ESTUDIOS DE ECONOMÍA APLICADA VOL. 33-2 2015 PÁGS. 463–486

Forecasting Accuracy of a Multi-Country Macroeconometric Model for the Former Yugoslavia

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ABSTRACT

In this paper, the forecasting performance of a structural multi-country model for Slovenia, Serbia, Croatia and Bosnia and Herzegovina is compared to the forecasting ability of ARMA and VAR models. It turns out that in many cases the time series approaches deliver more accurate predictions of economic growth, inflation and the unemployment rate than the structural model which is based both on economic theory and on time series for the included countries. This shows that it is not so easy to beat time series models in forecasting. However, the usefulness of structural models should not be evaluated on the basis of their forecasting performance alone, since these models can in addition be used to investigate the macroeconomic effects of policy measures or of exogenous shocks.

Keywords: Structural Macroeconometric Models, Time Series Models, Forecasting, Forecasting Performance.

Capacidad predictiva de los modelos estructurales frente a modelos de series temporales. Aplicación a un sistema multi-país en la antigua Yugoslavia

RESUMEN

En el presente artículo se analiza la capacidad predictiva de un modelo estructural multi-país, aplicado a las antiguas repúblicas yugoeslavas (Eslovenia, Serbia, Croacia y Bosnia Herzegovina), rente a modelos basados en la dinámica de series temporales (ARIMA y VAR). De acuerdo con la experiencia empírica, en muchas ocasiones los modelos de series temporales ofrecen mejores predicciones de los agregados macroeconómicos (Crecimiento del PIB, Inflación o Tasa de desempleo) que los modelos estructurales, que incorporan, además de las propias series temporales, las interrelaciones derivadas de la teoría económica. Nuestros resultados iniciales, aunque no de forma concluyente, parecen corroborar esta hipótesis; sin embargo, la utilidad de los modelos estructurales no puede juzgarse, únicamente, por su capacidad predictiva; ya que estos modelos ofrecen además la posibilidad de analizar alternativas de política económica, o impactos de shocks exógenos.

Palabras clave: Modelos macroeconómicos estructurales, Modelos de series temporales, Predicción, capacidad predictiva.

JEL Classification: C52, C53, E37

Artículo recibido en marzo de 2015 y aceptado en abril de 2015
Artículo disponible en versión electrónica en la página www.revista-eea.net, ref. ə-33210

ISSN 1697-5731 (online) – ISSN 1133-3197 (print)

1. INTRODUCTION

Economic forecasts are important for the public budget preparation, for planning purposes of companies, for the wage bargaining process, and for many other purposes (see also Klein 1984). A large variety of techniques is at hand for generating economic forecasts. Macroeconomic models range from pure time series approaches to models based on sound economic theory. The latter models are in some cases not based on actual data. The issue how reliable the forecasts generated with different types of models is almost as old as the existence of econometric models (see, e.g. Klein 1971, 1973; Klein *et al.*, 1974; Pulido San Roman and Pérez Garcia 2006).

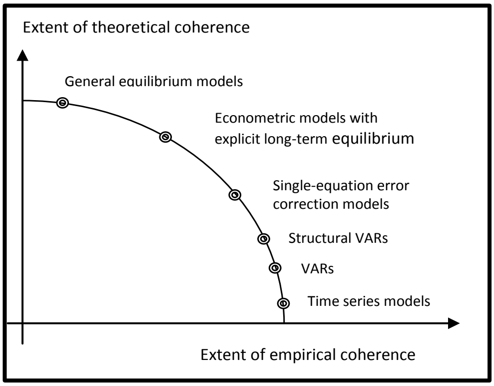
In this paper, the forecasting performance of a structural macroeconometric multi-country-model for the countries Slovenia, Serbia, Croatia and Bosnia and Herzegovina is compared to time series models for these economies. Forecasts for real GDP growth, the inflation rate and the unemployment rate are evaluated. The forecasting performance is evaluated on the basis of (i) statistical tests (mean absolute error, root mean squared error, Theil's inequality coefficient), (ii) the number of time period each model comes closest to the actual realisation of the investigated variables, and (iii) the test whether the forecasts generated with the different models are unbiased.

The paper is organised as follows. In the following chapter, the available different types of macroeconomic models are described. Then, in chapter 3, the structural multi-country model for the former Yugoslav countries is depicted. The tests of the forecasting performance are described in chapter 4, and chapter 5 concludes.

2. MACROECONOMIC MODELS USED FOR FORECASTING

Forecasting is an important topic in economic research institutes, central banks, and government bodies. Hence, a huge variety of forecasting methods and models has been developed. This development has been affected by the evolution of macroeconomic theory as well as econometric techniques. In order to classify these approaches, it is useful to rank them with regard to their empirical and theoretical coherence. Empirical coherence means the ability of a forecasting method to replicate more or less accurately the history of one or more time series. Theoretical coherence means that the forecast can be explained in line with an economic theory. As pointed out by Pagan (2003), for many reasons a trade-off exists between both concepts. Therefore the selection of a forecasting method includes a weighting of theoretical and empirical coherence. In Figure 1, some widely-used methods are ranged with regard to empirical and theoretical coherence.

Figure 1
Trade-off between theoretical and empirical coherence of macroeconometric models



Source: Adapted from Pagan (2003).

If the forecaster is interested in predicting the future outcome of single time series like GDP growth or the inflation rate, a time series approach is one option. However, formal tests of the information content of time series give ambiguous results. For example, Galbraith (2003) shows that there is no valuable information in US GDP after two quarters. Öller (1985) finds that using an ARIMA model for a three year ahead forecast for Finnish GDP contains valuable information. Using a different approach, Diebold and Kilian (1997) get the result that the information content of US GDP is close to zero after 15 quarters.

While time series methods are suitable if one is interested in only one variable, structural models are required if forecasts are not only interested in the development of GDP, but in a consistent projection of a comprehensive set of macroeconomic variables. This is usually the case. Structural models allow to predict a large number of macroeconomic aggregates and to account for their interactions over the forecasting horizon. This is not the case with univariate time series models and, due to the degrees of freedom problem, not feasible with VAR models. Furthermore, when using a macroeconometric model it is possible to interpret the outcome of important economic variables with regard to the evolution of exogenous variables and the underlying economic structure of the model. This dependence of the forecast on assumptions about exogenous influences and the underlying structure is the reason why these projections are not forecasts in the technical sense.

A category of models with a sharp focus on empirical coherence includes those operated by the New Zealand and Australian Treasuries (Powell and Murphy 1997). Both of these models also have a very strong theoretical foundation and derive the short-term relationships from Keynesian theory; the nature of the long-run relationships is neoclassical. Concessions are made in these models, however, to facilitate their use for forecasting in the Treasuries. As an example, in the New Zealand model the NAIRU is predetermined exogenously because it is plausible to assume that it remains relatively constant over the short to medium run. In models with an explicit long-term equilibrium, the two components are specified independently and brought together only later. This modelling approach is adopted by the Australian and New Zealand models. To arrive at the equations for the long-term equilibrium, the supply block is jointly estimated with a maximum likelihood approach in the New Zealand model. The demand-side equations are estimated with OLS because the relations are interpreted as co-integrating relations. The model's dynamic structure is especially significant for the short and medium-term forecasts.

Most of the models used for medium-term forecasting belong to the class of multi-equation error correction (or structural error correction) models. For this reason, this class contains the largest variety. Although their theoretical foundations differ considerably, they are all based on the neoclassical synthesis. The neoclassical supply side plays a prominent role in those models that are used to compute scenarios or produce forecasts over a period of up to 15 years; that is to say the medium to long term. The JADE model of the CPB, for example, which was built to analyse the medium- and long-term effects of shocks and policy measures, contains a fairly extensively modelled production sector and labour market. In this model the equilibrium unemployment rate is endogenous so that the adjustment of the reaction of the labour market is important for the transition to the long-run equilibrium. Also many models used in institutions participating in the UN project LINK[1] use structural multi-equation macroeconometric models which combine theoretical coherence with empirical validation. Examples are the model LIMA operated at the Institute for Advanced Studies in Vienna, Austria (Hofer and Kunst 2005), and the macroeconomic model run at the Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI) in Essen, Germany (see, e.g. Heilemann 2004).

In contrast, models covering a period of no more than five years generally dispose of a comprehensively modelled demand side and thus place more emphasis on Keynesian elements. In these models the transition to the steady state takes place mainly through the adjustment of prices and wages. Examples are the HMTM of the UK Treasury and models in Nordic countries like ADAM and KESSU. These models facilitate testing of the effects and relationships derived from theory at least on the level of the single equations. Within this framework a two-step procedure is used to perform a medium-term forecast. In a first step, the level of potential GDP over the next five years is determined. The second step is to derive the transition path of actual GDP from its current level towards potential GDP.

[1] http://projects.chass.utoronto.ca/link/desc0305.htm

Recently, New Keynesian DSGE models have become increasingly popular also for forecasting in addition to simulations which these models had originally been designed for. In an influential paper, Smets and Wouters (2007) show that forecasts with these models are able to outperform those of Bayesian VARs at a time horizon of three years.

The multi-country macroeconomic model whose forecasting performance is evaluated in this paper can be characterised as a traditional structural macroeconometric model with a theoretical basis, but with a focus on an empirical foundation. The model will be described in some detail in the following chapter.

3. THE MACROECONOMETRIC MULTI-COUNTRY MODEL

3.1. General modelling philosophy

The structural model whose forecasts are evaluated in this paper comprises the countries Slovenia, Serbia, Croatia and Bosnia and Herzegovina. All four sub-models have a similar structure and will be verbally described in this section. A complete listing of the model equations would go beyond the scope of this paper. They can be found in the following publications. A detailed description of a previous version of the model for Serbia can be found in Weyerstrass and Grozea-Helmenstein (2013a). Earlier versions of the model for Slovenia have been described in e.g. Weyerstrass and Neck (2008, 2007). A description of the multi-country model can be found in Behrens *et al.* (2011). The model for Serbia has been used several times to generate forecasts for the Serbian economy (e.g. Grozea-Helmenstein *et al.*, 2012). The model for Slovenia has been applied in several studies to analyse various aspects of Slovenia's continuous European integration process. The models for Slovenia and Serbia have been applied to analyse the macroeconomic consequences of different scenarios of the euro area future (Weyerstrass and Grozea-Helmenstein 2013b). All equations were estimated with OLS. It might have been preferable to estimate those blocks with high interdependencies (in particular the wage-price system) with Full Information Maximum Likelihood or Three-stage least squares, but the shortness of available time series prevented these approaches. Furthermore, OLS gives under some general conditions unbiased estimates.

As described in detail in Weyerstrass (2011), weak exogeneity of the right-hand side variables of a structural econometric model is required for efficient estimation and hypothesis testing. In the case of weak exogeneity, no useful information is lost when other variables are made conditional on these variables without specifying their generating process. Strong exogeneity is the combination of weak exogeneity and Granger non-causality. It ensures valid forecasting of the endogenous variables, conditional on assumptions about the explanatory variables. Super exogeneity requires weak exogeneity of the model variables and structural invariance. A conditional model is structurally invariant if all parameters are invariant to changes in the distribution of the conditioning variables. Super exogeneity is required for policy analyses, since such analyses assume that the parameters of the model do not change when the policy regime changes. The super-exogeneity condition may be investigated using a test for weak exogeneity combined with a test for parameter invariance. The CUSUM test and a Chow breakpoint test were performed to test the Slovenian model for parameter stability. For almost all behavioural equations, the tests indicate that the parameters have been stable over time. Granger causality tests indicate that in almost all equations the right-hand side variables, i.e. the explanatory variables, are indeed not directly influenced by the endogenous variables. Based on the Granger causality and parameter stability tests, the model for Slovenia can be viewed as being appropriate for both forecasting and policy analysis, although it cannot be excluded that future changes in the policy regimes might induce private agents to change their behaviour in a different way than they did in the past (see Weyerstrass 2011).

For the models for Serbia, Bosnia and Herzegovina and Croatia, only parts of these tests could be performed due to short time series. Evaluations based on the mean absolute percentage error and on Theil's inequality coefficient, indicate that the ability of the macroeconometric sub-models for Serbia to replicate the endogenous variables can be regarded as satisfactory (Behrens *et al.*, 2011). Due to the shortness of the time series, formal tests for Heteroscedasticity were refrained from, since they are designed for large samples. In addition, the estimated coefficients are valid even under heteroscedasticity, and any methods for dealing with heteroscedasticity like instrumental variables would also require longer time series without structural breaks. Furthermore, in the design of the behavioural equations, theoretical considerations have been given priority over statistical properties when choosing the variables and functional form of the equations.

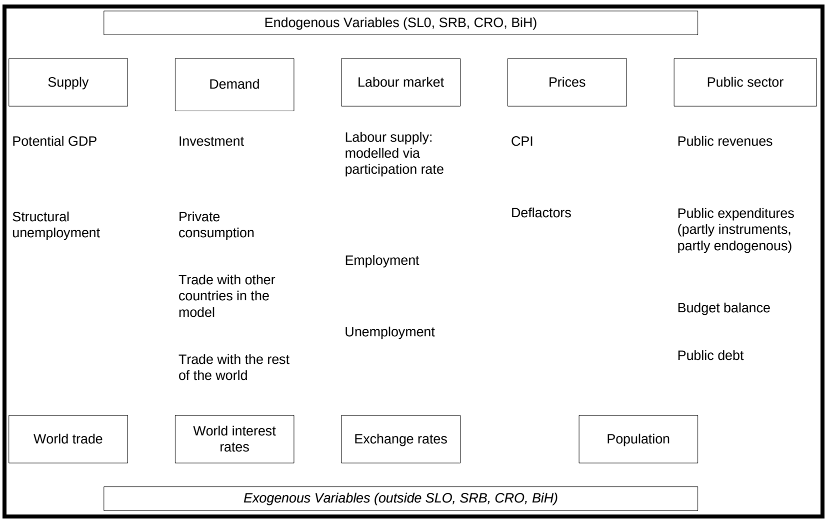
Unit root tests identify most variables as integrated of order one, i.e. the variables are non-stationary in levels, but the first differences are stationary. In many cases, the results of the unit root tests are inconclusive. This problem is foremost caused by the shortness of the time series. Based on the results of the unit root tests, for almost all behavioural equations error correction models (ECM) were chosen as the most appropriate modelling technique for all four country models, despite the short history of reliable time series especially for Serbia, Bosnia and Herzegovina and Croatia.

3.2. Description of the model equations

The macroeconomic models contained in the multi-country model combine Keynesian and neoclassical elements. The former determine the short and medium run solutions in the sense that the models are demand-driven and persistent disequilibria in the goods and labour markets are possible. The supply side incorporates neoclassical features. The models are based on the conventional aggregate supply / aggregate demand (AS-AD) framework, where the long-run relationships have mainly been chosen on the basis of theoretical considerations. The wage-price system is based on a bargaining model between employers and trade unions (Layard, Nickell, Jackman 1991). In this labour market model, prices are set as mark-up over marginal costs. The wage-setting rule is based on a Nash bargaining process which produces an expected real wage that varies inversely with the unemployment rate.

The econometric estimations are based on quarterly data, starting in 1995 (Slovenia), 1997 (Serbia), 1999 (Croatia), and 2000 (Bosnia and Herzegovina), respectively. However, for some variables the time series for all countries except for Slovenia start later, some only in 2003. Furthermore, for some macroeconomic aggregates (e.g. the capital stock) quarterly data are not available. In these cases, quarterly data were derived from the respective annual aggregates by recurrence to related variables for which higher-frequency data have been available. For example, the quarterly time series for the capital stock in the country models have been calculated on the basis of the perpetual inventory method. This implies the estimation of an initial capital stock. This initial value was taken from international data. Then, this capital stock was extrapolated by adding gross fixed investment and subtracting depreciation, whereby the depreciation rate was also based on international experience.

Figure 2
Block structure of the country models



Source: Own illustration.

Figure 2 visualises the block structure of the country models in the structural multi-country model. Each model has essentially the same structure, with some deviations in details, depending on data availability.

In the supply blocks of the models, potential GDP is determined, based on a Cobb-Douglas production function with constant returns to scale and with the production factors labour, capital and autonomous technical progress. Since potential GDP is a measure of the long-run production possibilities of an economy, it is the long-run trends rather than the actual realisations of the production factors that enter the production function. Technical progress is defined as total factor productivity (TFP). Trend employment is calculated by subtracting natural or structural unemployment (the non-inflation accelerating inflation rate of unemployment, or the NAIRU) from the labour force. Since structural unemployment is non-observable, this variable has to be approximated. This is done by applying a Hodrick-Prescott (HP) filter to the actual unemployment rate. Structural unemployment is then defined as the long-run trend in actual unemployment. In order to endogenise the NAIRU, it is modelled as a moving average (MA) process. Total factor productivity is calculated as the Solow residuum, i.e. that part of the change in real GDP that is not due to increased labour and capital input, where both production factors are weighted with their production elasticities, i.e. 0.35 for the capital stock and 0.65 for labour, respectively. The TFP trend is derived by applying the HP filter to actual TFP.

On the demand side, the models comprise the labour, goods, financial, and foreign exchange markets. Hence the models are made up of equations for the GDP expenditure components (private and public consumption, capital formation, exports and imports), prices, wages, employment, unemployment, interest rates, and exchange rates. In addition, the most important revenue and expenditure items of the public budgets are modelled. Consumption of private households depends on current real disposable income (the Keynesian consumption theory), and on the real long-term interest rate. The latter incorporates the permanent income hypothesis according to which it is the expected future rather than current income which is relevant for private consumption. Discounted future income can be used as an approximation of wealth. Lacking reliable data on private wealth in the countries comprised in the model, wealth effects are approximated by the real long-term interest rate. The interest rate as a determinant of consumption accounts also for the fact that some households finance part of their consumption via bank credits, and for the intertemporal decision on the allocation of income to consumption in the present period and in the future. Gross fixed capital formation is undertaken to renew the capital stock and to adjust it to changes in final demand. Hence, the accelerator theory stipulates that changes in demand determine fixed capital formation. According to theories focussing on the profitability of investment projects, the value of the capital stock equals the discounted future income that can be generated by employing the capital stock. Therefore, the interest rate, which is used to discount future income, is crucial for the profitability of an investment project. The market interest rate is formed on the basis of the time preferences of the individual investors. According to this strand of theories, investment is a function of the real interest rate. The neoclassical investment theory combines the investment determinants according to the accelerator hypothesis and profitability considerations. In this case, the optimal capital stock equalises the marginal revenue product of capital and the user cost of capital. Due to data availability as well as significance and sign of the estimated coefficients, the user cost of capital is approximated solely by the real long-term interest rate. In particular time series of company taxation which are relevant for investment decisions are lacking.

The sub-models for Bosnia and Herzegovina, Slovenia, Serbia and Croatia are linked via their bilateral trade relations and bilateral exchange rates. Data on exports and imports are available by country for trade in goods at current prices, but not for trade in services or measured at constant prices. Hence, the bilateral trade relations between the countries included in the multi-country model were based on nominal export and import data from balance of payments statistics. These data were used to divide total exports and imports into trade between Croatia, Bosnia and Herzegovina, Serbia and Slovenia and trade of these countries with the rest of the world. The resulting shares were applied to exports and imports according to national accounts at current and constant prices. For modelling the trade relations between the countries of the former Yugoslavia, behavioural equations for bilateral exports between each country pair were estimated, while by definition the imports of country i from j are identical (aside from measurement errors) to the corresponding exports in the other direction, transferred into the domestic currency of the recipient country. In each sub-model, real exports from country i to country j depend on real demand in the recipient country and on the bilateral real exchange rate. The real bilateral exchange rate is composed of the nominal bilateral exchange rate and the ratio of the price levels in the two countries.

In addition to exports and imports, the four country models are linked via their bilateral exchange rates. The exchange rates between the currencies of the countries (the Bosnian convertible mark KM, the Croatian kuna, the Serbian dinar and the euro in the case of Slovenia) are explained by the interest differential and the ratio of the price levels between each country pair. For Slovenia, which has been a member of the euro area since 2007, the euro series was extended backwards for the period prior to 2007 using the conversion rate between the Slovenian tolar and the euro. The inclusion of the interest differential is based on the theory of interest rate parity. The inclusion of the ratio of price levels between each pair of countries in the bilateral exchange rate equations is based on the Purchasing Power Parity (PPP) theory. In the export and import equations of the former Yugoslav republics with respect to the rest of world, international price competitiveness is represented by the real effective exchange rates.

Labour demand by companies (i.e. actual employment) is influenced by the production level (real GDP) and by labour costs. In the models, labour costs consist of the average gross wage per employee. Labour supply by private households is made endogenous via the labour force participation rate which depends on the real net wage, implying that the substitution effect of higher wages dominates over the income effect. The participation rate is then multiplied by the exogenous working-age population. The consumer price index (CPI) is related to internal and external determinants. The most important internal cost-push factors are wages. In addition, rising capacity utilisation exerts upward pressure on prices. As important external cost factors, either the oil price or total import prices determine domestic prices. The GDP deflator and other deflators are linked to the development of the consumer price index. In an extended Phillips curve equation, the wage rate is negatively influenced by the difference between the actual unemployment rate and the non-accelerating inflation rate of unemployment, or the NAIRU. In addition, wages are positively influenced by consumer prices and by labour productivity. On the financial market, interest rates and exchange rates are determined. Since the National Banks of Serbia and of Croatia run independent monetary policies, the short-term interest rates have been included in the models for Serbia and for Croatia, respectively, as monetary policy instruments. These sub-models contain Taylor rule type equations, i.e. the respective short-term interest rate depends positively on the inflation rate and on the output gap. Since Slovenia as a euro area member state cannot pursue an independent monetary policy, in the model for Slovenia the short-term interest rate is solely determined the three months EURIBOR. The central bank of Bosnia and Herzegovina runs a currency board with the euro as the anchor currency, therefore also for this country monetary policy is (mostly) exogenous. In term structure equations, the long-term interest rates depend on the short-term interest rates. The long-term market interest rates then determine the respective implicit interest rates on outstanding public debt.

4. EVALUATION OF FORECASTING PERFORMANCE

The forecasts of real GDP growth, the inflation rate and the unemployment rate in Slovenia, Serbia, Croatia and Bosnia and Herzegovina, respectively, generated with the multi-country model are compared to forecasts created with (i) pure autoregressive moving average (ARMA) models of the variables under consideration, hence 12 models altogether (3 variables x 4 countries); (ii) vector-autoregressive (VAR) models (one model for each country, containing all three variables). The ex-post forecasts are generated for the period 2005q1 to

2010q4. This is the time span for which for all variables contained in the models data were available in the database used for the estimations of the model. Forecasts are produced for the entire time period, i.e. for 24 quarters.

For the time series models, first the properties of the time series (real GDP growth, inflation rate, unemployment rate) are investigated. Based on the Augmented Dickey Fuller test, the Phillips-Perron test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test, real GDP growth and inflation are regarded as stationary, while the unemployment rate is integrated of order 1, i.e. I(1). Hence, the ARMA and the VAR models for GDP growth and for inflation are specified in levels, while the models for the unemployment rate take the first difference as the endogenous variables. As the structural model, all-time series models are based on quarterly data. The final specifications of the ARMA models were chosen according to the Akaike information criterion. Since quarterly data have been used, seasonal autoregressive (SAR) and seasonal moving average (SMA) terms have been allowed for. The VAR models have the lag length 4. This lag length was based on the relatively short time series and on the fact that quarterly data were used. Hence, lags of one year were allowed for. The estimation periods vary between models, depending on the available time series for the different countries. The final models can be found in the appendix.

The projections are evaluated by means of the following criteria:

1. Statistical forecast evaluation tests.
2. It is analysed which of the models how often comes closest to the actual outcome.
3. It is investigated whether the structural model forecasts are on average unbiased, or if there are systematic forecast errors.

Turning to the first criterion, i.e. the comparison of the forecasts generated with the structural multi-country model to projections generated with the VAR and ARMA models, the projections are analysed on the basis of the following statistical tests:

a. Mean absolute error (MAE). The MAE measures the absolute differences between the projection and the actual outcome:

$$MAE = \frac{1}{N}\sum_{t=1}^{N}|\hat{x}_t - x_t|$$

b. Root mean squared error (RMSE). The RMSE is the most important criterion for fit if forecasting is the main purpose of the model:

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(\hat{x}_t - x_t)^2}$$

c. Theil's inequality coefficient U2. The U2 statistic will take the value 1 under the naïve forecasting method. Values less than 1 indicate a better forecasting accuracy than the naïve forecasts, values above 1 indicate the opposite.

$$\text{THEIL} = \sqrt{\frac{\sum_{t=1}^{N-1}\left(\frac{(\hat{x}_{t+1}-x_{t+1})}{x_t}\right)^2}{\sum_{t=1}^{N-1}\left(\frac{x_{t+1}-x_t}{x_t}\right)^2}}$$

The results of the forecast evaluation tests can be found in Tables 1 to 3.

Table 1
Mean absolute error (MAE)

		Macromodel	ARMA	VAR
Slovenia	GDP growth	**2.69**	4.45	3.94
	Unemployment rate	1.54	**1.29**	1.42
	Inflation	**1.24**	1.24	1.60
Serbia	GDP growth	2.94	**2.72**	3.07
	Unemployment rate	**1.77**	2.60	1.78
	Inflation	4.96	**3.13**	7.90
Croatia	GDP growth	3.17	**2.71**	3.97
	Unemployment rate	1.83	3.32	**1.24**
	Inflation	2.85	1.40	**1.37**
Bosnia-Herz.	GDP growth	5.08	4.26	**3.87**
	Unemployment rate	1.59	**1.52**	1.58
	Inflation	**0.90**	2.15	2.14

Source: Own calculations.

Table 2
Root mean squared error (RMSE)

		Macromodel	ARMA	VAR
Slovenia	GDP growth	**3.20**	5.35	5.11
	Unemployment rate	1.89	**1.77**	1.92
	Inflation	**1.41**	1.67	1.84
Serbia	GDP growth	3.80	**3.16**	3.86
	Unemployment rate	**2.04**	3.24	2.05
	Inflation	5.70	**3.65**	10.72
Croatia	GDP growth	3.93	**3.26**	5.08
	Unemployment rate	2.31	3.70	**1.58**
	Inflation	3.56	**1.75**	1.89
Bosnia-Herz.	GDP growth	5.98	4.98	**4.52**
	Unemployment rate	1.77	1.83	**1.74**
	Inflation	**1.06**	2.70	2.79

Source: Own calculations.

Table 3
Theil's inequality coefficient

		Macromodel	ARMA	VAR
Slovenia	GDP growth	**0.357**	0.758	0.632
	Unemployment rate	0.090	**0.084**	0.091
	Inflation	**0.214**	0.270	0.262
Serbia	GDP growth	0.371	**0.363**	0.382
	Unemployment rate	0.034	0.053	**0.034**
	Inflation	0.223	**0.168**	0.359
Croatia	GDP growth	**0.449**	0.505	0.658
	Unemployment rate	0.104	0.154	**0.076**
	Inflation	0.516	**0.258**	0.284
Bosnia-Herz.	GDP growth	0.372	0.451	**0.371**
	Unemployment rate	0.021	0.021	**0.020**
	Inflation	**0.121**	0.339	0.382

Source: Own calculations.

For ***Slovenia***, the structural macroeconometric model gives the best fits in terms of all three statistical tests for GDP growth and inflation, while the ARMA model is best for the unemployment rate. For ***Serbia***, the opposite is true, i.e. the ARMA model delivers the best forecasts of GDP growth and inflation, while the structural model is best regarding the unemployment rate. For ***Croatia***, the VAR model gives the best forecasts of the unemployment rate. For GDP growth and inflation, the VAR model is better. For ***Bosnia and Herzegovina***, the structural macromodel gives the best inflation forecast, while the VAR model is better regarding GDP growth and the unemployment rate. Overall, only for Slovenia, i.e. the country with the longest available time series and with less structural breaks during the estimation period, the structural model gives the best forecasts, while for the other countries in the model the time series models give better ex post forecasts for the evaluation period. However, the structural model has its virtues which cannot be captured by analysing the forecasting performance alone. Structural models enable the analysis of macroeconomic consequences of policy measures as well as exogenous shocks. When using VAR and ARMA models, this is not so straightforward, since these time series models do not include explicitly truly exogenous variables or policy instruments. Furthermore, the results of the statistical tests have to be interpreted with caution given the shortness of the time series for the former Yugoslav countries contained in the model. Insofar the results for Slovenia are promising since this is the country with the longest history of reliable time series.

In addition to looking at the absolute or relative deviations of the projections from the true values of the target variables, another way of comparing different projections is to analyse how often which forecast comes closest to the actual outcome. The respective results are summarised in Table 4.

The structural model is best only in three out of 12 cases (4 countries with 3 variables each), namely GDP growth in Slovenia, inflation in Serbia and the unemployment rate in Bosnia and Herzegovina. On the other hand, the ARMA model forecasts come closest to the true values in as much as 8 cases. This exercise shows that it is not so easy to beat time series models in forecasting.

Table 4

Number of quarters with lowest deviation

		Macromodel	ARMA	VAR
Slovenia	GDP growth	**16**	4	4
	Unemployment rate	9	**13**	2
	Inflation	8	**9**	7
Serbia	GDP growth	7	**11**	6
	Unemployment rate	7	**14**	3
	Inflation	**9**	**9**	6
Croatia	GDP growth	8	6	**10**
	Unemployment rate	4	**12**	8
	Inflation	6	2	**16**
Bosnia-Herz.	GDP growth	7	**11**	6
	Unemployment rate	**16**	3	5
	Inflation	6	**12**	6

Source: Own calculations.

A further criterion of forecast accuracy is the test whether systematic errors can be detected in the projections or if the forecasts are unbiased. In the absence of systematic errors, the mean of the projection should be equal to the mean of the actual outcome. As suggested by Mincer and Zarnowitz (1969), this can be tested by estimating the following equation:

$$\hat{x}_t = a + b \cdot x_t + \varepsilon_t$$

$\hat{x}$ and x denote the projection and the actual value, respectively, t is the time period, and ε is the error term. It is formally tested whether the constant a is zero and b takes the value 1. If the constant is significantly different from zero, the projections systematically under- or over-estimate the variable in question, as a constant value biases the projection. If the coefficient b is significantly different from 1, the projection deviates more or less proportionally from the actual outcome. The Hypotheses (a = 0, b = 1) are jointly tested by estimating the above equation and then performing a Wald test on coefficient restrictions. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions. The power of the Wald tests has to be qualified insofar as the underlying time series are relatively short, given the limited data availability for the countries of the former Yugoslavia, except for Slovenia. The tests for unbiasedness of the forecasts have been run for the structural multi-country model. The results are summarised in Table 5. Notwithstanding the shortness of the time series, the forecasts for Serbia are unbiased, while those for Slovenia are on average biased, although the time series for Slovenia are much longer and more reliable.

Table 5

Test whether structural model forecasts are biased

Variable	Wald test	Unbiased (yes/no)
Slovenia		
Real GDP growth	37.960***	no
Unemployment rate	28.314***	no
Inflation rate	2.379	yes
Serbia		
Real GDP growth	0.994	yes
Unemployment rate	1.033	yes
Inflation rate	3.072*	(yes)
Croatia		
Real GDP growth	1.270	yes
Unemployment rate	10.336***	no
Inflation rate	6.320***	no
Bosnia and Herzegovina		
Real GDP growth	8.602***	no
Unemployment rate	14.138***	no
Inflation rate	7.154***	no

*Notes: Test equation: projection = a + b· true value. ***, **, * denotes significance on the 1 percent, 5 percent and 10 percent level, respectively, regarding the rejection of the null hypothesis of bias of the forecasts.*

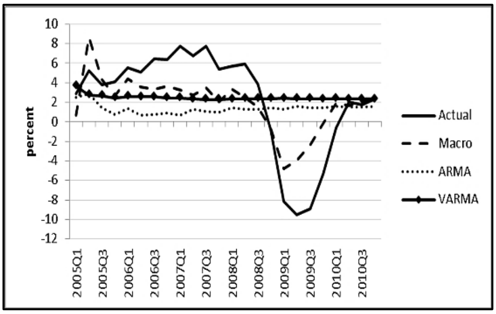
Source: Own calculations.

The following figures serve to visualise the actual realisation of the variables and the forecasts of the different models. In each equation, “actual” denotes the actual outcome the variables, while “macro”, “ARMA” and “VAR” denote the forecasts of the structural model, the ARMA models and the VAR models.

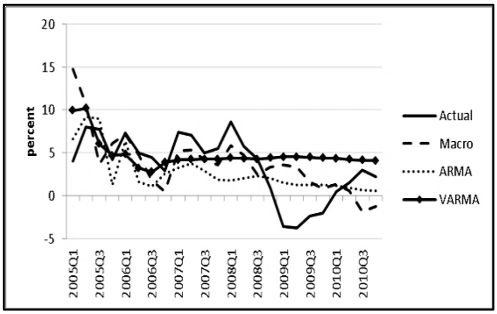
The figures show that the structural macroeconometric model is best able to reproduce the swings of economic growth, particularly during the Great Recession of 2009, and especially for Slovenia and Croatia. The time series models tend to converge to a stable average growth path. Regarding inflation, the structural macromodel delivers good forecasts for Bosnia and Herzegovina, while it overshoots some swings in Slovenia and especially in Croatia. Also for the unemployment rate the structural model tends to produce too large swings.

Figures

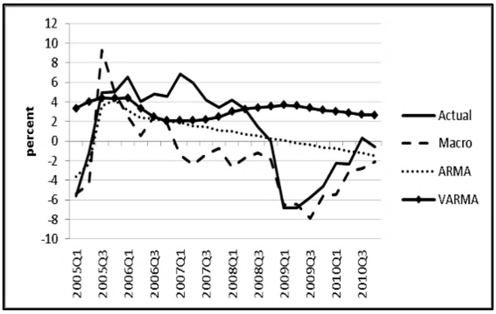
Real GDP growth in Slovenia



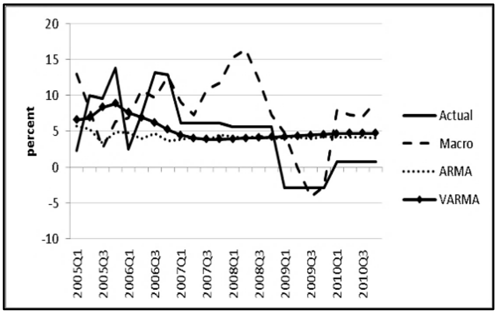
Real GDP growth in Serbia



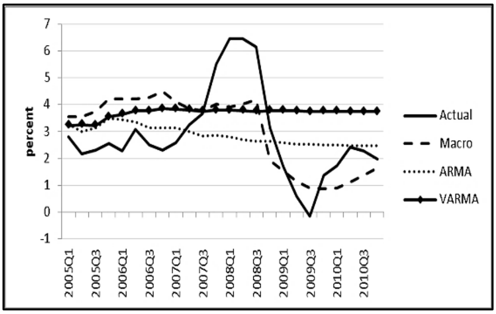
Real GDP growth in Croatia



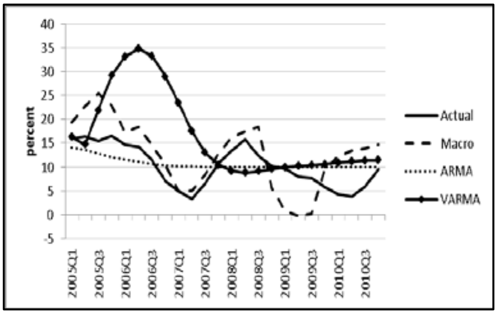
Real GDP growth in Bosnia and Herzegovina



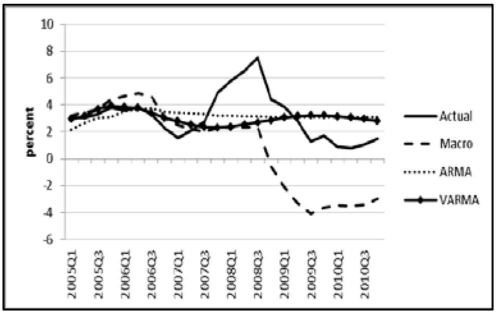
Inflation rate in Slovenia



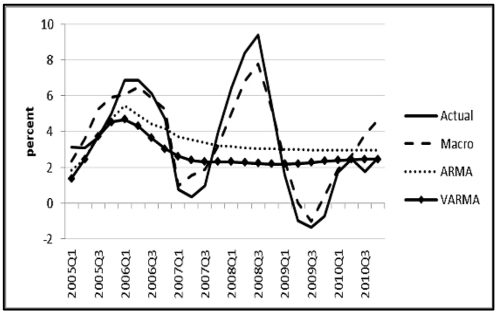
Inflation rate in Serbia



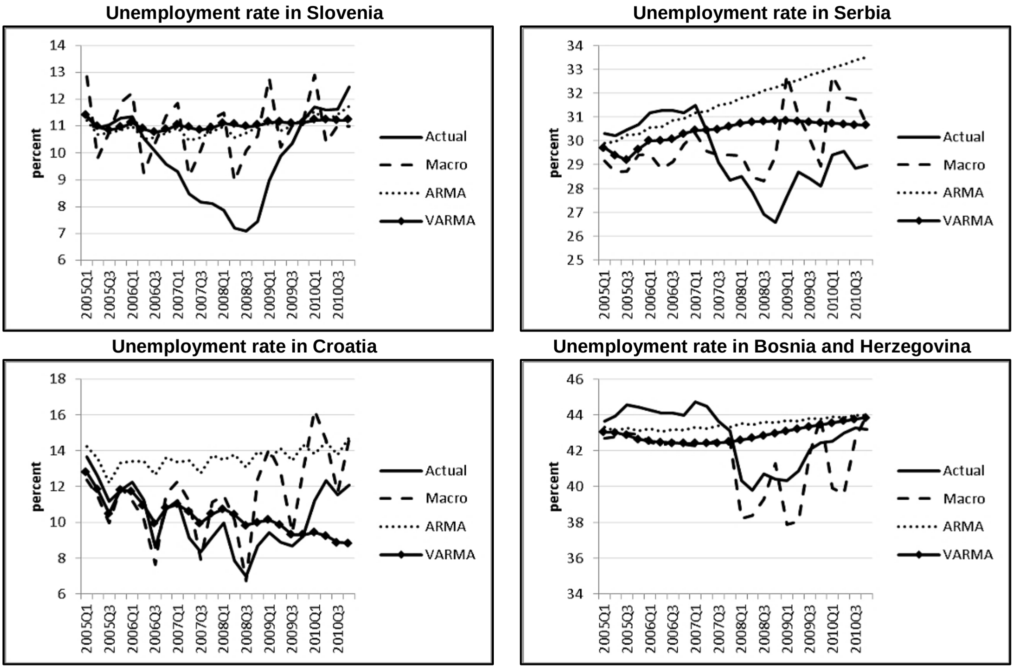
Inflation rate in Croatia



Inflation rate in Bosnia and Herzegovina



Figures ***(continue)***



Source: Own calculations.

5. CONCLUSIONS

Governments, companies and the general public are interested in reliable forecasts of important macroeconomic variables like real GDP growth, inflation and unemployment. In the course of time, with the evolution of both macroeconomic theory and time series modelling, a large variety of models has been developed. These models range from pure time series approaches to purely theoretical models. In this paper, the forecasting performance of a structural multi-country model for Slovenia, Serbia, Croatia and Bosnia and Herzegovina is compared to the forecasting ability of ARMA and VAR models. It turns out that in many cases the time series approaches deliver more accurate predictions of economic growth, inflation and the unemployment rate than the structural model. The latter is based both on economic theory and on time series for the included countries. Hence, while the old debate whether theory or measurement should be given priority in forecasting (see, e.g. Loría 2006, and Pérez 2006) cannot be solved the former Yugoslavia. If an accurate forecast is the only focus, then in many circumstances time series models are sufficient. However, structural models have their virtues that go beyond forecasting, since these models can in addition be used to investigate the macroeconomic effects of policy measures or of exogenous shocks. Therefore, the usefulness of structural models should not be evaluated on the basis of their forecasting performance alone.

BIBLIOGRAPHY REFERENCES

BEHRENS, D., G. HABER AND K. WEYERSTRASS (2011). European Economic Integration of the Successor States of the former Yugoslavia. Development of a Macroeconomic Model, Institute for Advanced Studies (IHS): Vienna. Research Report.

DIEBOLD, F. X. and KILIAN, L. (1997). "Measuring Predictability: Theory and Macroeconomic Applications". *Technical Working Paper 213*. NBER, Cambridge.

HOFER, H. and KUNST, R.M. (2005). "The Macroeconometric Model LIMA". In: Fenz, G., M. Schneider (eds.): *Macromodels and Forecasts for Austria*. Proceedings of OeNB Workshops. No. 5, 87-116.

GALBRAITH, J. W. (2003). "Content Horizons for Univariate Time-Series forecasts", *International Journal of Forecasting 19,* 43-55.

GROZEA-HELMENSTEIN, D., K. WEYERSTRASS, V. IVANIC, T. KARAULAC, L. ALEKSIC, S. SCEPANOVIC and S. PAJKOVIC (2012). "Economic forecast for Serbia 2012 and 2013. W-shaped European crisis reflected on the Serbian economy". Agency for balanced regional Development of AP Vojvodina. http://vojvodina-rra.rs/document.php?fileid=1603&m=2&f=80f705a430a80050e12016395a2a30eb&attachment=1&c=1255&preview=1&previewcode=bec1966ff7ba1b54e640e689ac9caf44

HEILEMANN, U. (2004). "Das RWI-Konjunkturmodell - Ein Überblick". In W. Gaab, U. Heilemann und J. Wolters (Hrsg.): *Arbeiten mit ökonometrischen Modellen.* Heidelberg: Physika, 161-212.

KLEIN, L.R. (1971). "An Essay of the Theory of Economic Prediction". Yrjo Jahnsson Foundation, 1968, 2nd edition, Markham, 1971.

KLEIN, L.R. (1973). "The Precision of Economic Prediction: Standards, Achievement, Potential". *The Economic Outlook for 1973*. Un. Of Michigan, 1973.

KLEIN, L.R. (1984): "The Importance of the Forecast". *Journal of Forecasting*; Jan-Mar 1984, Vol. 3 Issue 1, 1-9.

KLEIN, L.R.; HOWREY, E.P., McCARTHY, M.D. (1974). "Notes on Testing the Predictive Performance of Econometric Models". *International Economic Review*, vol. 15, June, 366-383.

LAYARD, R., S. NICKELL, JACKMAN, R. (1991): "Unemployment: Macroeconomic Performance and the Labour Marke", Oxford, Oxford University Press, Oxford/UK.

LORIA, E. (2006). "En defensa de la Macroeconomía estructural". *Estudios de Economía Aplicada* Vol. 24(1): April, 277-297.

MINCER, J., V. ZARNOWITZ (1969). "The Evaluation of Economic Forecasts". In Mincer, J. (ed.): *Economic Forecasts and Expectations: Analyses of Forecasting Behavior*. NBER Studies in Business Cycles, 1969 (19).

ÖLLER, L.-E. (1985). "How far can Changes in General Business Activity be Forecasted?". *International Journal of Forecasting* 1, 135-141.

PAGAN, A. (2003). “Report on Modelling and Forecasting at the Bank of England”. http://www.bankofengland.co.uk/publications/news/2003/paganreport.pdf

POWELL, A. A. and MURPHY, C. W. (1997). *Inside a Modern Macroeconometric Model*. Berlin: Springer.

PEREZ GARCIA, J. (2006). “Algunas consideraciones en torno a las técnicas economé-tricas”. *Estudios de Economía Aplicada* Vol. 24(1), April, 299-310.

PULIDO SAN RROMAN, A., PEREZ GARCIA, J. (2006). “Lawrence R. Klein y la eco-nomía aplicada”. *Estudios de Economía Aplicada* Vol. 24(1), pp.43-94, Abril 2006.

SMETS, F., WOUTERS, R. (2007). “Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach”. *American Economic Review* 97(3), pp. 586-606.

WEYERSTRASS, K. and R. NECK (2008). “SLOPOL6: ‘A Macroeconometric Model for Slovenia”. *International Advances in Economic Research*, vol. 19, pp. 85-106.

WEYERSTRASS, K. and D. GROZEA-HELMENSTEIN (2013a). “A Macroeconometric Model for Serbia”. *International Advances in Economic Research*, vol. 19, pp. 85-106.

WEYERSTRASS, K. and D. GROZEA-HELMENSTEIN (2013b). “Euro Area Scenarios and their Consequences for Slovenia and Serbia, International Managing Global Transitions”. *Winter 2013*, vol. 11, issue 4, pp. 323-351.

WEYERSTRASS, K. (2011). “SLOPOL, a Macroeconometric Model of the Slovenian Economy”. *IB Revija* 1-2/2011, pp. 57-66.

Appendix

Var and Arma Models

a) ARMA models

GDP growth in Slovenia

Sample: 1998Q1 2011Q4			
Variable	Coefficient	Std. Error	t-Statistic
C	1.697106	1.249578	1.358143
AR(1)	0.089277	0.135182	0.660424
AR(2)	0.381943	0.104224	3.664626
AR(3)	0.454338	0.112049	4.054798
AR(4)	-0.398646	0.127346	-3.130423
SAR(4)	0.688247	0.146229	4.706624
MA(1)	1.136468	0.035598	31.92530
MA(2)	0.983453	0.012357	79.58475
SMA(4)	-0.930260	0.027931	-33.30590
Adj. R^2	0.835		

GDP growth in Serbia

Sample: 2000Q1 2010Q4			
Variable	Coefficient	Std. Error	t-Statistic
C	-1049.570	539360.2	-0.001946
AR(1)	1.266671	0.444682	2.848486
AR(2)	-0.721263	0.659008	-1.094467
AR(3)	0.198984	0.519276	0.383195
AR(4)	0.255402	0.280139	0.911697
SAR(4)	-0.123662	0.184102	-0.671704
MA(1)	-1.051072	0.469246	-2.239915
MA(2)	1.095045	0.445744	2.456668
SMA(4)	-0.113634	0.476391	-0.238530
Adj. R^2	0.733		

GDP growth in Croatia

Sample: 2000Q3 2011Q1			
Variable	Coefficient	Std. Error	t-Statistic
C	-414.4495	31673.29	-0.013085
AR(1)	0.038076	0.028895	1.317706
AR(2)	0.960892	0.076956	12.48629
MA(1)	1.224591	0.147287	8.314319
MA(2)	-0.433632	0.267079	-1.623612
MA(3)	-0.665505	0.157327	-4.230065
SMA(4)	-0.949111	0.048141	-19.71507
Adj. R^2	0.711		

GDP growth in Bosnia and Herzegovina

Sample: 2001Q1 2011Q4			
Variable	Coefficient	Std. Error	t-Statistic
C	4.112887	1.089470	3.775126
AR(1)	-0.075405	0.144677	-0.521198
AR(2)	0.087947	0.101295	0.868230
AR(3)	0.019235	0.066236	0.290403
AR(4)	-0.568770	0.098356	-5.782747
MA(1)	0.485114	0.228410	2.123873
MA(2)	0.175400	0.209968	0.835365
SMA(4)	0.999813	0.082049	12.18563
Adj. R^2	0.401687		

Inflation rate in Slovenia

Sample: 1999Q1 2012Q1			
Variable	Coefficient	Std. Error	t-Statistic
C	2.519577	0.487762	5.165590
AR(1)	1.230233	0.127086	9.680354
AR(2)	-0.521101	0.168720	-3.088560
AR(3)	0.802952	0.156375	5.134796
AR(4)	-0.550458	0.105470	-5.219079
SAR(4)	0.262113	0.182387	1.437125
MA(1)	-0.348106	0.080726	-4.312204
MA(2)	0.309798	0.055300	5.602140
MA(3)	-0.961554	0.071160	-13.51255
SMA(4)	-0.924065	0.037183	-24.85147
Adj. R^2	0.944		

Inflation rate in Serbia

Sample: 2002Q1 2010Q4			
Variable	Coefficient	Std. Error	t-Statistic
C	9.950280	0.739395	13.45732
AR(1)	0.419225	0.168953	2.481309
AR(2)	0.300649	0.065666	4.578452
AR(3)	-0.001904	0.084235	-0.022603
AR(4)	-0.135072	0.078025	-1.731148
SAR(4)	0.265523	0.084945	3.125824
MA(1)	0.810951	0.190397	4.259264
MA(2)	0.624920	0.182419	3.425736
SMA(4)	-0.926689	0.024583	-37.69627
Adj. R^2	0.949		

Inflation rate in Croatia

Sample: 2001Q2 2011Q1			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	3.089709	0.228558	13.51825
AR(1)	0.653740	0.128178	5.100260
SAR(4)	0.142749	0.099769	1.430788
MA(1)	0.276471	0.066410	4.163118
MA(2)	0.236243	0.064535	3.660665
MA(3)	0.959477	0.046687	20.55146
SMA(4)	-0.963053	0.030284	-31.80089
Adj. R^2	0.883332	S.D. depedent var	

Inflation rate in Bosnia and Herzegovina

Sample: 2002Q1 2010Q4			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	2.958326	0.304032	9.730316
AR(1)	0.007581	0.178025	0.042586
AR(2)	0.462763	0.198538	2.330857
AR(3)	0.242766	0.153292	1.583680
AR(4)	-0.163784	0.140505	-1.165677
MA(1)	1.499998	0.079970	18.75707
MA(2)	0.999574	0.058363	17.12687
SMA(4)	-0.984356	0.035597	-27.65250
Adj. R^2	0.902		

D(Unemployment rate) rate in Slovenia

Sample: 1997Q1 2011Q4			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	8.627328	56.65018	0.152291
AR(1)	0.734611	0.089595	8.199242
SAR(4)	0.995977	0.025920	38.42515
MA(1)	-0.183643	0.040168	-4.571889
MA(2)	-0.009051	0.030883	-0.293055
MA(3)	0.154563	0.038726	3.991165
MA(4)	-0.906818	0.036223	-25.03422
SMA(4)	-0.240161	0.159854	-1.502379
Adj. R^2	0.634		

D(Unemployment rate) rate in Serbia

Sample: 1997Q3 2010Q4			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	0.159697	0.092315	1.729912
AR(1)	-0.940797	0.032475	-28.96963
MA(1)	1.504648	0.133024	11.31112
MA(2)	0.217551	0.252944	0.860077
MA(3)	-0.390258	0.132109	-2.954069
Adj. R^2	0.317		

D(Unemployment rate) rate in Croatia

Sample: 2001Q2 2011Q1			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	0.110274	0.327956	0.336246
AR(1)	-0.246930	0.305390	-0.808573
AR(2)	0.171829	0.240123	0.715586
AR(3)	-0.713918	0.246897	-2.891565
AR(4)	-0.021067	0.458449	-0.045952
SAR(4)	0.680723	0.245471	2.773127
MA(1)	0.220693	0.402244	0.548654
MA(2)	-0.910881	0.431510	-2.110916
MA(3)	1.197780	0.583126	2.054067
MA(4)	0.260397	0.568331	0.458179
SMA(4)	-0.138545	0.379233	-0.365330
Adj. R^2	0.680		

D(Unemployment rate) in Bosnia and Herzegovina

Sample: 2001Q2 2011Q1			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	0.050861	0.076763	0.662569
AR(1)	-0.372244	0.228090	-1.632003
AR(2)	-0.171823	0.253100	-0.678875
AR(3)	-0.398536	0.223574	-1.782568
AR(4)	0.329776	0.392057	0.841145
MA(1)	0.980327	0.300247	3.265067
MA(2)	0.047765	0.364872	0.130909
MA(3)	0.782457	0.371126	2.108336
MA(4)	0.145980	0.462450	0.315666
SMA(4)	-0.408158	0.296957	-1.374470
Adj. R^2	0.343		

Source: Own calculations.

b) VAR models

Slovenia

Sample: 1998Q1 2011Q4			
Standard errors in ( ) & t-statistics in [ ]			
	GRGDPR_SLO	INFL_SLO	D(UR_SLO)
GRGDPR_SLO(-1)	0.959040	0.211371	-0.149248
	(0.14570)	(0.06857)	(0.02465)
	[6.58224]	[3.08272]	[-6.05487]
GRGDPR_SLO(-2)	-0.119299	-0.226508	0.042328
	(0.23868)	(0.11232)	(0.04038)
	[-0.49983]	[-2.01662]	[1.04829]
GRGDPR_SLO(-3)	-0.107688	-0.017820	0.045738
	(0.23485)	(0.11052)	(0.03973)
	[-0.45855]	[-0.16124]	[1.15120]
GRGDPR_SLO(-4)	-0.122483	0.080414	-0.037953
	(0.15476)	(0.07283)	(0.02618)
	[-0.79145]	[1.10416]	[-1.44962]
INFL_SLO(-1)	0.927591	1.250078	-0.195340
	(0.32456)	(0.15274)	(0.05491)
	[2.85797]	[8.18444]	[-3.55755]
INFL_SLO(-2)	-1.090174	-0.307537	0.220353
	(0.56694)	(0.26680)	(0.09591)
	[-1.92292]	[-1.15270]	[2.29744]
INFL_SLO(-3)	-0.487408	-0.117782	-0.002408
	(0.58575)	(0.27565)	(0.09909)
	[-0.83211]	[-0.42729]	[-0.02430]
INFL_SLO(-4)	0.721009	0.083134	-0.036848
	(0.33187)	(0.15618)	(0.05615)
	[2.17254]	[0.53230]	[-0.65629]
D(UR_SLO(-1))	-1.024314	0.034003	-0.059475
	(0.69747)	(0.32823)	(0.11800)
	[-1.46862]	[0.10360]	[-0.50405]
D(UR_SLO(-2))	-0.129057	-0.301850	-0.272896
	(0.65451)	(0.30801)	(0.11073)
	[-0.19718]	[-0.98000]	[-2.46456]
D(UR_SLO(-3))	-0.603223	0.220690	-0.242428
	(0.72014)	(0.33890)	(0.12183)
	[-0.83765]	[0.65120]	[-1.98987]
D(UR_SLO(-4))	-0.274339	-0.132834	0.508332
	(0.67300)	(0.31671)	(0.11386)
	[-0.40764]	[-0.41942]	[4.46473]
C	0.693032	0.236122	0.311444
	(0.72694)	(0.34209)	(0.12298)
	[0.95336]	[0.69023]	[2.53246]
Adj. R^2	0.788419	0.912847	0.678880

Serbia

Sample: 2001Q1 2010Q4			
Standard errors in ( ) & t-statistics in [ ]			
	GRGDPR_SRB	INFL_SRB	D(UR_SRB)
GRGDPR_SRB(-1)	0.572450	0.360701	-0.044939
	(0.19167)	(0.48770)	(0.03355)
	[2.98667]	[0.73960]	[-1.33938]
GRGDPR_SRB(-2)	0.246646	-0.638840	0.023575
	(0.21770)	(0.55392)	(0.03811)
	[1.13298]	[-1.15330]	[0.61863]
GRGDPR_SRB(-3)	0.066572	0.327704	-0.015776
	(0.15265)	(0.38842)	(0.02672)
	[0.43611]	[0.84369]	[-0.59036]
GRGDPR_SRB(-4)	-0.470652	0.842127	0.020406
	(0.11447)	(0.29127)	(0.02004)
	[-4.11151]	[2.89122]	[1.01836]
INFL_SRB(-1)	0.121207	1.312852	0.025878
	(0.07858)	(0.19995)	(0.01376)
	[1.54242]	[6.56586]	[1.88121]
INFL_SRB(-2)	0.071940	-0.777578	-0.029982
	(0.14580)	(0.37098)	(0.02552)
	[0.49342]	[-2.09600]	[-1.17474]
INFL_SRB(-3)	-0.275608	0.399750	-0.004498
	(0.14396)	(0.36631)	(0.02520)
	[-1.91444]	[1.09129]	[-0.17847]
INFL_SRB(-4)	0.127946	-0.143138	0.015359
	(0.06990)	(0.17785)	(0.01224)
	[1.83052]	[-0.80483]	[1.25527]
D(UR_SRB(-1))	-1.216707	1.773521	0.353825
	(1.02159)	(2.59940)	(0.17883)
	[-1.19100]	[0.68228]	[1.97855]
D(UR_SRB(-2))	1.536235	-3.002444	-0.299084
	(1.07512)	(2.73561)	(0.18820)
	[1.42890]	[-1.09754]	[-1.58918]
D(UR_SRB(-3))	-2.509656	4.812927	0.191310
	(1.06143)	(2.70077)	(0.18580)
	[-2.36442]	[1.78205]	[1.02963]
D(UR_SRB(-4))	2.868697	-3.533682	0.153747
	(0.95789)	(2.43733)	(0.16768)
	[2.99481]	[-1.44982]	[0.91691]
C	1.965471	-1.550016	-0.020984
	(1.03029)	(2.62155)	(0.18035)
	[1.90768]	[-0.59126]	[-0.11635]
Adj. R^2	0.411969	0.927295	0.335751

Croatia

Sample: 2001Q1 2011Q1			
Standard errors in ( ) & t-statistics in [ ]			
	GRGDPR_CRO	INFL_CRO	D(UR_CRO)
GRGDPR_CRO(-1)	0.808227	-0.003177	-0.060291
	(0.20711)	(0.04410)	(0.04781)
	[3.90232]	[-0.07204]	[-1.26096]
GRGDPR_CRO(-2)	-0.426038	0.003929	-0.035571
	(0.25368)	(0.05402)	(0.05856)
	[-1.67940]	[0.07274]	[-0.60739]
GRGDPR_CRO(-3)	0.194218	-0.013191	0.039998
	(0.25196)	(0.05365)	(0.05817)
	[0.77084]	[-0.24587]	[0.68767]
GRGDPR_CRO(-4)	-0.080612	0.025722	-0.097829
	(0.19815)	(0.04219)	(0.04574)
	[-0.40683]	[0.60963]	[-2.13866]
INFL_CRO(-1)	0.692126	0.763207	-0.038848
	(0.80393)	(0.17119)	(0.18559)
	[0.86093]	[4.45829]	[-0.20932]
INFL_CRO(-2)	-0.764905	0.132768	-0.041939
	(1.08640)	(0.23134)	(0.25080)
	[-0.70407]	[0.57391]	[-0.16722]
INFL_CRO(-3)	-0.352654	0.110528	-0.083098
	(1.07225)	(0.22832)	(0.24753)
	[-0.32889]	[0.48408]	[-0.33570]
INFL_CRO(-4)	-0.023858	-0.466241	0.110941
	(0.82988)	(0.17672)	(0.19158)
	[-0.02875]	[-2.63837]	[0.57908]
D(UR_CRO(-1))	-0.350802	-0.022360	-0.457264
	(0.74751)	(0.15917)	(0.17257)
	[-0.46929]	[-0.14047]	[-2.64980]
D(UR_CRO(-2))	-0.473912	-0.003524	-0.559201
	(0.65664)	(0.13983)	(0.15159)
	[-0.72172]	[-0.02520]	[-3.68893]
D(UR_CRO(-3))	-0.340706	-0.051108	-0.494248
	(0.69989)	(0.14903)	(0.16157)
	[-0.48680]	[-0.34293]	[-3.05899]
D(UR_CRO(-4))	-0.326263	-0.017386	0.196725
	(0.68604)	(0.14609)	(0.15838)
	[-0.47557]	[-0.11901]	[1.24214]
C	2.645193	1.276221	0.345660
	(1.97420)	(0.42039)	(0.45575)
	[1.33988]	[3.03583]	[0.75844]
Adj. R^2	0.348758	0.721957	0.551484

Bosnia and Herzegovina

Sample: 2001Q1 2011Q4			
Standard errors in ( ) & t-statistics in [ ]			
	GRGDPR_BIH	INFL_BIH	D(UR_BIH)
GRGDPR_BIH(-1)	0.387113	-0.003305	0.016614
	(0.17662)	(0.05716)	(0.02818)
	[2.19180]	[-0.05782]	[0.58956]
GRGDPR_BIH(-2)	0.027179	0.040845	-0.037234
	(0.19178)	(0.06207)	(0.03060)
	[0.14172]	[0.65805]	[-1.21682]
GRGDPR_BIH(-3)	0.062334	-0.007677	0.009759
	(0.19237)	(0.06226)	(0.03069)
	[0.32403]	[-0.12330]	[0.31795]
GRGDPR_BIH(-4)	0.250070	0.068411	-0.033469
	(0.18064)	(0.05846)	(0.02882)
	[1.38439]	[1.17012]	[-1.16124]
INFL_BIH(-1)	0.448530	0.894195	-0.055269
	(0.58292)	(0.18867)	(0.09301)
	[0.76945]	[4.73953]	[-0.59423]
INFL_BIH(-2)	-0.902474	-0.131334	0.079990
	(0.79782)	(0.25822)	(0.12730)
	[-1.13118]	[-0.50861]	[0.62837]
INFL_BIH(-3)	1.049794	-0.240094	0.004024
	(0.77581)	(0.25110)	(0.12379)
	[1.35315]	[-0.95617]	[0.03250]
INFL_BIH(-4)	-0.973359	-0.021516	-0.002930
	(0.51277)	(0.16596)	(0.08182)
	[-1.89825]	[-0.12964]	[-0.03582]
D(UR_BIH(-1))	0.505071	-0.749728	0.284822
	(1.24667)	(0.40350)	(0.19891)
	[0.40514]	[-1.85808]	[1.43189]
D(UR_BIH(-2))	-0.330800	-0.300733	-0.182691
	(1.27355)	(0.41220)	(0.20320)
	[-0.25975]	[-0.72959]	[-0.89905]
D(UR_BIH(-3))	-0.019671	0.135356	0.259149
	(1.29908)	(0.42046)	(0.20728)
	[-0.01514]	[0.32192]	[1.25025]
D(UR_BIH(-4))	1.330681	0.391211	-0.082405
	(1.31421)	(0.42536)	(0.20969)
	[1.01253]	[0.91972]	[-0.39298]
C	2.029102	0.806543	0.208858
	(1.50526)	(0.48719)	(0.24017)
	[1.34801]	[1.65549]	[0.86961]
Adj. R^2	0.250283	0.774229	-0.093849

Source: Own calculations.