WORKING PAPER

A BAYESIAN ESTIMATION OF A SMALL STRUCTURAL MODEL FOR THE ALBANIAN ECONOMY

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ABSTRACT

In this paper we develop a small structural model for the Albanian economy and estimate it using Bayesian estimation techniques. The model captures the essential of small, open, flexible exchange rate economy linkages between the policy instrument (repo rate) and the main macroeconomic variables of output, inflation, exchange rate and unemployment. The main structure of the model relies on the paper presented by Carabenciov et.al. (2008), which we have enriched by incorporating also the exchange rate as an important transmission channel mechanism for the Albanian economy. We conduct three different shocks on three key sources of uncertainty like the output gap, inflation and policy rate and we evaluate the properties and the model performance.

I. INTRODUCTION

Models of the economy are very useful to monetary policy decision making. They are not only used to produce projection and forecasts of the main macroeconomic variables, but they also provide a structured way to discuss various features of the economy, and also to construct analysis of what might happen if a given shock occurs. IS/LM models are the first to have been introduced for monetary policy analysis. Generally, they include the main transmission channels and use calibrated and/or estimated coefficients in order to construct a good representation of the economy. However, as new theoretical and practical arguments on the importance of the expectations on the behaviour of the economy's agents began to arise, it became clear that there was a need to incorporate them into modelling. This second type of modelling is known as DSGE model; generally DSGE models incorporate a detailed theoretical structure of the optimization process for businesses and consumers. However, as these models are mainly theoretical, bringing them to the data is difficult.

If we put these two types of models in a straight line, the so-called structural model lies somewhere in between. This third type of model has features of both sides: it incorporates expectations, it is based on theoretical background but it also makes use of the data in order to provide a good representation of the economy.

Currently, the Bank of Albania uses MEAM (Macro Econometric Model of the Albanian Economy) which is an IS/LM macro model used mainly for shock analysis and economic projections (Dushku, Kota and Binaj (2006), Kota and Dushku (2010)). This macro model incorporates the main transmission channels of the Albanian economy, and it has a good description of all the sectors of the economy. Therefore it is considered to be a medium size macro model. MEAM is a dynamic model with a linear functional form which uses only backward looking expectations. The model has also a monetary reaction rule which is switched on, only for analysis of possible movements in the monetary policy.

However, monetary policy decision-making at the Bank of Albania would also profit from a smaller macroeconomic model which would be more focused on the monetary policy reaction. This is the aim of this paper. Here we present a small structured model of the Albanian economy, which will be a support to the policy analysis on an inflation targeting regime to be implemented by the Bank of Albania in the near future. We propose a simple structural model because it captures the essential small, open, flexible exchange rate economy linkages between the policy instrument (repo rate) and the main macroeconomic variables of output, inflation, exchange rate and unemployment. The main structure of the model relies on the paper presented by Carabenciov et.al. (2008), which we have enriched by incorporating also the exchange rate as an important transmission channel mechanism for the Albanian economy.

The structure of the paper is as follows. The second section includes an introduction to the core developments of the Albanian economy during the last decade. The third section presents the specification of the model followed by the fourth section, which deals with model estimation using Bayesian approach. Finally, we present model behaviour and some shocks in order to discuss what the impulse responses of the model are. The last section concludes and specifies the need for future research.

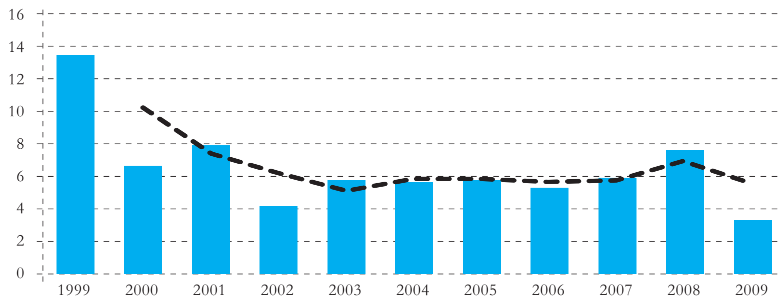
II. THE ALBANIAN ECONOMY OVER THE PERIOD 2000-2009

Albanian economic performance over the last decade has been satisfactory, with significant economic growth, inflation rate within the 2-4 % target set by the Bank of Albania and stable exchange rate vis-à-vis euro. The paragraphs below provide a more detailed picture of these developments:

- Real GDP growth

Figure 1 gives the real GDP growth figures in Albania suggesting that the economy has experienced a strong sustained economic growth from 1999 to 2008, with an average of 6.8 percent. Only during 2009, the real GDP growth shrank to about 3.6 percent as credit growth almost dimidiated, trade deficit widened, and consumption and investment slowed down. All these developments were results of the global crisis in 2008.

Figure 1: Real GDP Growth, 1999-2009 (in percent, in bars); moving average (the line)



Source: Instat (2010)

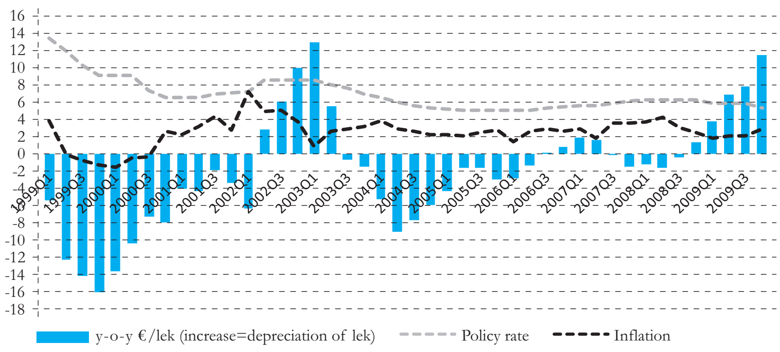
- The exchange rate, policy rate and inflation

Figure 2 presents the main developments of exchange rate, policy rate and inflation in Albania over the last decade. At the beginning of the period, the interest rate (policy rate) was very high, approximately 13 percent, reflecting a high country risk and the determination to keep inflation under the central bank's target. As inflation rate slowed down within the Bank of Albania's target, repo rate was accommodated to the current level of 5%.

An interesting feature of the Albanian economy is that a change in exchange rate has a significant impact on the changes of CPI (inflation), so the pass-through in Albania appears to be considerable. This is confirmed by empirical results in MEAM (Kota and Dushku, 2010) which states that the long run coefficient of the exchange rate impact on domestic CPI is 0.75. This result is also confirmed by Istrefi (2007) for the period 1996-2006. Therefore exchange rate is considered to be one of the main transmission channels of the monetary policy.

Finally, inflation rate in Albania after 2003, has mainly lied within the target set by the Bank of Albania, currently 3+/-1%.

Figure 2: Exchange rate, policy rate and inflation (1999-2009)



Source: Bank of Albania, Instat (2010)

The model we aim to construct should replicate these developments of the Albanian economy, by also capturing the important turning points and having reasonable impulse response functions to a given shock.

III. THE SPECIFICATION OF THE MODEL

The model we present here is based on Carabenciov et.al. (2008), a structure that mixes the New Keynesian theory on nominal and real rigidities and the role of aggregate demand in output determination with the real business cycle tradition of DSGE. This macro model approach aims to forecast future developments of output, exchange rate, inflation and unemployment and also analyze their behaviour. The differences between the model presented by Carabenciov et.al. (2008) and the model that we propose in this paper, deal mainly with two issues:

a. Carabenciov et.al. (2008) incorporates in the model not only shocks to the growth rate of the variables, but also to their level. In our case we will focus on shocks only to the growth rate of the variables, as one can easily incorporate shocks to the levels of the variables using our approach.

b. Carabenciov et.al. (2008) proposes a closed economy model which does not incorporate exchange rate developments. Given the importance of exchange rate in Albanian economy, we enriched the model by adding exchange rate determination using uncovered interest rate parity. This way, the Albanian economy will be directly impacted by developments in the European market, which is an important feature of the actual developments.

At its core the model has five equations; (1) an aggregate demand or IS curve that relates the level of real activity to expected and past real activity, the real interest rate, the real exchange rate and the foreign real activity: (2) a Phillips curve that relates inflation to past and expected inflation, the output gap and the exchange gap: (3) an uncovered interest rate parity condition for the nominal exchange rate that includes forward and backward looking expectations and a country risk premium; (4) a rule for the monetary policy, that under an Inflation Targeting definition the loss function will attach a high cost to deviation of inflation from the target and the output gap (5) and a dynamic version of Okun's law, where unemployment gap is a function of output gap and its lagged value.

All variables of the model are determined in terms of deviations from the equilibrium, or in "gap" terms. The model itself does not intend to explain the factors that determine movements in equilibrium variables like real output, real exchange rate and the real interest rate. But the aim of the model is to explain how the variables react to a given shock, as compared to their equilibrium level. The model abstracts from issues related to aggregate supply and fiscal solvency and does not explore the determinants of current account. It is relatively transparent, simple, and takes into consideration all the key features of the economy for monetary policy analysis and forecasting (Berg, Karam, and Laxton 2006).

The section below explains in detail all the relationships of the model.

• Phillips Curve

Equation 1 is the inflation equation, otherwise known as the Phillips curve. In this equation, inflation depends on its past and future values, the lagged output gap and the exchange rate gap, as follows:

$$\pi_t = \alpha_1 \pi_{t+1} + (1-\alpha_1)\pi_{t-1} + \alpha_2\, ygap_{t-1} + \alpha_3 \Delta z_t + \varepsilon_t^{\rho} \qquad (1)$$

Where π_t is inflation, measured as the annualized quarterly change[1], π_{t+1} and π_{t-1} are the forward-looking and backward-looking components of inflation, $ygap_{t-1}$ is the output gap and Δz_t is the change in the real exchange rate (z_t) from the last periods level (z_{t+1}). α_1 and α_2 are model parameters and ε_t^{p} is the disturbance term that captures other exogenous supply shocks, not included in the model, like oil price shocks.

Aggregate supply or the New Keynesian Phillips Curve is based on price-setting model by Calvo (1983), where we assume an imperfect competition and nominal rigidities. Two distinct features characterize the relationship between inflation and economic activity in the New Keynesian Phillips Curve. First, the forward-looking character of inflation is a consequence of the fact that firms set

1 Where $\pi_t = 400*[\log(cpi_t)-\log(cpi_{t-1})]$ and $\pi 4_t = (\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})/4$ is the four-quarter change in consumer price index (CPI) and is considered a year-on-year rate.

prices on the basis of their expectations about the future evolution of demand and cost factors. Second, the link between inflation and real activity, which comes through the potential effect on the latter of the real marginal cost (Gali & Lopez-Salido, 2000).

In equation 1, the size of α_1 plays an important role because it measures the relative weight of the forward-looking and backward-looking expectations in the inflation process. The main restrictions in the Phillips curve are that the coefficients before lagged and expected inflation sum to one, and the coefficient on the level of the output gap and forward-looking element should be greater than zero. These restrictions ensure that the monetary policy takes the commitment to adjust the policy rate in response to nominal variables to provide an anchor to the system (Berg, Karam, and Laxton 2006). The residual term enters in the equation with positive sign, so the shock to the residual will be treated as a shock that results in upward pressure on the inflation rate.

Output gap equation

Domestic output depends on the real interest rate, the real exchange rate and the demand in the rest of the world, represented by European Union. The output gap is the deviation of actual output from equilibrium level of GDP (a positive number indicates that output is above the potential) as follows:

$$ygap_t = 100 * \left(gdp_t - gdp_t^* \right) \quad (2)$$

Where gdp is real output measured in logs, and gdp^* is potential GDP.

The equation above is simply a definition of the output gap, because GDP and potential GDP are measured in logs, therefore ygap is measured in percent.

While equation (3) below is a behavioural equation of output gap that is a function of its lead and lagged value, the gap between the actual real interest rate and its equilibrium value, the real exchange gap and the EU output gap. Dynamics are added through the influence of past and future domestic output gap, and lagged reactions to the interest rate and exchange rate gap:

IS curve:

$$ygap_t = \beta_1 ygap_{t-1} \quad \beta_2 ygap_{t+1} - \beta_3 (rr_t - rr^*_{t-1}) + \beta_4 z_{t-1} + \beta_5 ygap^{EU}_t + \varepsilon^{ygap}_t \qquad (3)$$

where $ygap$ is the output gap, rr[2] is the real interest rate gap, **z** is the real exchange rate, $ygap^{EU}$ is the European Union output gap and the star above a variable, denotes the equilibrium value of the variable.

The equation above represents the IS curve, where the real interest rate provides the crucial link between monetary policy and the economy. As Albania is a small open economy, the real exchange rate affects the level of activities through the prices of imports and exports, while the foreign output gap is an important determinant of exports demand. The $\varepsilon^{ygap}_{\varepsilon}$ term captures other temporary exogenous factors, such as the fiscal policy and other demand shocks. Equation (4) below provides a stochastic process for potential GDP, where potential GDP is a function of its lagged value plus the quarterly growth rate $g^{gdp*}/4$ thus assuming that the shock can affect only the growth rate of potential output, not the level of potential output.

Stochastic process for potential GDP:

$$gdp^*_t = gdp^*_{t-1} + g^{gdp*}_t / 4 \qquad (4)$$

As shown in equation (4) above, in the long run the growth rate of potential GDP, g^{gdp*} is equal to its steady-state rate of growth g^{55}. However, it can diverge from this steady-state growth following a positive or negative value of the disturbance term ε^{gss}_t and will return to g^{55} gradually with the speed of return based on the value of ϖ_1 (Laxton, Rose and Scott, 2009).

$$g^{gdp*}_t = \omega_1 g^{ss} + (1-\omega_1) g^{gdp*}_{t-1} + \varepsilon^{gss}_t \qquad (5)$$

[2] The real interest rate gap in Albania is measured as the difference between policy rate and inflation $rr_t = rs_t - \pi 4_{t+1}$.

Exchange rate

In order to incorporate exchange rate development, we introduce a nominal uncovered interest parity (UIP) equation in this model, where the nominal exchange rate depends on the difference between real interest rate in Albania and the counterpart in the EU, the change in real exchange rate, the change in real exchange gap and the risk premium. We divide the risk premium in two components: permanent risk premium and temporary risk premium.

The equation for the nominal exchange rate may thus be written as:

$$\left[rs_t - rs_t^{EU}\right]/4 = \Delta z_t^* - \Delta z_t + s_{t+1} + s_{t-1} - \left(\pi_t - \pi_t^{EU}\right)4 - \left(risk\_p_t + risk\_t_t\right) \qquad (6)$$

Where rs_t is the policy interest rate in Albania and rs_t^{EU} is the three-month Euribor in EU, (these rates are divided by four because they are in annual term). S_{t+1} and S_{t-1} are the expected and lagged values of nominal exchange rate, π^{EU} is the inflation in EU, $risk\ p_t$ and $risk\_t_t$ are the risk premium and the temporary risk premium.

Below we present how permanent risk premium and temporary risk premium develop to their steady state value.

Exchange rate risk definition

Blanchard and Quah (1989) provide an econometric technique which allows researchers to decompose a time series into its temporary and permanent components (Sarno and Taylor). Lastrapes (1992) based on the Blanchard and Quah (1989) decomposition finds that the real shocks cause a permanent real and nominal appreciation of the exchange rate, while nominal shocks are found to cause a permanent nominal depreciation. The idea we follow here is similar, we divide risk premium into temporary and permanent component and then determine how they develop to their steady state.

Equation (7) below gives the permanent risk premium:

$$risk\_p_t = 0.5 * risk\_p_{t-1} + (1 - 0.5) * risk\_p_t^* + \varepsilon_t^{risk\_p} \qquad (7)$$

Where ***risk_p_t**** is risk premium at steady state and the disturbance term is $\varepsilon_t^{risk\_p}$ captures the permanent shocks to the permanent risk premium, which we use here as permanent shocks to exchange rate, as $risk\ p_t$ determines the equilibrium real exchange rate equation as given in equation (11).

The development of temporary risk premium is given as:

$$risk\_t_t = \gamma_1 * risk\_t_{t-1} + \varepsilon_t^{risk\_t} \qquad (8)$$

Where $\varepsilon_t^{riks\_t}$ captures the temporary shocks that affects the movement in the temporary risk premium, which can be considered as temporary shocks to exchange rate.

In our model the real exchange rate (*z-real*) depends on nominal exchange rate (s) and the difference on price level between European Union, cpi^{EU} and Albania, cpi, while the real exchange rate gap is calculated as the difference between the real exchange rate and the real exchange rate equilibrium.

$$z\_real_t = s_t + cpi^{EU} - cpi \qquad (9)$$

$$z_t = z\_real_t - z_t^* \qquad (10)$$

The equilibrium real exchange rate equation is defined as follows:

$$z_t^* = z_{t-1}^* + (rr_t^* - rr_t^{*EU})/4 - risk\_p_t \qquad (11)$$

Where rr_t^* and rr_t^{*EU} are the real interest equilibrium in Albania and in EU. Thus the equilibrium of real exchange rate is a function of its lagged value, the interest rate differential and permanent risk premium.

The equations below determine the real interest rate $r\_real_t^{EU}$

and the real interest rate gap (rr_t^{*EU}) in the foreign country.

$$r\_real_t^{EU} = rs_t^{EU} - \pi_{t+1}^{EU} \tag{12}$$

$$rr_t^{EU} = r\_real_t^{EU} - rr_t^{*EU} \tag{13}$$

Real interest rate equilibrium equation in European Union is as follows:

$$rr_t^{*EU} = \phi_1 rr_{t-1}^{*EU} + (1-\phi_1) rr_t^{ss\_EU} + \varepsilon_t^{*EU} \tag{14}$$

Where $rr_t^{ss\_EU}$ represents the real interest rate at steady state and ε_t^{*EU} is the shock to the real interest rate equilibrium.

The real interest gap equation is arranged as follows, where the disturbance term ε_t^{rrEU} captures the shocks to the real interest rate gap in the European Union:

$$r\_real_t^{EU} - rr_t^{*EU} = \delta_1 * rr_{t-1}^{EU} + \varepsilon_t^{rrEU} \tag{15}$$

Monetary policy rule

The monetary policy rule determines the decisions of the central bank to use the instrument variable (the policy rate) in order to achieve its target level for inflation. Clarida, Gali and Gertler (1999) emphasize that for the central bankers it is very important to take into account the movements in economy, when they take a decision, thus in our reaction function we have included also the output gap. The monetary policy rule is as follows:

$$rs_t = \lambda_1 rs_{t-1} + (1-\lambda_1)\left(rr_t^{*} - \pi 4_{t+4}\right) + \lambda_2\left(\pi 4_{t+4} - \pi_t^{ss}\right) + \lambda_3 ygap_t + \varepsilon_t^{rs} \tag{16}$$

Where λ_1 is the degree of interest rate smoothing, the λ_2 term measures the aggressiveness of monetary policy in achieving the inflation target, the λ_3 term is the coefficient on the output gap, and ε_t^{rs} is interpreted as economic shock (demand and supply shocks).

Foreign country (European Union)

The rest of the world in the model is represented by the European Union. We have modelled only the Phillips curve and the output gap for European Union, as these are the main variables that have an impact on the Albanian economy. As expected, we suppose that the Albanian economy does not affect the European Union economy as it is a small country.

Output gap (EU)

$$ygap_t^{EU} = 0.8 * ygap_{t-1}^{EU} + \varepsilon_t^{EU} \quad (17)$$

Where $ygap_t^{EU}$ is the output gap in European Union and it is measured as the difference of real output from potential value; ε_t^{E} measures the disturbance term in output gap equation for the European Union.

Inflation equation (EU)

$$\pi_t^{EU} = \sigma_1 \pi_{t-1}^{EU} + (1 - \sigma_1)\pi_t^{ss\_EU} + \varepsilon_t^{\pi\_EU} \quad (18)$$

Where π_t^{EU} represents inflation in European Union, measured as quarterly annual changes of HCPI; $\pi_t^{ss\_EU}$ is the equilibrium value of inflation in steady state; and $\varepsilon_t^{\pi\_EU}$ is the supply shock term.

Unemployment equation

The equation below provides a dynamic version of Okun's law, where unemployment gap (measured as the difference between equilibrium level of unemployment rate and actual unemployment rate) is a function of its lagged value, the output gap and the disturbance term ε_t^{un}.

$$un_t = \mu_1 un_{t-1} + \mu_2 ygap_t + \varepsilon_t^{un} \quad (19)$$

The equilibrium level of unemployment or NAIRU rate of unemployment is defined in equation (20), where un^* is a function of its past value plus a growth term, g_t^{un*}. The growth rate of potential unemployment rate is a function of its lagged value and the disturbance term ε^{gun*} as given in equation (21).

$$un_t^* = un_{t-1}^* + g_t^{un*} \tag{20}$$

$$g_t^{un*} = (1-\vartheta)\, g_{t-1}^{un*} + \varepsilon_t^{gun*} \tag{21}$$

Thus, we have assumed that NAIRU can be affected only from growth shocks.

Once we have specified the model, we move to model estimation. The next section discusses in detail the steps we follow to determine the structural parameters of the macro model.

IV. MODEL ESTIMATION

There are two possible ways to determine the parameters of the structural model. The first approach is to calibrate the parameters so that shocks and impulse response given by the model would match as closely as possible their empirical counterparts. Calibration can be carried out on the basis of experts' knowledge on the economic structure of the given country and/or make use of the conclusions from studies of similar countries and use them as a benchmark. The model can also be calibrated using theoretical expectations on the size of the parameters. However, in order for the model to be used as a serious tool for policy analyses, rigorous econometric evaluation is needed. This is the second approach to determine the parameters of the structural models. Both approaches have some drawbacks, as the first one does not really relate to the data, while the second approach could undermine the importance of the theoretical background.

Therefore, it is important that the researcher brings the data to the model by incorporating not only experts' knowledge but also the information that comes from the latest. This is the approach we follow here by using Bayesian estimation. We suggest not only to estimate the model, but also to incorporate other knowledge from outside the data. First we will discuss the data we use in the model, and then briefly present the basic idea of Bayesian estimation.

a. Data

To estimate the model we use quarterly data on output, inflation, interest rate and exchange rate from 2003 to 2009. Data are collected from INSTAT concerning inflation and output, and the Bank of Albania for interest rate and exchange rate in Albania. We choose this time period in order to avoid potential structural breaks in the data of output, as INSTAT started to publish quarterly GDP data only after 2003. Foreign GDP data and 3-month Euribor interest rate are collected from Eurostat. The output growth rate is the log-difference in the real gross domestic product (GDP). The inflation rate is the log difference in the consumer price index (CPI). All the data used in the estimation are demeaned.

b. Estimation Methodology-Bayesian approach

Bayesian analysis allows the researcher to formally incorporate uncertainty and prior information on the parameters of the model. The idea is that the model builder uses prior information, e.g., from earlier microeconometric or macroeconometric studies for calibration purposes. In this context, Bayesian estimation is considered as a generalization of the calibration. In the Bayesian approach the values of the prior information are considered as the means or modes of the prior densities to be specified, where the prior uncertainty about these values can be expressed by choosing the appropriate variance of the prior.

When estimating a model, two sets of random variables have to be considered: the parameters and the data. The Bayesian approach makes use of the likelihood principle according to which all relevant information about the unknown parameters can be learned from the likelihood function (their probability distribution). This is given in the equation below known as the Bayes' theorem. The theorem gives the relationship between the posterior density and the prior and the likelihood as given below:

$$p\Xi/Y = \frac{L(\Xi/Y)\pi(\Xi)}{\int L(\Xi/Y)\pi(\Xi)d\Xi} \propto L(\Xi/Y)\pi(\Xi) \qquad (22)$$

Where $p(\Xi/Y)$ gives the posterior density of Ξ which is the vector of the parameters, $L(\Xi/Y) \equiv f\ Y/\Xi)$ is the likelihood of the sample Y (observables) and $\propto$. Draws from the posterior density of the structural parameters can be generated through the Metropolis-Hastings algorithm. Summary statistics of the parameters like posterior means (the point estimate of the structural parameters), standard deviations and confidence intervals are then calculated using these draws.

The first step of the Bayesian estimation requires the specification of the prior distribution and calculation of the likelihood function. We will estimate only the parameters of the Philips Curve, IS curve and monetary policy rule. The reason we exclude estimating the labour market and directly calibrate the labour coefficients is due to poor data statistics. Even in MEAM, labour market uses basically calibrated and restricted parameters, which we will import directly to the GAP model.

c. Choice of Prior

The prior distribution of the parameters describes the available information prior to observing the data used in the estimation. We choose as prior information, coefficients which we obtain after running three shocks to MEAM:

1. *Government expenditure shock*
2. *Exchange rate shock*
3. *Monetary policy shock*

The results of the shocks are then used to derive the prior mean of the structural parameters of the GAP model so that the impulse response of similar shocks in the structural model would be comparable to the results of MEAM. We are confident in using MEAM as our prior information as it has been used for some time in policy decision making. Also MEAM incorporates the best knowledge on the full linkages of the Albanian economy, being the only macro model in Albania in terms of variables and structure of the economy. This macro model includes a wide range of information concerning the main relationships between all the sectors of the economy, it is estimated with some calibration, and therefore it includes also experts' knowledge. Since the Bayesian estimation technique allows us to use prior information from earlier studies in a formal way, we are confident that MEAM provides a very good orientation on these priors.

Table 1 reports the prior distribution and initial values for the parameters. For all the parameters bounded between 0 and 1 we use the beta distribution, basically all the autoregressive parameters. Forward-looking output gap in aggregate demand and forward-looking interest rate in Philips Curve are also set to have beta prior distribution with not large standard deviations. For parameters assumed to be positive, such as the impact of exchange rate and interest rate on output, we use an inverse gamma distribution. The prior mode of exchange rate parameter in Philips Curve is set, so that pass-through is 6 % in the first quarter. Finally, the prior mean on the inflation coefficient is set to 1 with normal distribution and narrow standard deviation. The lagged interest rate coefficient to 0.5 implies that interest rate smoothing is not very large and the output reaction of 0.1 per quarter corresponds to a standard Taylor response of 0.4 for the annualized interest rate. Finally, for the standard deviations of the shock, we use the inverse gamma distribution with mean 1 and a wide standard deviation equal to 1.

The equilibrium conditions of the structural model are determined around the steady state conditions. Movements of the variables around the steady states are interpreted as cyclical fluctuations. We calibrate the steady state of the main variables to values commonly agreed for the Albanian economy. The steady state growth rate of GDP is calibrated to 6 %, which is the average growth rate of the Albanian economy prior to the global financial crisis (commonly agreed as the potential growth in Albania). Real interest rate steady state equals 3% and inflation rate steady state equals the Bank of Albania's target (3%). The same holds for foreign inflation steady state of EU, which equals 2 % with 2% real interest rate.

d. Estimation Results

The results of the joint posterior distribution of all estimated parameters are reported in Table 1. Combining the joint prior with the likelihood leads to the posterior density that is analytically untraceable. Hence, in order to sample from the posterior we employ the Metropolis-Hastings algorithm and generate 1600 draws from the posterior. Table 1 shows the posterior mean of all the parameters along with the 5th and 95th percentiles of the posterior distribution.

Table 1. Prior and posterior distributions

	Prior distribution			Posterior distribution		
Parameter	Type	Mean	St.dev.	Mean	5%	95%
Lagged output gap in aggregate demand	Beta	0.800	0.100	0.910	0.827	0.986
Forward output gap in aggregate demand	Beta	0.100	0.050	0.063	0.019	0.107
Real interest rate gap in IS equation	Inv_gamma	0.050	0.050	0.031	0.016	0.042
Real exchange rate gap in IS equation	Inv_gamma	0.050	0.010	0.059	0.037	0.081
Foreign output gap in IS equation	Inv_gamma	0.050	0.050	0.054	0.021	0.097
Forward looking inflation in Philips Curve	Beta	0.200	0.100	0.058	0.012	0.126
Output gap in Philips Curve	Inv_gamma	0.300	0.020	0.299	0.254	0.345
Real exchange rate in Philips Curve	Inv_gamma	0.120	0.100	0.087	0.046	0.143
Interest rate smoothing	Beta	0.500	0.100	0.725	0.657	0.816
Inflation aggressiveness -1	Normal	1.000	0.200	1.175	0.945	1.436
Output gap in reaction function	Inv_gamma	0.100	0.100	0.078	0.032	0.111
Autoregressive coefficient of permanent risk premium	Beta	0.500	0.100	0.590	0.482	0.688
Autoregressive coefficient of transitory risk premium	Beta	0.500	0.100	0.472	0.320	0.614
Autoregressive coefficient of real interest rate	Beta	0.500	0.100	0.658	0.569	0.729
Autoregressive coefficient of foreign output gap	Beta	0.500	0.100	0.5333	0.392	0.676

In the following we discuss the results in terms of the means of the marginal posteriors. The model appears to support a high degree of persistence in output (0.9) paired with a low impact of interest rate (0.03) and exchange rate (0.06) on output. Low degree of forward looking in inflation (0.06) is accompanied by high persistence in inflation (0.94) and a moderate exchange rate pass-through. A relatively high degree of inflation persistence was also found by Kota (2009) for headline inflation.

The parameters of the Taylor rule display reasonable values with a mean for the inflation coefficient of about 1.2, and the mean of the output gap coefficient of about 0.08. We recall that Taylor (1993) suggested values of 1.5 and 0.5 on inflation and the output gap, respectively. However, in his original rule inflation is measured as an average over the last four quarters, whereas in the present study inflation is the annualized quarterly growth rate of the CPI, which may be one reason for the weaker responsiveness of the interest rate to inflation in our study. Of course, the structure of the economy in Albania is different from that of the USA, therefore aggressiveness of the monetary policy to inflation and to output gap (which is not a target of the Bank of Albania) is expected to be different. The degree of interest rate smoothing has a mean of about 0.6. Finally, permanent and transitory risk premiums are not very persistent with an average mean of around 0.5.

V. SHOCK ANALYSIS

In this part we examine how different shocks affect the main macroeconomic variables and as compared to their steady state. Here we will present the results of the model from an unanticipated temporary shock that we have named as supply and demand shock and an anticipated temporary monetary policy shock.

Most research distinguishes between anticipated and unanticipated shock to a variable. The anticipated shock refers to a situation in which the behaviour of one variable in our case the level of prices, output or interest rate is rising/or decreasing at a rate that all economic agents expect. While the unanticipated shock to one variable characterizes situations when agents cannot predict or adjust for in advance of what they expect for the behaviour of variables. Fisher (1992) emphasizes that both anticipated and unanticipated solutions tend to converge towards the same long-run solution with the difference largely in terms of dynamic, but the unanticipated effects are stronger than in the anticipated case in the period in which the shock is introduced.

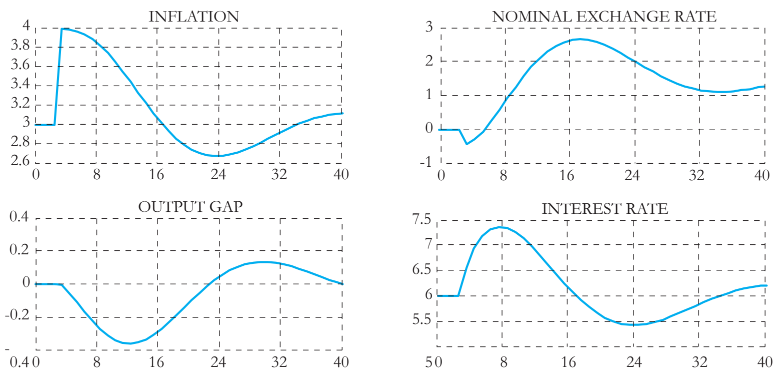
Another concept related to monetary policy shocks is permanent and temporary policy changes. Based on the Wallis et al. (1986) we can conclude that the difference between a permanent and temporary policy change is restricted to the period following the removal of temporary change. So the backward looking models react in the same way to permanent and temporary shocks during the period in which they are forced. A permanent policy change will generally take the solution to the model on to a new steady-state trajectory, while a temporary policy shock will take the model solution on the same path, whilst it is in force. The long-run difference between the temporary and permanent shock is a feature of the model with forward expectations variables. In addition, they may react differently to a shock, depending on whether this shock is anticipated to be permanent or temporary.

In our example we will carry out two unanticipated and temporary shocks that are demand and supply shocks and at the end, an anticipated temporary shock to the monetary policy due to an increase in future inflation.

- Supply shock

A positive shock of 1 percent to inflation equation leads to 1 basis point increase to inflation, while interest rate increases by 1.25 basis points after 4 quarters. Higher interest rates put downward pressures on inflation, which falls from 4 basis points to target after 2.5 years. The real exchange rate appreciates leading to lower aggregate demand, represented by a fall in output gap and inflation. The rest of the dynamic developments reflect the system returning to its steady state.

Figure 3: 1 percent unanticipated shock to inflation

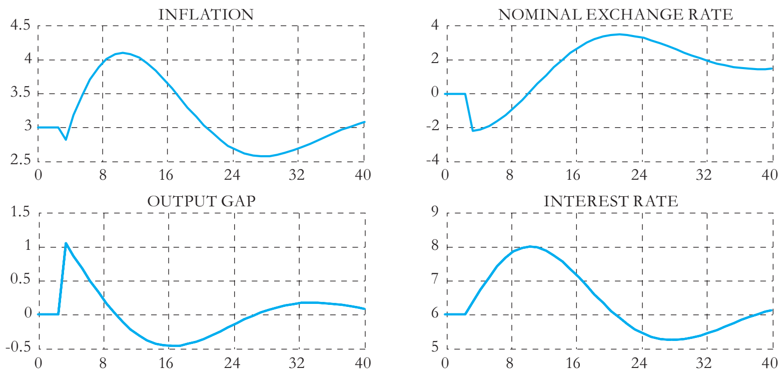


- Demand shock

1 percent shock to output gap that can be a credit shock or a fiscal shock at first, puts downward pressures on inflation up to 0.3 pp, which is followed by higher inflationary pressures due to exchange rate depreciation. Interest rates will increase to keep inflation within the target, so that around 1 pp wider output gap accompanied by 1 pp higher inflation, increases the interest rate up to 2 pp. This indicates the monetary policy is very sensitive to

changes in inflation, regardless of the developments in output gap and exchange rate.

Figure 4: 1 percent unanticipated shock to output gap

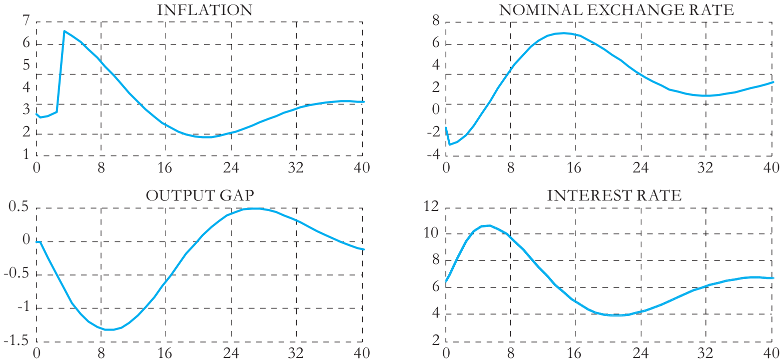


- Monetary policy shock

A very useful application of this model is that we can analyze the changes in the policy instrument and discuss its impact on other variables of the model. This type of analysis is necessary, since it serves directly as policy analysis to the decision-making process. We have analysed a one basis point anticipated shock to the repo rate due to a future shock on the Phillips curve. Based on inflation expectations, we assume that the inflation rate will go up after 4 quarters; therefore the policymakers decide to increase the repo rate at this moment by 1 basis point. The figure below shows that an increase in repo rate has a direct impact on exchange rate appreciation, followed by an immediate deprecation and a wider negative output gap. Then the shock is transmitted to the inflation rate that goes to the target level of 3 percent within two years.

In general, we can say that the impact of output gap on inflation appears to be high, among all shocks and therefore future research is required on this area. As expected, nominal interest rates react to changes of inflation, which includes the transmission of the output gap impact. Also, it appears that exchange rate is the relevant transmission channel of the monetary policy, which also requires some future research.

Figure 5: 1 percent anticipated shock to policy rate in response of future shock in Phillips curve



VI. CONCLUDING REMARKS AND FUTURE WORK

In this paper we present a small quarterly model for Albanian economy, where we include an endogenous output, inflation, policy rate, exchange rate and unemployment. The aim of the model is to unify the theoretical framework and the empirical evidence of the Albanian economy. The model has been designed to support policy analysis and to capture the essential linkages between the policy instrument of the Bank of Albania and the rest of the macroeconomic variables.

Based on Bayesian approach we used to estimate the model, we find a lagged output gap term on IS curve around 0.9 % that is the same like in other studies[3] for similar economies and a small coefficient on the lead of the output gap. We also find that the coefficient of interest rate is small implying that one percentage point increase in interest rate would lead to a 0.03 percent fall in the output gap on the following period. Being a small open economy, we would expect the coefficient on the real exchange rate to be higher, but we estimate a coefficient of around 0.08 %.

The results of the estimation indicate a relative high degree of inflation persistence in the Phillips curve and also a moderate exchange rate pass-through. To ensure that monetary policy has an effect on inflation, we expect that the coefficient on output gap and exchange rate gap to be higher than zero. In our case we have found a moderate pass-through but a higher effect of aggregate demand on inflation, as we expected.

The parameters of the Taylor rule display reasonable values with a mean of the inflation coefficient at about 1.2 %, and the mean of the output gap coefficient at 0.08 %. The degree of interest rate smoothing is moderate with a mean of about 0.7 %. Finally, permanent and transitory risk premiums are not very persistent with an average mean of around 0.5 %.

[3] Berg, A., et al (2006)

As future research, we plan to work on tuning the model so that impulse responses following a given shock better match our expectations and knowledge of the Albanian economy. Also it is important to estimate the labour market, so the model can be estimated and solved as a whole. Once the model is well-established, we aim to use it for forecasting purposes, besides policy and shock analysis.

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