoring has necessarily encouraged the development of complex econometric models for purpose of forecasting. Accurate and reliable forecasts of future macroeconomic trends improve efficiency of decision-making process of all economic entities in one country. With the increase of economic knowledge and empirical potential in this area, the re-examination of existing models for macroeconomic indicators forecasting from the aspect of their application is becoming more and more acute.

Econometric forecasting models are very useful in understanding future developments in the economy, but the authors and users of these models must be aware of limitations that are inevitably present when concluding, as well generalizing on the basis of individual cases. The purpose of prognostic models does not end only with the final outcome, in terms of confirming the future values of the observed economic variables. The forecasting process cannot reduce negative outcomes and uncertainty in the future, but increases managements confidence in making important

decisions (Milenković et al., 2014). Also, successful forecasting requires economic and econometric expertise, knowledge of complex political and social factors, personal judgment and forecaster experience.

The paper examines the possibility of short-term forecasting of GDP using econometric models with parameters that are variable over time and which allow explicit modeling of these structural changes.The aim of this paper is to determine an adequate econometric model for GDP modeling and forecasting in the short-term period of time. In D'Agnostino et al (2010) and Mumtaz et al (2012) works, the forecasts for the USA, EU and UK were evaluated, while in this paper the aim is to develop a model for an small economy such as Serbian, strongly influenced by shocks coming from the environment. In this sense, an appropriate prognostic VAR model was developed, where the estimates were conducted by using of the least squares (OLS) method and prognosis was further evaluated.

1. Forecasting of Economic activity

To understand development of macroeconomic forecasting theory requires understanding of relationship between measurement and theory, and appropriate development of a non-structural and structural approach to forecasting. Creation of new and overcoming of old models is a continuous process, which brings special interest and uncertainty to this area (Caraiani, 2010). Thus, for example, large-scale forecast macroeconomic models did not live up to expectations, but they left an indelible mark and contributed to the further development of forecasting. They encouraged the development of very powerful theories about model identification and evaluation, computer and simulation techniques, understandable computer macroeconomic databases, etc. As macroeconomic theory has advanced since 1970, questioning its own ideas and postulates, so macroeconomic forecasting has been improved. Kostic and others (Kostić et al., 2016) in their work successfully develop a model for inflation forecasting in Republic of Serbia for 2016. After global economic crisis in 2008, economists have often been criticized that using conventional econometric and macroeconomic models are not enough to predict such large macroeconomic disturbances. All this has resulted in a large number of papers appearing in recent years which examine the predictive performance of alternative methods for forecasting macroeconomic indicators. In that sense, vector autoregressive models (VAR models) are becoming more and more important. D'Agnostino et al (2010) uses forms of the VAR model in forecasting of unemployment, inflation, and interest rates in U.S., and finds out that the above approach yields much better results on average than classical approach through

univariate models. Mumtez et al (2012), in the case of United Kingdom, examine the prognostic performance of almost the same set of variables by applying a large number of models (25) to an extremely large sample (1976-2007) and conclude that macroeconomic variables are better predicted by applying some kind of VAR model than univariate approach.

2. Vector autoregressive models

Vector autoregressive models (VAR) has gained a significant place in econometrics in early 1980's thanks to Sims work (Sims, 1980), as a natural generalization of univariate autoregressive models.

VAR models offer a very simple procedure for generating forecasts. They are based on the idea that theoretical constraints are numerous and often arbitrary. Their origin stemmed from desire that the model can rely more on data than on theoretical assumptions, so the approach of a vector autoregressive (VAR) model was developed, as an alternative to traditional models of simultaneous equations (Jovičić and Dragutinović, 2011). Considering the forecasts obtained by applying the VAR model ,Roy (Roy H. Webb 1999)finds that these are very simple forecasts based on the idea of extrapolation of the recent past. In essence, the VAR model is a flexible approximation of the reduced form of a wide range of dynamic econometric models. In general, VAR models suffer from presence of many parameters that are not statistically significant (overfitting). As a result, such models do not give good forecasts outside the sample. Engle's and Granger's concept of cointegration has posed many different and interesting questions about prognostic performance of error-corrected models, giving empirical conclusions that these models outperform VAR, especially with long time intervals.

Evaluation of VAR model is performed by the method of generalized least squares (GLS), where is, with the set conditions, the random component a vector process of white noise. The scores obtained by GLS method are unbiased and consistent, as well as identical to the scores obtained by the maximum reliability method if the errors are normally distributed. This allows the application of the standard theory of statistical inference. In practice, the optimal order of the model is usually determined through information criteria. For the selection of an adequate model, as with univariate models, it can be used AIC, SCH and HQC information criteria, just now in multidimensional variant with k variables.

3. Application of VAR model in forecasting of the Republic of Serbia GDP

3.1. Model evaluation

In this paper, VAR model represents a framework for an empirical analysis of the relationship between the following two time series: GDP growth rates (GDPR) and unemployment rates (UNR). Time series were observed for period from the first quarter of 2011 to the fourth quarter of 2019. The analysis was conducted using the software package Eviews 7. A similar approach is found in work of Lada and Wójcik (Lada., And Wójcik, 2007).

Before evaluating of the VAR model, the stationarity of the series should be examined. It is generally known that the concept of stationarity is of elementary importance in the analysis of time series. If this feature of the series is impaired, consistent ratings cannot be expected.

The stationarity of the given series was checked by using of Dickey-Fuller test. Based on the test results, we find that the GDPR series do not have a single root, and it is stationary. In contrast, the UNR series is not stationary, so we need to transform original series. In transformation of a given series, the method of differentiation was used. The series reaches stationarity after the second difference. In order to check if there is a significant correlation between the observed series (GDPR and UNR), we conduct an empirical analysis that resolves dilemma of whether these series are cointegrated time series, is there a one-way causality between these series, or it is mutual. The results of analysis showed that these are cointegrated time series, so there is a long-term coherence between the GDPR and the UNR. As these two series are cointegrated and as we have shown that there is mutual causality, we evaluate the appropriate VAR model.

In the process of selecting the appropriate model, we a priori select the fourth-order VAR model since there are quarterly data.

After checking the assumptions of the econometric model, we found that the model is stable and satisfactory. Further, a causality test was performed. Namely, based on estimated VAR (4) model, we examine whether there is a simultaneous interdependence between GDPR i UNR, ie whether GDPR causes UNR, on the one hand, and whether UNR causes GDPR, on the other hand.

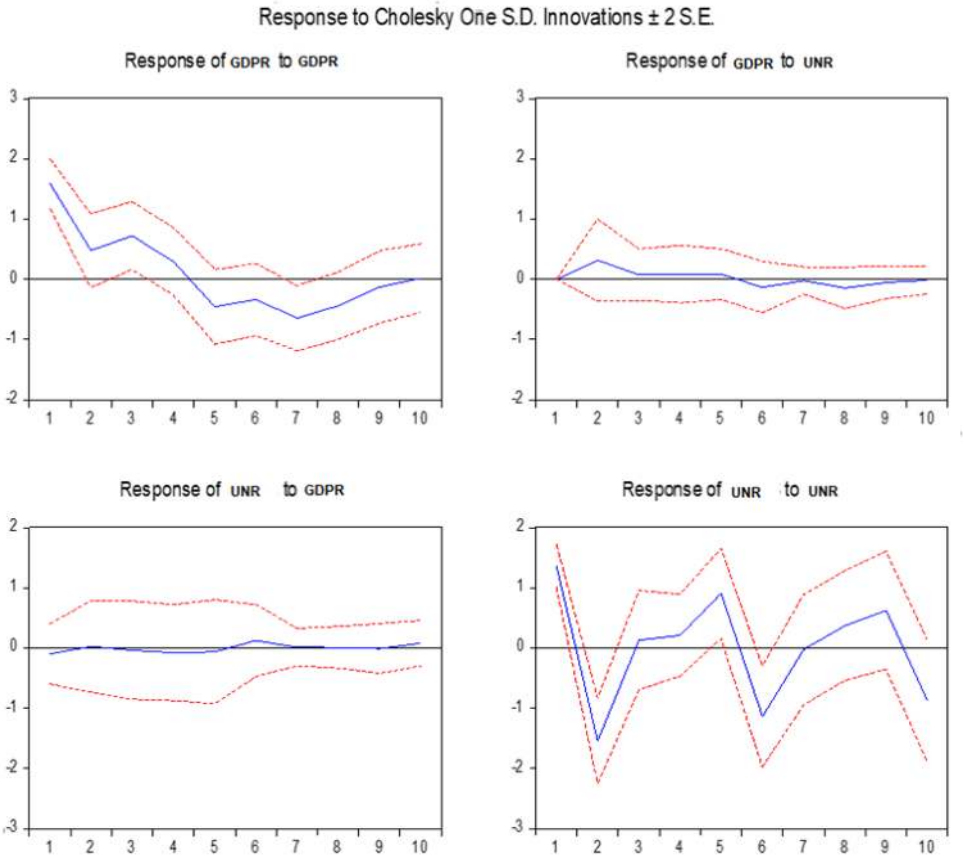

Fig. 1. Reactions of variables from the VAR model to shocks from one standard deviation

The application of Granger Causality tests to the selected VAR model unequivocally shows that there is causality between GDPR and UNR in both directions, in terms of Granger. The impulse response function and variance decomposition are particularly important tools for analysing the relationships between variables in the VAR model. The previously established stability of VAR models is a guarantee that they are accurately calculated. Measurement of the magnitude of the accumulated impact of unit shock on the observed variables, as well as the assessment of the duration of shock absorption and the significance of the impact of each shock on the variables, are analysed based on the impulse response function. Although the analysis of the impulse response function is less informative than the decomposition of variance during the construction of the forecasting model, we believe that it should not be neglected because it can point to interesting conclusions about the relationships between variables in the model. Based

on the estimated parameters of the VAR model, the cumulative responses of the variables to shocks (impulses) of both variables from one standard deviation were calculated, which is shown in Figure 1. The figure with impulse response functions clearly shows the presence of causality between GDPR and UNR. Namely, the reactions of the GDPR in the first five quarters to the shock of one standard deviation at UNR will be positive, while in the next five quarters it will be negative. The reaction of the UNR to the shock of one standard deviation in the GDPR in the first six quarters will be negative, in the seventh quarter it will be positive, and by the end of the observed period there will be no reaction in the UNR.

3.2. Evaluation of VAR model forecast

We will observe the evaluation of the forecast of the estimated VAR model through the analysis of the forecast within the sample (in-sample). Figure 2 gives a very clear impression of the quality of the GDPR and UNR forecast using the VAR model, where the forecast growth rates of these two macroeconomic variables largely coincide with the actual values.

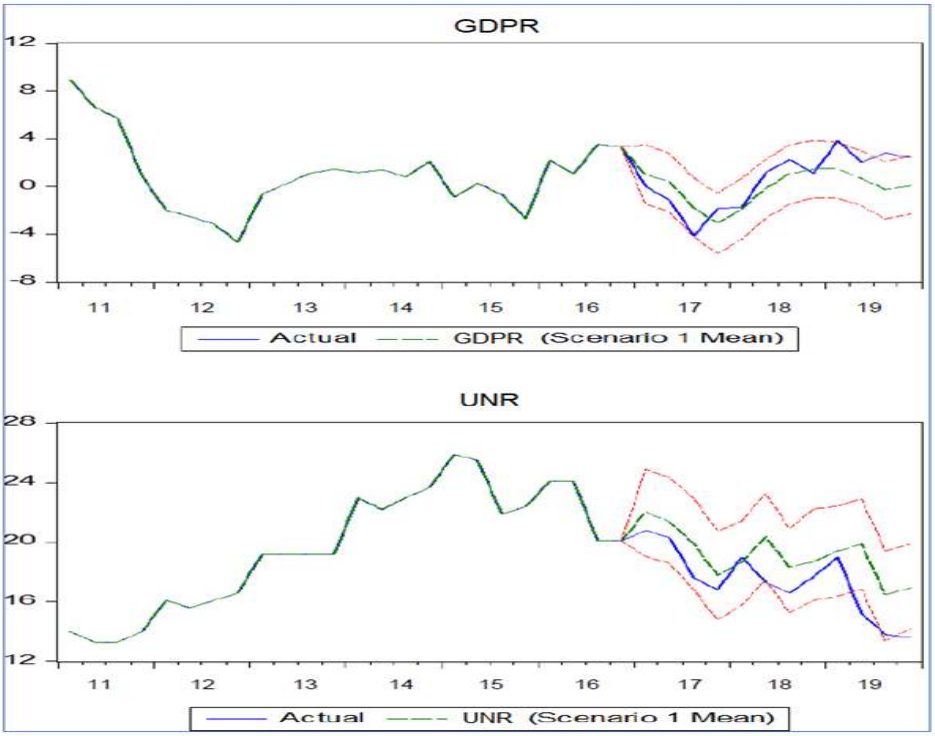

Fig. 2. Actual and forecast growth rates of GDPiUN from the VAR model for period 2017-2019

Conclusion

Forecasting is a dynamic and complex process, which successful implementation depends on many factors. Adequate forecasting model selection and its application are just some of the prerequisites for successful forecasting. In that sense, the paper first provides methodological base for construction of an econometric model for forecasting of two key macroeconomic indicators - GDP growth rates and unemployment rates in Republic of Serbia. As one of the most suitable models for forecasting, the VAR model was chosen. Due to the numerous specifics of the Serbian economy and pronounced shocks in the last twenty years, primarily of a structural nature, the complexity of forecasting is particularly come to the fore.

Applying of theoretical understandings provides a framework for practical modelling of the gross domestic product growth rate and unemployment rate in Republic of Serbia, as two key macroeconomic indicators of a country. Empirical research has confirmed the initial idea that it is possible to successfully forecast the most important macroeconomic indicators by applying the VAR model in small economies such as Serbia.

The basic conclusion which is imposed after assessment and evaluation of the appropriate VAR (4) model, and after calculating of the cumulative response of variables to shocks from one standard deviation of both selected variables, is that there is a clear presence of causality between GDPR and UNR. Namely, the reactions of the GDPR in the first five quarters to the shock of one standard deviation at UNR will be positive, while in the next five quarters it will be negative. The reaction of the UNR to the shock of the standard deviation in the GDPR in the first six quarters will be negative, in the seventh quarter it will be positive, and by the end of the observed period there will be no reaction in the UNR.Based on the conducted analyzes, it can be concluded that in the given conditions, based on available statistical infrastructure, the models that include more information about other variables, such as VAR models, excel the univariate models. However, the conclusions reached in the paper are not definitive, because the analysis was conducted on the basis of one selected model. Any improvements to the selected VAR model may lead to the results being somewhat different.

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