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ABSTRACT

The Macro Econometric Albanian Model (MEAM) is a semi-structural model consistent with neo-classical growth models for small-open economies. While the long-run properties are closely linked to theory, the short-run dynamics are estimated and data driven. This paper provides an update of the MEAM model. The elasticities and the properties of the MEAM are demonstrated through shock analysis in terms of single equations and systems of equations. The model diagnostics are tested with different techniques in and out of sample. The MEAM is used to produce medium-term forecasts, alternative scenarios, stress test scenarios, counterfactual analysis, and is employed alongside other econometric tools for evaluating the impact of monetary and fiscal policy.

Keywords: *Macro-econometric models, Albania, forecasting, policy simulation, diagnostics*

1. INTRODUCTION

Macro-econometric models are analytical instruments designed to describe the functioning of an economy with an optimal degree of certainty. Models are usually employed for providing a framework of reality, for conducting forecasts and providing quantitative measures of policies or shocks. According to their employment, models can be grouped into those used for forecasts (short term, medium term or long term) and for policy analysis.

The Bank of Albania uses several models for forecasting i.e. inflation forecasting models, now-casting models, medium term models, financial models, etc.,[1]. In this paper, we present the macro-econometric model used at the Bank of Albania for generating macroeconomic medium-term forecasts and evaluating the impact of macroeconomic policies.

The macro-econometric Albanian model (MEAM) is a middle-scale 'semi-structural' macro-econometric model with 90 endogenous variables, of which 29 are estimated by stochastic equations and the rest are generated by identities. The econometric specification of the equations is generally motivated by the need of simultaneously achieving theoretical soundness and good empirical performance. The MEAM was at first developed in 2006, and since then has evolved continuously by changing and enriching its framework, through introducing a financial market block (Skufi (2020)), to add interactions and feedback between the real and financial sectors and through introducing a detailed price formation block (Skufi and Kika (2019)). In this paper, we provide an update of the elasticities of the main equations of the model. The elasticities of single equations and the properties of the full model are demonstrated through impulse response functions of different shocks. Model diagnostics are checked through the comparison of forecast versus actual data, the uncertainty around the forecast, the suitability of calibrated parameters, and the comparison of MEAM forecasts to those of simple statistical models. This version of the model updates and expands the one detailed in Vika et al. (2016).

[1] *Most of the materials can be assessed at https://www.bankofalbania.org/Publications/Research/*

Major specification and parametrization updates of this new version cover the foreign trade block, the cost and price block and the monetary and financial block. The financial block introduces a richer transmission mechanism that, takes into account the bank lending channel and introduces a feedback loop between the real economy and bank lending rates that tend to amplify the effect of real and financial shocks. Nevertheless, the MEAM is primarily used to produce medium term macroeconomic forecasts on a quarterly basis. Together with other econometric tools at BoA's disposal, the MEAM is used for assessing the macroeconomic impact of different monetary and fiscal policies, counterfactual analysis, and stress testing of the economy.

The paper is organized as follows. Chapter 2 provides an overview of the structure of the model regarding the demand and the supply side of the economy. Chapter 3 gives the estimation and the properties of the main equations of the model. Chapter 4 analyses the response of the model to monetary and fiscal policy shocks, to an exchange rate shock and to a foreign demand shock. Chapter 5 reviews specific model diagnostics. Chapter 6 provides examples of the uses of the model, limitations and further work. Appendices present detailed information of parameters estimated in Chapter 3, model responses of shocks of Chapter 4 and graphical results and methodologies behind simulations in Chapter 5.

2. AN OVERVIEW OF THE MODEL STRUCTURE

The MEAM is a semi-structural model designed to capture long run relationships of the Albanian economy specified to be consistent with neo-classical growth models and macroeconomic models for small-open economies with flexible exchange rate regimes. In the long-run, aggregate output is determined by production factors and technological progress, and as such money is 'neutral' with respect to output. Conversely, in the short run, prices and wages are sticky and subject to aggregate demand fluctuations, introducing thus Keynesians principles to the model. While the long-run properties are closely linked to theory, the short-run dynamics are not derived from an optimisation framework but instead estimated on the basis of historical data. Nevertheless, short-run dynamics are constrained by the need to fulfil long-run properties via the use of ECM terms and appropriate homogeneity properties.

The supply side of the model comprises of a production function in which output depends on technical progress, the capital stock and the effective labour supply. The derivation of the latter factor of production is done through taking into account the rate of structural unemployment, which together with the actual labour force determines, effective labour supply as an exogenous variable. Capital stock is determine as a function of investments flows and depreciations rates.

Prices are set as a mark-up over marginal costs, determined in the context of the wage-price block, in which wages feature a Phillips curve and prices are functions of unit labour costs.

Given the sluggishness of price adjustment, the output in the short-run is determined by the aggregate demand. The MEAM contains fairly standard equations for the main components of demand - household consumption, private investments, exports and imports – while government consumption and public investment are exogenous.

Expectations are treated implicitly by the inclusion of lagged values of the variables in most equations, known as backward looking expectations. The specification through adaptive expectations is not satisfactory for constructing a forward-looking monetary policy rule, targeting a specific inflation rate, or an explicit uncovered interest parity equation for the exchange rate. Regardless, as it stands now, the MEAM comprises of all the necessary elements to describe efficiently the transmission of monetary policy and the framework is flexible enough to permit the introduction of forward-looking behaviour, in a straightforward manner, when necessary.

2.1 The supply side

Potential output is assumed to follow a constant returns to scale Cobb-Douglas production function with calibrated factor share parameters. Total factor productivity TFP represents the Solow Residual derived from this production function.

(1) $$SGDP=TFP*SCS^{0.3}SLS^{0.7}$$

Where, **SGDP**, potential output; **TFP**, total factor productivity; **SCS**, capital stock; **SLS**, effective labour supply.

The capital stock is estimated separately for private and public sector with differentiated deprecation rates (Gupta et al, 2011). Initial values for private and public capital stock are ratios to GDP in 1996 according to IMF estimates in their "Investment and Capital Stock Dataset (ICSD)" (IMF, 2015). We assume investment at time **t**, which implies that capital stock is calculated at the end of the period.

(2) $$SCS=(SCSP_{t-1}-\delta_P SCSP_{t-1}+GFCFP_t)+(SCSG_{t-1}-\delta_G SCSG_{t-1}+GFCFG_t)$$

Where, **SCS**, capital stock; **SCSP**, private capital stock; **SCSG**, public capital stock; δ_P, depreciation rate of private capital stock, set at 8.03% per year; δ_G, depreciation rate of public capital stock, set at 3.55% per year; **GFCFP**, private investment; **GFCFG**, public investment. The distinct depreciation rates for the private and public capital stock are calculated from the IMF database described above.

Equilibrium unemployment rate to which the observed unemployment rate must converge is exogenous, (for NAIRU methodology see, Çela and Skufi, 2018). The labour force is also exogenously determined. Following the two assumptions effective labour supply is as below:

(3) SLS=LS*(1-nairu)

Where, SLS, effective labour supply; LS, labour force; nairu, equilibrium unemployment rate.

Potential output combined with actual output determines the output gap.

(4) gap=100*GDP/SGDP-100

Where, gap, output gap; GDP, output; SGDP, potential output.

Supply prices are determined based on the long run equilibrium condition that prices are set by monopolistically competitive firms as a mark-up over the average minimum cost. Unit labour costs proxy the marginal costs, while mark-ups are influenced by cyclical conditions and commodity prices. The import prices follow a pricing to market approach.

In the long run, nominal wages evolve in line with labour productivity and inflation. Because of structural breaks the labour market indicators exhibit, the wage Phillips curve goes through two stages. First, the minimum wage is assumed to be set according to inflation and unemployment developments and, second, actual wages are adjusted in line with minimum wage. For a detailed account for the price formation process in the MEAM, see Skufi and Kika (2019).

2.2 The demand side

On the demand side, real GDP is split into eight components (household consumption; government consumption; private investment, public investment; exports of goods; exports of services;

imports of goods and services and inventories). Bar the government variables and inventories that are exogenous in the model, all the other demand components have their individual behavioural equations.

Households set their consumption according to their disposable income in the long-run. In the short-run, consumption is a function of both the real disposable income and the real interest rate, capturing the intertemporal substitution of consumption.

Private investment is assumed to depend on the level of economic activity and on the user cost of capital. The user cost of capital is a function between the cost of bank loans and the opportunity cost associated to financing with own funds. As the gross fixed capital formation in the long-run is not derived from the theoretically consistent first order conditions of the production function, private investment depends also on population developments.

Exports are specified in terms of a standard foreign demand variable (with unit elasticity in the long run) and in terms of a competitiveness term, with two separate equations for the goods and services components which reflect different types of foreign demand and prices according to their markets. Imports are driven by an absorption variable, which takes into account the different import content of the various aggregate demand components, and relative prices.

Demand deflators are derived on the basis of a homogeneity assumption in domestic supply prices and import prices. Instead of putting the emphasis on the statistical significance of parameters, equations have been specified so that prices evolve around their theoretical steady states, with the addition of some simple dynamic terms to capture observed short-term effects.

The next chapter provides a detailed account of the empirical specification of the main equations of the MEAM and presents single-equations' short and long-run properties (i.e. the dynamic multipliers).

3. PROPERTIES OF THE MAIN EQUATIONS AND BLOCKS

This chapter presents the specifications and the dynamics of the main equations of the model. All the equations are estimated and specified in order to ensure convergence and a stable path to the long run. The demand components are driven by the economic activity, while the exports of goods and services reflect full developments in foreign demand, taking into account price competitiveness. Prices and wages grow in line with productivity. Production factors match economic output and the market clears. The following paragraphs summarize the specifications of the main equations together with auxiliary identities.

3.1 Consumption

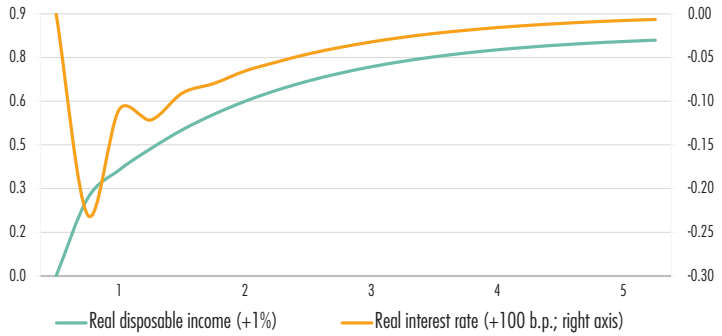
The equation for household consumption is estimated via a dynamic adjustment with an error correction mechanism around the long-run equilibrium. Small letters stand for natural logarithms.

$$(5) \qquad \Delta conhh_t = -\alpha_0(conhh_{t-1} + \alpha_1 di_{t-1} + @TREND + \alpha_2) + \alpha_3 \Delta TB12_t + \varepsilon_t$$

Where **conhh** is real household consumption, **di** is real disposable income (nominal GDP is corrected for the various net-transfers associated with balance of payments data[2] and the fiscal side of the economy; then is deflated by the household consumption price index), **TB12** is the real interest rate (yield of 12 months treasury bills minus inflation rate), and **TREND** is a time trend capturing the decline of remittances and the effect of fiscal consolidation on disposable income. See Table A.1 in Appendix A for the estimates of the parameters of the equation.

[2] *These include remittances, primary income and secondary income, all expressed in domestic currency.*

GRAPH 1. Dynamic responses of households' consumption to permanent shocks in its determinants. Percentage deviations from a baseline.



Graph 1 shows the response of consumption (as a percentage deviation from the baseline levels) to a permanent increase by 1 per cent in real disposable income and to a permanent increase of 100 basis points in the real interest rate, over a five-year horizon.

The elasticity of consumption to disposable income is about 0.84, reflecting the marginal propensity to consume. The adjustment of consumption toward income is gradual and complete almost after three and a half years, reflecting a pro-cyclical behaviour of savings.

Fluctuations in consumer prices have a two-fold effect in overall household consumption via two distinct channels. In the short-run, higher inflation rates lead to lower spending, due to the substitution effect, while in the long-run, higher inflation reduces the purchasing power of nominal disposable income.

3.2 Private investments

Private investments are modelled in terms of the general economic activity and capital costs, according to the following equation:

(6) $$\Delta gfcfp_t = -\beta_{-0}(gfcfp_{t-1} + \beta_1 gdp_{t-1} + \beta_2 ssqp_{t-1} + \beta_3 IPOND_{t-1} - \beta_4) + \beta_5 \Delta poil_{t-1} + \varepsilon_t$$

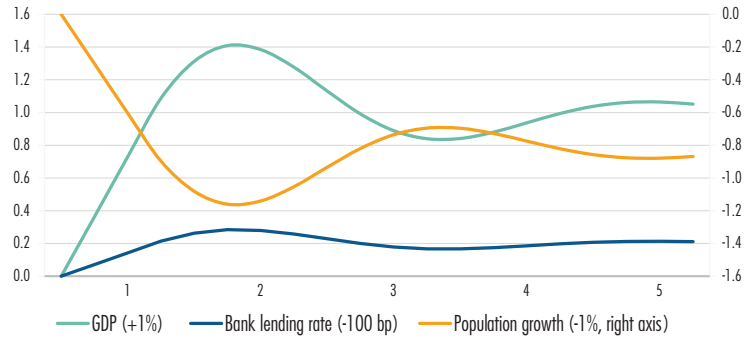
Where **gfcfp** is private gross fixed capital formation, **gdp** is real gross domestic product, **ssqp** represents inhabited meter square per capita, **IPOND** stands for capital costs, and **poil** is the oil price.

GDP is the long-run demand-pull factor of private investments used as a proxy for general economic activity. If activity expands, in the short-run investment needs to follow suit to accommodate the current and expected shift in demand but in the long-run over-investment is not an equilibrium condition. As such, the long run economic activity coefficient is calibrated to a unit value. To help enforce the convergence path of investments, the stock of inhabited surface per capita is added in the long-run relationship (as investments are not derived from optimality conditions of long term growth, with respect to labor). In case of a demographic expansion, investments need to pick up to match the expected effect on the housing stock.

The capital costs variable is a compound real interest rate constructed as a composite of the opportunity cost of investment (reflecting the share of financing with own funds approximated by the real yield of government papers) and the financial cost (reflecting the cost of new borrowing approximated by real bank lending rate) . Intuitively, it has a negative long run elasticity to private investments (calibrated at -1). Higher market interest rates are translated into less investment. The oil price is a short-run cost factor in investment, with higher prices suppressing investment only in the short-term.

Graph 2 shows the dynamic response of private investments to a permanent increase of GDP by 1 per cent; a 1 percent decrease in the growth rate of the population; and 100 basis point decrease in the bank lending rate. In response to a GDP shock, private investments accelerate during the first two years, overshooting by almost 50 per cent the initial shock in the second year. Thereafter, they move back towards the long-run value of 1. A permanent decrease of population growth of 1 per cent has a gradual negative impact on investments, stabilizing in the sixth year toward the new equilibria.

GRAPH 2. Dynamic responses of private investment to permanent shocks in its determinats. Percentage deviations from a baseline.



3.3. External trade

Exports and imports are modelled separately. Separate individual equations are estimated for the exports of goods and the exports of services. Unlike exports, imports of goods and services are modelled in their entirety. Both trade variables are modelled in terms of conventional indicators.

Exports of goods and exports of services are modelled as a function of foreign demand, with unit elasticity in the long run, and of a competitiveness term. Oil prices are added to the exports of goods equation in the short run to capture their increased share in overall commodity exports since 2010.[3] The equations are modelled as below.

(7) $\Delta expg_t = -\gamma_0(expg_{t-1} + \gamma_1 fdemg_{t-1} + @TREND - \gamma_2) + \gamma_3 \Delta comnessg_{t-1} + \gamma_4 \Delta poil_{t-1} + \varepsilon_t$

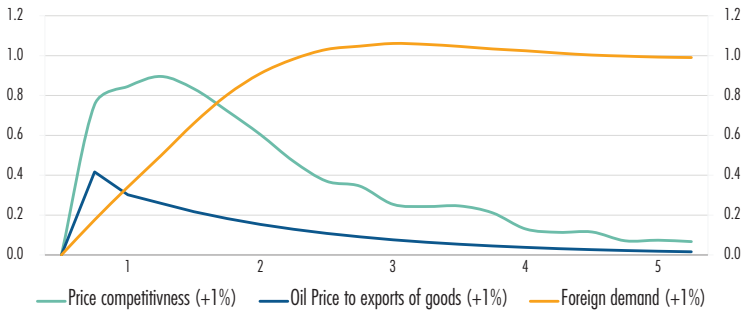
(8) $\Delta exps_t = -\delta\_0(exps_{t-1} + \delta_1 fdems_{t-1} - \delta_2) + \delta_3 \Delta comnesss_{t-1} + \varepsilon_t$

[3] *Data suggest a strong correlation between oil exports and oil prices, with strong fluctuations in exports responding to symmetrical behaviour in prices. The variable is included to proxy such short term effects.*

Where **expg** and **exps** are exports of goods and services, **fdemg** and **fdems** are foreign demand, **comnessg** and **comnesss** are competitiveness terms, and **poil** is the international oil price. Foreign demand for goods is a compound index based on the commodity export structure in terms of categories and partners, while the foreign demand for services is a compound index of partner travel export shares and expenditures. Competitiveness terms are ratios between international prices (implicit deflators index) expressed in domestic currency and domestic export deflator index.

The graph shows the dynamic response of exports to permanent changes in foreign demand and price competitiveness. The elasticity to foreign demand gradually goes beyond the long-run value of 1 and then stabilizes to its long term path. While the response to competitiveness is quick, with waves in the response paths, due to changing shares between goods and services in exports.

GRAPH 3. Dynamic responses of exports to permanent shocks in its determinants. Percentage deviations from a baseline.



The real import of goods and services equation assumes imperfect substitutability between imported and domestically produced goods and is specified as a function of an absorption variable, as a proxy of long run import demand, and of relative prices of imports and domestically produced goods. The absorption variable is derived as a weighted average from the aggregate demand components with weights computed on the basis of input-output coefficients.

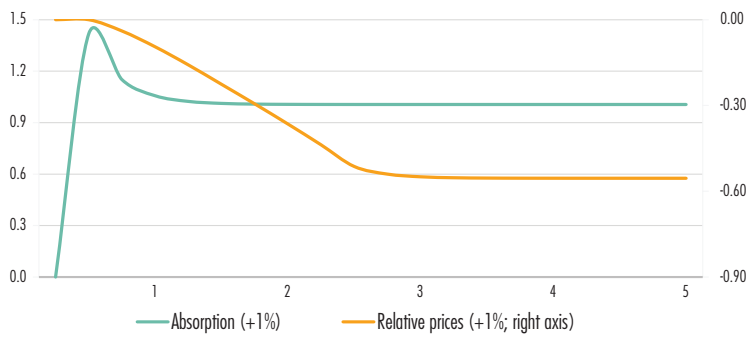
Private investments and exports of goods and services are the most import intensive.

$$(9) \qquad \Delta imp_t = -\zeta_0(imp_{t-1} + \zeta_1 impdem_{t-1} - \zeta_2) + \zeta_3\, pimprel_{t-1} + \varepsilon_t$$

Where **imp** is real imports of goods and services, **impdem** is absorption variable, and **pimprel** are relative prices. The relative price indicator is constructed as a ratio between the import deflator index and the domestic demand deflator index. Relative prices are included as a moving average, to reflect the gradual adjustment in substitution between imported and domestically produced goods. The parameter is estimated at unity so in the long run imports grow same speed as absorption.

Graph 4 shows the response of imports to a 1 per cent permanent increase of the absorption variable and a 1 per cent permanent increase in relative prices. In the short run, the elasticity of imports to absorption is notably higher than in the long run, as an unexpected increase in demand is easier to be met with higher imports. The slow adjustment of relative prices reflects the presence of imperfect substitution of goods.

GRAPH 4. Dynamic responses of imports to permanent shocks in its determinats. Percentage deviations from a baseline.



Exports and imports are later combined with their specific price deflators to derive trade in nominal terms (see Skufi and Kika, 2019

for a detailed description of price formation in the MEAM). See Appendix B for the elasticity of trade balance to certain shocks.

3.4. Labour market

The number of people employed at a certain moment in the economy is determined by its real costs, the labour requirement of each sector of economy related to the expenditure level of agents, and the demand of labour linked to developments in the capital stock. The explanatory equation falls across the following lines:

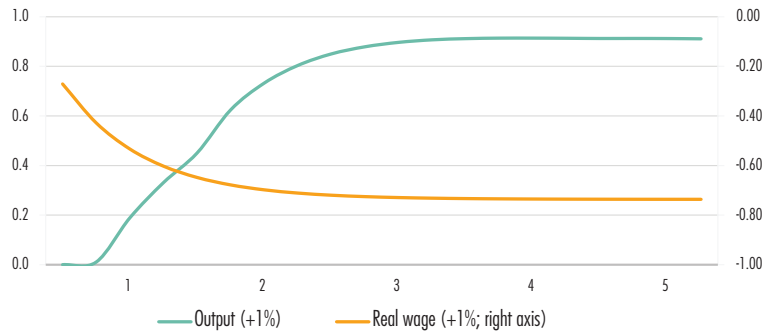
$$(10) \qquad \Delta ld_t = -\eta_0 (ld_{t-1} + \eta_1 w_{t-1} + \eta_2 lddem_{t-1} + \eta_3 (gdp/cs)_{t-1} + @TREND - \eta_4) + \varepsilon_t$$

Where, **ld** is labour demand, **lddem** is a compound index based on the labour intensity of aggregate demand components, with weights calibrated on the basis of detailed sectoral employment data combined with input-output coefficients, and **gdp/cs** is capital productivity.

Graph 5 shows the response of employment to a 1 per cent permanent increase in output and real wages. The long run elasticity of labour demand to output is almost 0.9 after to 2 years working via two channels: first, labour intensity of each aggregate demand component (); and second, the complementarity between labour and capital productivity (). The elasticity of labour demand to real wage is lower (0.7) and the pass-through is smoother, due to labour market rigidities. Labour force is determined as a function of exogenously given population growth and participation rates. The effect of 'discouraged workers' in labour supply is captured through the shock component, while an assumption is needed to capture this behaviour in the future. The unemployment rate is determined by an identity.

The average wage variable in the model combines both the private and public sector wages. In terms of wage-setting institutions, there is a minimum legal wage, with changes in it directly affecting average wages. As the average wage closely tracks the minimum wage, the wage Phillips curve follows two consequential processes.

GRAPH 5. Dynamic responses of labour to permanent shocks in its determinants. Percentage deviations from a baseline.



First, the minimum wage is assumed to be set according to past inflation, cyclical conditions, and productivity developments and, second, average wages are adjusted in line with minimum wage. The specifications as follows:

$$(11) \qquad \Delta wnmin = -\vartheta_0 + \vartheta_1 \Delta lp_{t-1} + \vartheta_2 \Delta wnmin_{t-1} + \vartheta_3 \Delta cpi_{t-1} + \vartheta_4 \Delta (UN\text{-}NAIRU)_{t-1} + \varepsilon_t$$

$$(12) \qquad \Delta wn_t = \theta_1 + \theta_2 \Delta wn_{t-1} + \theta_3 \Delta wnmin_{t-1} + \varepsilon_t$$

Where, **wnmin** denotes the logarithm of the average minimum wage per employee over the past four quarters, **cpi** is the average inflation over the same period, **lp** is four-quarters average of labour productivity growth, **(UN - NAIRU)** is the unemployment rate gap, **wn** is the average wage per employee. For a detailed description of wage formation, indicators and parameters see Skufi and Kika (2019).

Graph 6 shows the dynamic response of the average wage to a permanent 1 per cent increase in the unemployment rate gap and in the level of consumer prices. An increase of prices affects wages through expected inflation, which is endogenously specified

through adaptive expectations. The pass-through of inflation to wage is complete after 3 years.

GRAPH 6. Dynamic responses of wage to permanent shocks in its determinants. Percentage deviations from a baseline.

3.5. Prices and deflators

The MEAM features a detailed description of the price formation process in the Albanian economy, taking into account both supply prices, through domestic supply prices and the import deflator, and demand prices, through aggregate demand deflators (i.e., consumption, gross fixed capital formation, exports).

Domestic supply prices are modelled based on the assumption that firms operate in monopolistic competition, and set the price as a mark-up over normal costs, which is later approximated with unit labour costs (featuring a proxy for real marginal costs). With the mark-up being unobservable, it is assumed to be a function of cyclical conditions, approximated with the output gap,[4] and of fluctuations in commodity prices. We assume there are symmetric effects in commodity prices.

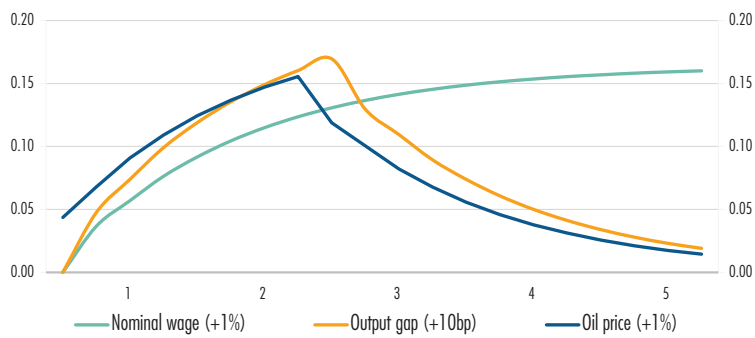
[4] *Foreign developments should also affect the mark up via foreign prices and the exchange rate, but given the low elasticity of substitution of imports no significant relationship was found between domestic supply prices and the foreign sector indicators. See Skufi and Kika (2019), for more details.*

(13) $\Delta dsp=-\psi_0(dsp_{t-1}+\psi_1 ulc_{t-1}-\psi_2)+\psi_3\, poil_t+\psi_4 GAP_t+\varepsilon_t$

Where, **dsp** is the domestic supply prices index calculated as a ratio of turnover value over production volume in the economy, **ulc** represent the ratio of compensation per employee divided by a moving average of labour productivity to smooth cyclical fluctuations, so as to reflect "normal" unit labour costs, **GAP** is output gap, and **poil** is the oil price representing an important component in the cost-structure.

Graph 7 shows the dynamic response of domestic supply price to a permanent increase of 1 per cent in the nominal average wage, and temporary (2 year) shocks in the output gap, by 10 basis points, and in oil prices, by 1 per cent. The latter two shocks impact domestic supply prices immediately, peak at around 2 years after the initial shock and start to dissipate thereafter. The opposite is true for the adjustment of domestic supply prices to the wage shock, which is slower and reflects rigidities in the labour market.

GRAPH 7. Dynamic responses of domestic supply prices to permanent shocks in its determinants. Percentage deviations from a baseline.



Import prices are modelled under the assumption of pricing to market, implying that the price of the good or service exported to Albania may differ from the price of the same good or service exported elsewhere, on the basis of domestic developments and exchange rate fluctuations. All other demand prices are expressed

as a function of domestic supply prices and import prices, restricted to a first order homogeneity condition that allows for a long-term equilibrium in prices. The equations follow the pattern below:

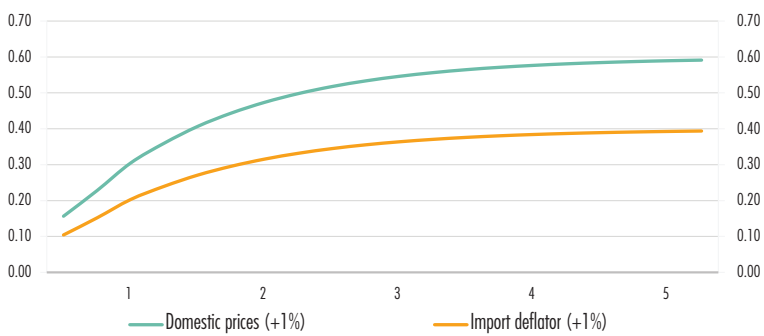
(14) $\Delta pimp_t = -\varsigma_0(pimp_{t-1} + \varsigma_1 pexpeu_{t-1} + \varsigma_2 alleur_{t-1} + \varsigma_3)$

(15) $\Delta p_t^i = \Omega^i(\lambda^i dsp_{t-1} + (1-\lambda^i) pimp_{t-1} - \phi^i)$

Where **pimp** is the import deflator index, **pexpeu** is the foreign prices index, **alleur** is the lek-euro exchange rate, **p** is the domestic deflator index with **'i'** represents the component of aggregate demand and, **λ** the weight of the domestic content for each component calibrated according to input-output coefficients.

Graph 8 shows the dynamic response of the household consumption deflator to a permanent increase of 1 per cent in domestic supply prices and in import prices. The long term elasticity of the consumption deflator to domestic supply prices and import prices reflects also the share of domestically produced and imported goods in households' expenditures.

GRAPH 8. Dynamic responses of domestic supply prices to permanent shocks in its determinants. Percentage deviations from a baseline.



3.6. The public sector

The MEAM includes several indicators of fiscal items in terms of revenues and expenditures. Fiscal indicators are not set endogenously in the model, are all kept exogenous, but reflect the fiscal policy implemented in the country. On the revenue side, most of fiscal items are used in the calculation of the disposable income (i.e., grants, non-tax revenues etc.) whereas on the expenditure side, some items enter the disposable income (i.e. transfers, debt service payments), while others enter the gross domestic product equation. Out of model calculations generate government consumption and public gross fixed capital formation from the fiscal accounts. The next chapter discusses in detail the impact of alternative fiscal expenditures on economic activity and prices.

3.7. Monetary policy, interest rates and credit

Monetary policy shocks are transmitted to all interest rate indicators, with the latter affecting demand through the cost of capital and intertemporal substitution of consumption channels. Demand pressures are later transmitted to the price – wage block, helping the economy to adjust to the shock.

The transmission of the monetary policy impulse in financing costs is initially assumed, then tested and calibrated to be complete in the long run. The yield of 12 months treasury bills adapts quicker to the change in monetary policy, while the pass-through to bank lending rates to businesses is more gradual. The latter variable is determined in terms of a risk-free asset and a risk premium linked to the probability of default in the private sector that implies an inverse relationship between borrower solvency conditions and risk premium. The latter is approximated with the non-performing loans (NPL) rate, which in turn is a function of cyclical conditions, lending rates, and the ratio of borrowing costs to revenues. Since a large share of business loans is in foreign currency, two different stochastic equations are estimated for NPLs:

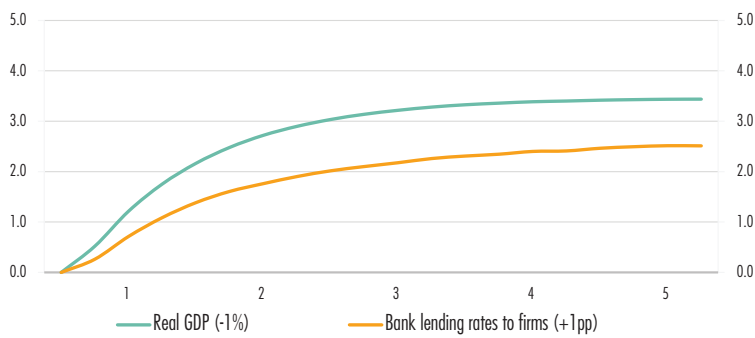
$$(16) \qquad NPL_t=\chi_0+\chi_1 NPL_{t-1}+\chi_2 GAP_t+\chi_3 ((I_t+h_t) L_t)/GDP_t+\varepsilon_t$$

(17) $NPL_t^*=\Pi_0+\Pi_1 NPL_{t-1}^*+\Pi_2 GAP_t+\Pi_3((I_t^*+h_t^*)L_t^* ALLEUR_t)/GDP_t+\varepsilon_t^*$

Where **NPL** is the non-performing loan rate of firms denominated in domestic currency, **GAP** is output gap, **I** is bank lending rate for the loans given to businesses in Lek, **h** is the fraction of the total loan that gets repaid in period **t** for loans denominated in domestic currency, **L** is the stock of loans given to businesses denominated in Lek, **GDP** is gross domestic product, **ALLEUR** is Lek-Euro exchange rate level, and index **'*'** stands for Euro.

Graph 9 shows the dynamic response of the non-performing loan rate to a permanent decrease of 1 per cent in GDP, and a permanent increase of 1 percentage point to the nominal bank lending rate. There is a contemporaneous interplay between cyclical conditions, borrowing costs and firms' solvency rates that introduce a feedback from the financial sector to the real economy. This feedback between the financial and the real side of the economy was absent in older model versions (see Skufi (2020) for more details on the financial block).

GRAPH 9. Dynamic responses of non-performing loan rate to permanent shocks in its determinants. Percentage deviations from a baseline.



The stock of loans to businesses is modelled on the assumption that the share of economic activity financed by bank intermediation remains largely unchanged, whereas the equation of the level of loans granted to businesses denominated in domestic currency is supplemented with lending rates of borrowing in domestic currency.

The difference between the two determines the stock of loans in foreign currency. A substitution effect takes place between currencies, based on the price of loan (lending rate) while introducing macro indicators to the specification adds another channel to the feedback mechanism between the financial and the real side of the economy. The supply side (i.e., bank profits and capital) is still missing but the model is flexible enough to provide simulation for a given state of the banking sector and be used for macro prudential purposes.

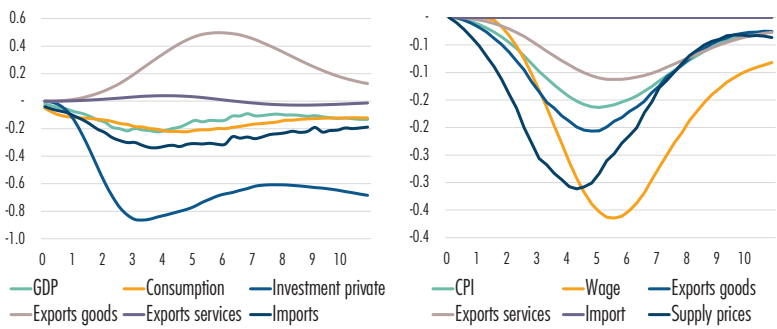
4. MODEL PROPERTIES

This chapter presents full model responses of GDP, its main components, wages and prices to a set of standard shocks to exogenous variables in the model. The results are reported in terms of (cumulated) percentage deviations from the baseline scenario, for a period of 10 years. For all shock simulations, it is assumed that the central bank does not respond to changes in macroeconomic conditions with the exception being the simulation of the monetary policy shock. For all shocks there is no reaction of the exchange rate.

4.1 Monetary policy

We introduce a 100 basis points permanent increase of the REPO rate. The exchange rate does not change owing to its exogenous nature in the model. Interest rates increase both in domestic and foreign currency.[5]

GRAPH 10. MODEL ELASTICITIES: MONETARY POLICY SHOCK (100 B.P).
Percentage deviations from a baseline.



A contractionary monetary policy leads to a reduction of economic activity and a lower inflationary environment (graph 10 and table B1 Appendix B). Household consumption decreases due to the intertemporal substitution effect and the lower disposable

[5] *For a detailed description of the monetary policy pass through in the MEAM see Skufi (2020).*

income[6] as output contracts. Lower disposable income is partly compensated by the higher purchasing power due to lower inflation. Private investments decrease the most among aggregate demand components, because of joint negative effects from both the output accelerator and from higher capital costs. Net exports have a positive impact on GDP. Exports of goods and exports of services increase as the competitiveness terms improve, on the other hand imports decline as demand for imports contracts in line with domestic developments. GDP reaches its trough after 2 years and is nearly 0.3 per cent lower compared to the baseline.

There is no immediate response from the nominal side of the economy due to sluggish price adjustment and a missing parallel reaction of import prices as the exchange rate is exogenous. Wages react slowly because of a delayed and a smooth adjustment of the labour market. Wage stickiness is transmitted via unit labour costs into domestic supply prices, and subsequently to aggregate demand deflators. At the trough, domestic supply prices fall cumulatively by about 0.3 per cent and consumer prices by about 0.2 per cent. The competitiveness gains due to the fall in export prices contribute to the adjustment of GDP thereafter.

4.2 Foreign demand

The shock is a 1 percent permanent increase of foreign demand for Albanian goods and services. Exports expand as a response to the foreign demand shock. As all aggregate demand components have a non-negligible imported content, the increase in GDP will be dampened somewhat by the surge in imports. GDP reaches its peak in the third year, by about .25 per cent compared to the baseline (graph 11 and table B2 Appendix B). As demand pressures accumulate and cyclical conditions improve, inflationary pressures start to build up. As a result, worsening foreign competitiveness reduces the impact of the positive foreign demand shock and exports subsequently stabilize at a lower level compared to its peak.

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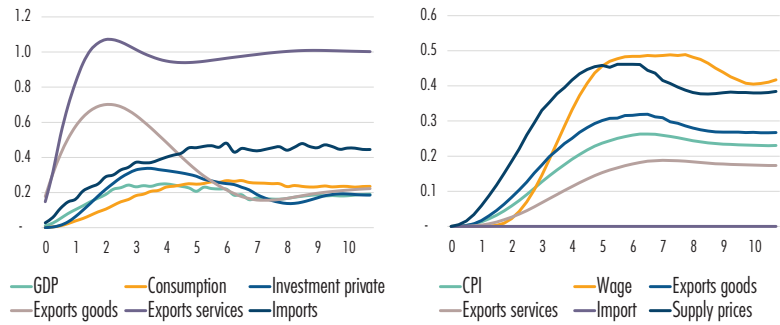
[6] *Interest revenues should adversely affect disposable income. Since the fiscal sector is exogenous and the financial sector lacks a households segment, the interest revenue channel is absent in household consumption.*

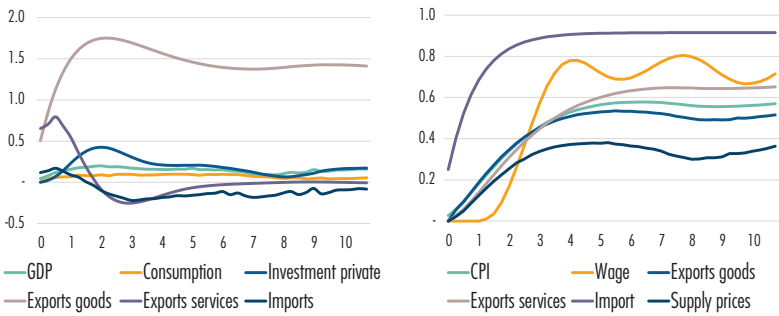
GRAPH 11. Model elasticities: foreign demand shock (1%). Percentage deviations from a baseline.



4.3 Exchange rate

The shock is a 1 percent permanent depreciation of the Lek against the Euro. The depreciation leads to an expansion of exports of goods and of services via the competitiveness term. Consumption is positively affected in line with the rise in economic activity. The increase in disposable income is attenuated by the impact of higher inflation. With output increasing, private investments accelerate, aided also by the decrease in the real cost of capital linked to higher inflation. Prices increase their impact as the exchange rate

GRAPH 12. Model elasticities: exchange rate shock (1%). Percentage deviations from a baseline.



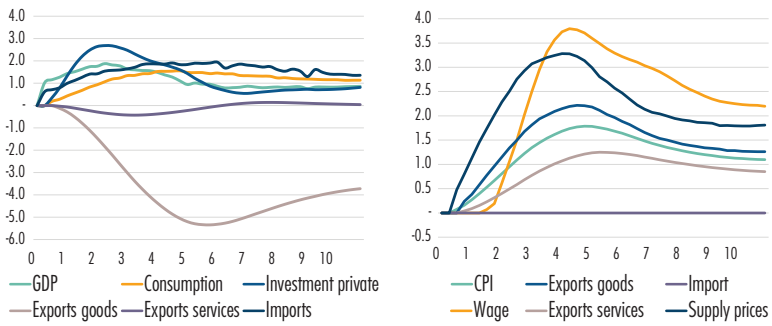
depreciates and the initial movement is subsequently amplified by the aggregate demand expansion. After five years, the price index is nearly 0.6 per cent higher than in the baseline scenario (graph 12 and table B3 of Appendix B).

4.4 Fiscal policy

The shock is a 1 per cent of GDP permanent expansion of fiscal policy using different fiscal items or alternative instruments i.e. higher public consumption; higher public investments; and higher transfers to households. In the simulation of these shocks, there is no response of monetary policy and higher fiscal expenditures are not accompanied by a shift in the government yield curve.

An increase of public consumption induces an increase of GDP almost equal to the size of shock in the first year (graph 13 and table B4 Appendix B). In the following years GDP starts to increase gradually, for about 4 years, before starting to decline. The Keynesian multiplier reaches its highest value of 1.8 in the third year. Higher fiscal expenditure boosts household consumption and private investments. Trade balance deteriorates due to a contraction of exports and an increase in imports. The acceleration of economic activity induces inflationary pressures, which in the absence of a monetary policy reaction, contributes to a CPI index

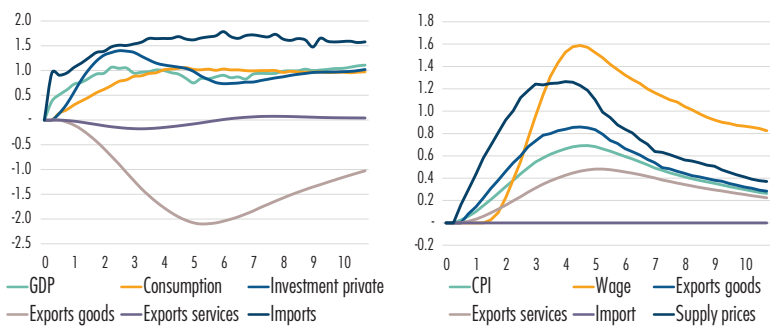
GRAPH 13. Model elasticities: public consumption shock (1% of gdp). Percentage deviations from a baseline.



about 1.7 percent higher compared to the baseline. High inflation induces a decline in real interest rates, generating an acceleration in private investments via the user cost of capital. Private investments reach their peak in the third year, by about 2.8 percent higher compared to the baseline. Household consumption also expands with the reaction of consumer spending similar but smoother to the GDP dynamic response. Net exports decrease, due to the surge in imports driven by the higher level of domestic demand at first and the deterioration in competitiveness following an increase in domestic prices later.

In the case of an increase in public investment (graph 14 and table B5 Appendix B), the results of the simulation are similar to the public consumption shock, with the only difference in the lower positive impact on GDP in the first years of simulation due to a surge in imports. The increase in output is attenuated by the effect of imports. The Keynesian multiplier reaches its highest value of 1.1 in the second year and remains close to unity for the rest of simulation period. Private investment follows the typical accelerator pattern, with the highest deviation of 1.4 per cent compared to the baseline after three years. Households spending increases by 1 per cent compared to the baseline after four years. The trade balance deteriorates sharply, reflecting the immediate need for foreign inputs to sustain the fiscal stimulus and the deterioration in the competitiveness terms due to higher domestic inflation. The

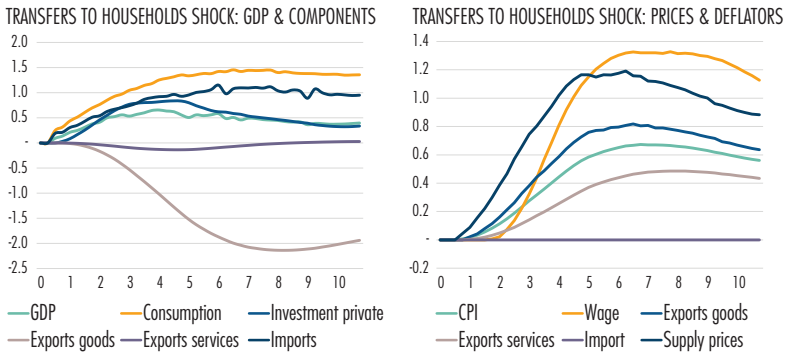
GRAPH 14. Model elasticities: public investments shock (1% of gdp). Percentage deviations from a baseline.



increase in inflation is nevertheless more moderate compared to the previous fiscal shock due to a smoother impact on cyclical conditions via increased capital stock and potential output.

The impact of higher transfers to households (i.e. social assistance, unemployment insurance benefits) on aggregate demand and prices is shown in graph 15 and table B6 Appendix B. The reaction of output is the smallest compared to fiscal expansion with other instruments. Higher fiscal expenditures affect the real economy via the disposable income channel. Households' consumption increases in line with the marginal propensity to consume (part of the increased disposable income goes for savings). Household consumption reaches its peak in the fifth year of the simulation at a level about 1.4 per cent higher compared to the baseline. Output peaks at around 0.6 per cent in the fourth year, and then starts to decline. Domestic inflation pressures are moderate, with the consumer price index increasing by a maximum of 0.7 per cent after 6 years. Capital accumulation is very low, about 0.3 percent compared to baseline after seven years.

GRAPH 15. Model elasticities: transfers to households shock (1% of gdp). Percentage deviations from a baseline.



5. MODEL DIAGNOSTICS

We evaluate MEAM model's accuracy and stability by assessing model diagnostics along 4 pillars: (i) forecast versus actual data; (ii) forecast uncertainty; (iii) suitability of calibrated parameters; (iv) forecast accuracy vis-à-vis simple statistical models. Similar evaluation strategies are used to uncover model properties by Andrle et al. (2009); Szilágyi et al. (2013); Budnik et al. (2009).[7]

Any macroeconomic model's accuracy is often tested out of the statistical environment as Tanku (2012) asserted: 'MEAM has been used in the process of policy making providing forecasts and shock analysis for years. This period has shown that MEAM has passed the tests for non-statistical criteria and that it is a reliable tool for analysis and forecast in the policy processes'

5.1 In-sample simulations

The in-sample simulation process compares the forecasting outcomes with actual data, for selected variables at different points in time. An 8 quarter forecast horizon is used to conduct 9 conditional forecasts on the known exogenous variable trajectories. The simulations cover the period 2015-2018 and for each, the actual values of endogenous variables are unknown at the beginning of the simulation. After completing each in-sample simulation, the actual path of the endogenous variable is attached to the set of forecast trajectories. The results for the real economy block, financial sector block and price formation block (see Appendix C1 graphs 17 to 19) are discussed below.

Aggregate demand components are well replicated throughout most of the samples. Additionally, the model manages to capture specific turning points in the evolution of most variables. Exception to this rule is only the drop in imports of goods and services in 2015 and 2016, not captured by the simulations. During the first half of 2015, imports contracted sharply as consumption decreased due to

[7] *This chapter includes only the results for the real economy and the financial sector blocks. For in detail diagnostics of the price block see Skufi and Kika (2019).*

a public measure to clear payments arrears in the domestic electricity distribution sector (BoA, 2015). As specific policy interventions are not possible to be captured, unless external judgment is added, the simulation will unavoidably deviate from data realisations. In the last quarter of 2016, imports experienced a slowdown linked to decreased activity in manufacturing (BoA, 2017a), which cannot be proxied by any explanatory variable in the model. These two deviations result in additional short-term volatility in the simulation of overall real GDP. Other than that, in-sample forecasts track closely the evolution of real GDP throughout the simulation horizon.

Financial sector indicators also replicate closely historical data. Nevertheless, specific moments in the simulation horizon stand out. The drop of TB-12 months yield in 2016 and 2018, as a result of Eurobond issuances (BoA, 2016a; and BoA, 2018) followed by a decreased public demand for domestic financing, is not captured within the model simulation. As short term fluctuations of government papers are not immediately transmitted to market interest rates, Lek bank lending rates' in-sample simulations approximate better the historical path. Simulated bank lending rates in euros have a flatter downward trajectory compared to actual data, reflecting the slower simulated drop of the NPL-rate in Euros. While the secular downward trend of the NPL rate in Euros is well captured, its acceleration from the last quarter of 2016 is not fully replicated. This path of NPLs is driven by a strong influence of the "Action plan for reducing non-performing loans"[8] in 2016, which started to intensify during the second-half of 2016 (BoA, 2016b). Since external judgement is not imposed on the forecast, macro-prudential policy interventions cannot be tracked without additional restrictions. The in-sample forecasts approximate correctly the trajectory of business credit stock variables.

The main indicators in the price formation block are well replicated throughout most of the simulation samples. There is however specific points in time where the in-sample simulation trajectories move away from actual historical paths. The initial average nominal wage simulations overestimate by a small margin

[8] *For more details see https://www.bankofalbania.org/Supervision/Action_plan_for_non-performing_loans/*

the actual evolution of the variable. The latter is a result of forecasts for higher labour productivity until end-2015 which feeds directly to higher minimum wage and thereafter average wages. Starting from 2016, the simulations replicate very closely actual data. Simulations on the path of domestic supply prices and import prices are very close to the indicators' actual trajectory. There is nevertheless some minor deviations. Domestic supply price simulations starting at the end of 2015 and early 2016 do not capture well the turning point of the actual trajectory of the variable after its sharp drop in the first quarter of 2016. In-sample simulations after this quarter replicate well the evolution of domestic supply prices. Import price simulations slightly overestimate the actual variable trajectory at the end of the last simulations covering the second half of 2017 and 2018. This period is characterised by both a fast appreciation of the currency and by increasing foreign prices. As these variables are exogenous to the model and simulations replicate well the evolution of import prices in normal times, the results of these in-sample simulations could potentially indicate the existence of non-linearities in the exchange-rate pass through in specific points in time, which cannot be captured by the model. The consumer price index path is replicated well by the in-sample simulations.

5.2 Simulation of conditional probability distributions around point forecasts ("fan-charts")

Probability distributions around central forecasts are effective in illustrating graphically the uncertainty in the intrinsic forecasting precision of the MEAM model. The first in-sample forecast in the previous section is extended to a longer horizon of 2015-2018 and 'fan charts' are constructed for the same set of indicators, with bands set at 1%, 30%, 60% and 90% (see Appendix D1 for the methodology used to populate the fan-charts). The graphical representations are shown in Appendix C2 graphs 20 to 22.

Real economy indicators result in general within 30%-60% of the probability density around the central forecast. The medium-term out-of-sample forecast for the household consumption variable is the most precise, with the uncertainty bands being the tightest

both in absolute terms, computed as a mean difference between the highest and lowest points in the uncertainty bands, and in relative terms, as a share of the actual variable outcomes for the period. The actual variable trajectory falls in general within a 60% confidence interval band. The medium-term forecast of the service exports displays the highest uncertainty in absolute terms, whereas the goods exports forecast the highest uncertainty in relative terms. The former tends to stabilise around a 60% confidence interval in the later forecast years, whilst the latter variable's forecast is more volatile and fluctuates across confidence bands. The actual historical values of real imports fall outside the fan-chart in the first year of the forecast, move to the lower 90% confidence interval band and the forecast performance stabilises thereafter. As discussed in the previous section, these are two unexpected adverse shocks that the model is unable to capture without imposing judgment. The forecast uncertainty of the GDP variable is a linear combination of the uncertainty of its components, while the confidence bands generally mimic the fan-chart of the households' consumption variable.

Financial market indicators results are generally similar to the real economy variables. Historical trajectories for the 2015-2018 period are on average within a 30%-60% probability distribution around the central forecast, with fluctuations across confidence bands more evident in the first year of projection. In the short-term, actual values fluctuate around the outer 90% confidence bands for the average bond yields and for the business credit interest rate in euros. Thereafter, the forecast precision improves and actual values for these variables stabilise within 30%-60% uncertainty bands. Actual values of the TB-12 months yield fall outside the lower 90% band of the fan-chart in 2016Q2, due to the Eurobond issuance. In the outer years, forecast uncertainty decreases and the actual trajectory of the TB-12 months yield fluctuates solely within the 30% and 60% confidence bands. In terms of precision, the average bond yield variable has the lowest uncertainty in relative terms whereas the TB-12 months yield has the highest. The NPLs in Lek variable is quite volatile and tends to fluctuate across upper and lower confidence bands of the fan-chart without falling outside the bands. Uncertainty around the NPLs in Euro generally falls within a 30%-60% confidence interval, bar the initial year of the out-of-

sample forecast where actual values move to the lower band of the fan-chart and off it for the last quarter of 2015. In terms of uncertainty, the NPLs in Lek forecast is more precise compared to the forecast of NPLs in Euros. The medium-term forecasts of the credit stock variables in levels are highly accurate and generally within a 30% confidence band for the whole sample.

Price formation block indicators' fluctuate on average within a 30%-60% probability distribution around the central forecast. Actual values of the average nominal wage and import prices in the short term fluctuate in the lower band of the 90% confidence interval. The forecast precision of average nominal wage improves thereafter stabilising within the 30% and 60% confidence bands. The out-of-sample forecasts of import prices continue to be volatile and fluctuate within the lower half of the fan-chart, within a confidence interval of 30%-90%. The domestic supply price forecast is more precise compared to the previous two indicators' out-of-sample forecasts and remains generally within the 30% confidence band, falling occasionally out of it. The consumer price index forecast has the highest precision and remains within a 30% confidence interval throughout the whole sample.

5.3 Probability distribution for estimates of calibrated parameters

As discussed in Chapter (3), a specific set of parameters is calibrated according to economic theory. In this section, we test the suitability of these parameters by comparing the calibrated parameters with estimated counterparts from the data by using a parametric bootstrapping technique (see Appendix D2). Through this method, an insight is obtained for the position of the calibration in the parameter space of their estimated counterpart and on the distance from the mean bootstrapped parameter estimates. The calibrated parameters in the model are the long run unit elasticities of: economic activity and capital costs in private investments and in eq (6); foreign demand in exports of goods and services eq (7) and eq (8); policy rate in TB-12 months; and TB-12 months yield in Lek lending rate.

The mean bootstrapped parameter estimates do not indicate major divergences from their calibrated counterparts (see Appendix C3, graph 23). Furthermore, the calibrations generally fall within a 60% area of the implied probability density surrounding the mean bootstrapped estimates.

In the private investment equation mean bootstrapped parameter estimates are close to the calibration. For the economic activity () the estimation is slightly above unity, precisely at 1.15. The bootstrapped estimates nevertheless yield a large number of outliers with the full sampling distribution falling within 0.7-2.7. The mean estimate for the capital cost () is -0.78 and the probability density falls within a -0.3 to -1.5 band.

Results for the mean bootstrapped foreign demand long-run elasticities are similar. The mean estimate for foreign demand in the goods equation () is 0.88 and for the services equation () is 0.91. The estimates in the second equation are slightly closer to the calibrated parameter, with the sampling distribution exhibiting a long tail due to a large number of outliers for parameters over 1.5.

Monetary policy transmission mechanism equations' estimates are more precise, with a tighter distribution around the mean. The mean parameter estimate for the elasticity of the policy rate to the TB-12 months is 0.84 and for the TB-12 months elasticity to lending rate in Lek is 0.88. The latter's mean estimate is comparatively more precise, with the probability distribution falling entirely within a 0.6-1.3 range.

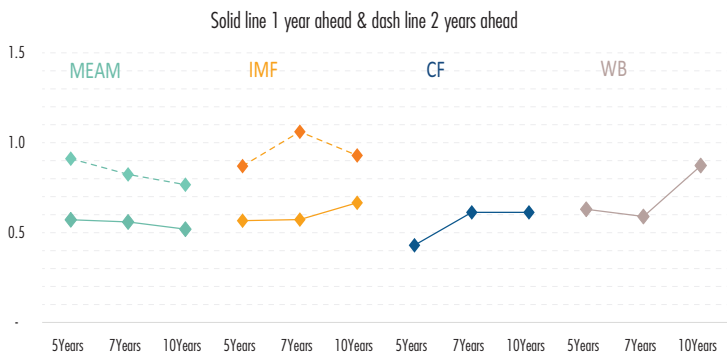
5.4 Comparative forecast error performance

As an additional diagnostic, this section introduces a comparative analysis of the MEAM's forecast errors vis-à-vis simple statistical models i.e., VAR (1), VAR (2) and random walk, for the GDP components, for the financial market indicators and for the price formation block. To make the comparative analysis complete, real GDP forecast errors of the MEAM model are compared to forecast errors of a range of international institutions that produce forecasts for Albania.

The 3 types of statistical models estimated use the same regressors and are estimated over the same sample as in the original behavioural equation of interest. Thereafter, 4 quarter and 8 quarter ahead rolling forecasts starting in 2015 and ending in 2018 are produced. Next, the forecast performance of the MEAM model is compared with that of the statistical models. We use a MAPE (mean absolute percentage error) and an MPE (mean percentage error) statistical measures to compare the size of the error and the bias for variables in levels, and a MAE (mean absolute error) and an ME (mean error) for errors of variables expressed in per cent (Stock & Watson, 2003). The results for the real economy, financial market and price formation indicators are shown in Appendix C4, tables C1 to C3.

The MEAM model's 4 and 8 quarter ahead forecasts of real economy indicators have a better accuracy compared to statistical models' forecasts, with the exception of exports of services. The largest forecast errors across all models are yielded by the exports of goods equations, concentrated mainly in the initial samples of the rolling forecasts. However, the forecast performance of the MEAM for this variable improves at longer horizon forecasts. Additionally, exports of goods have the highest upward bias in general. Amongst all the components of GDP, household consumption forecast errors are by far the smallest in the MEAM model.

GRAPH 16. Mean absolute error for gdp growth rate. Variables are in percentage points.



The MEAM's financial market indicators' forecast performance is superior to simple statistical models and performance has a stronger tendency to improve for longer horizon forecasts when compared to the real economy subset. The results for lending rate indicators are more nuanced between the two currencies. For the lending rate in Lek, the MEAM model has the smallest MAE for 8 quarter ahead forecasts but for the rest of the metrics, statistical models perform better. For the lending rate in Euros, the MEAM model has the lowest ME for 4 and 8 quarter ahead forecasts but that these errors are slightly more biased than the VAR (1) forecast errors. For the average bond yield indicator, forecast errors are both the smallest and the less biased in this group of indicators. The 4 and 8 quarter ahead forecast errors of the NPLs in Lek and Euros and those of the business credit in Lek to GDP from the MEAM model are by far the smallest and less biased. For all these indicators, the forecast performance improves in longer horizon forecasts while results on error bias are more mixed. Forecast accuracy of the business credit in Lek to GDP indicator is the best within this group.

The 4 and 8 quarter ahead forecasts of the main indicators in the price formation block generated by the MEAM model are more accurate when compared to statistical models' forecasts. The largest forecast errors across all models are yielded by the average nominal wage, present generally in the first samples of the simulations used to obtain forecast errors. The forecast performance of the MEAM for this variable and for domestic supply prices improves at longer horizon forecasts. This is not the case for the import prices and consumer price index forecast accuracy. Regardless, the forecast accuracy for this two variables outperforms by a considerable margin the forecast accuracy of the statistical models.

To complete the forecast error performance comparative analysis, real GDP growth forecasts of the MEAM model are compared to the forecasts of the International Monetary Fund (IMF), the average of private analysts surveyed by Consensus Economics, and the World Bank (WB). Graph 21 reports the MAE for real GDP growth over a 5, 7 and 10 year period starting from 2010 and ending in 2019. Errors are computed for the current year and for one year-ahead forecasts (taking the spring projections for IMF; April projection

for MEAM and CF, and for WB we use the forecasts released at about the same period). Overall, the MEAM real GDP growth projections are on average more accurate, although in many cases this difference is not statistically significant.

6. CONCLUSIONS

The model is used to conduct full medium-term forecasts. The forecast is based on a scenario simulated with the model within a pre-defined and realistic horizon and conditional on a set of assumptions for the fiscal sector, foreign sector, exchange rate and monetary policy rate. Of course, often the forecasts are subject of external judgment. This is especially the case when certain economic interlinks are not specified explicitly between the variables, or when the economy is in a crisis situation, like the latest Covid-19 pandemic induced crisis. Additional regular uses of the model are: (i) quantifying the macroeconomic impact of macroeconomic policies, in most cases in conjunction with other econometric tools at disposal (an illustration of the estimation of a policy change's macroeconomic impact is the increase of public wages by 10% in 2017); (ii) running alternative and risk scenarios during every official forecast round (i.e., alternative paths of exchange rate and monetary policy, and credit growth, as well as introducing shocks due to political elections, oil prices, foreign direct investments, etc.); (iii) aiding the process of implementing stress-test scenarios for financial stability purposes; (iv) counterfactual analysis, under which a hypothetical reality is assumed that underlines what the outcome would have been if the event would not have occurred (i.e., estimating the investment needs of the country to recoup the capital loss due to the earthquake of November 2019[9]).

By adding the financial block, and a more detailed price-wage formation block we have provided a more comprehensive transmission mechanism of the model to help a better use of the model. Additional work is needed to detail further the structure of the model in the financial block by including household credit. This would necessitate specific equations to capture the behaviour of mortgage credit and of consumer credit, in order to ensure the MEAM model incorporates fully private sector credit and its interlinkages with the aggregate demand components.

[9] *The official assessment for the losses from the earthquake was officially estimated through a collaboration of domestic and international institutions and published as a working document by the EC (2020) for the international donors' conference, "Together for Albania", organised by the European Union.*

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APPENDIX A: ESTIMATES OF THE MAIN EQUATIONS

Tabla A.1 Model Elasticities Parameters

		CONHH	GFCFP	EXPG	EXPS	IMP	LD	WMIN	W	DSP	PIMP
Adjustment speed		0.22***	0.26***	0.18**	0.12***	0.65***	0.37***			0.22***	0.27***
Autoregresive component								-0.49***	-0.38***		
Trend		0.001*		0.005*			-0.01*				
ALLEUR											0.91*
B12	(')	-0.23*									
COMNESS	(')			0.51**	0.53*						
CPI								1.00c			
DI		0.84***									
FDEM				1.00c	1.00c						
GDP			1.00c								
GDP gap	(')									0.48***	
GDP/CS							0.46**				
IPOND			1.00c								
IMPDEM						1.01***					
L_P								0.26*	1.15**		
LDDEM							0.68***				
PEXPEU											0.52*
POIL	(')		-0.07*	0.42***						0.04***	
PREL	(')					-0.36***					
SSQP			-0.83***								
ULC										0.16**	
UN gap	(')							-1.19*			
W							-0.74***				
WMIN									1.00c		
Adj - R2		0.29	0.44	0.19	0.47	0.74	0.62	0.54	0.08	0.20	0.12

(') Short run elasticities

c calibrated parameter

Regressor significance: *** at 99%; ** at 95%; * at 90%

Table A.2 List of Model Indicators

Acronym	Variable name
ALLEUR	Nominal ALL-Euro exchange rate
B12	Nominal 12-month treasury bond rate
COMNESS	Competitiveness term
CONHH	Household consumption
CPI	Consumer price index
DI	Real disposable income
DSP	Domestic supply prices index
EXPG	Real exports of goods
EXPS	Real exports of services
FDEM	Foreign demand index
GDP	Real gross domestic product
GDP gap	Output gap
GDP/CS	Capital productivity
GFCFP	Real private gross fixed capital formation
IMP	Real imports of goods and services
PIMP	Import deflator index
IMPDEM	Import demand indicator
IPOND	Real composite interest rate of credit interest rate and yield of goverment papers
L_P	Labor productivity
LD	Labor demand
LDDEM	Labor demand indicator
PEXPEU	Foreign prices index
POIL	Oil price index
PREL	Relative price index
SSQP	Square meters per capita
ULC	Unit labour cost index
UN gap	Unemployment gap
W	Real wage
WMIN	Minumum wage

APPENDIX B: MODEL RESPONSES TO VARIOUS SHOCKS

Table B1. Model elasticities: monetary policy shock (1pp)

		1	2	3	4	5	6	7	8	9	10
GDP	(1)	-0.04	-0.10	-0.19	-0.21	-0.19	-0.14	-0.11	-0.10	-0.10	-0.12
Household consumption	(1)	-0.09	-0.12	-0.15	-0.19	-0.22	-0.21	-0.19	-0.16	-0.13	-0.12
Gross fixed investment	(1)	-0.02	-0.26	-0.60	-0.71	-0.63	-0.56	-0.45	-0.39	-0.46	-0.49
Exports (goods and services)	(1)	0.00	0.01	0.03	0.06	0.08	0.08	0.08	0.04	0.05	0.04
Imports (goods and services)	(1)	-0.06	-0.15	-0.27	-0.32	-0.32	-0.31	-0.28	-0.25	-0.22	-0.21
CPI	(1)	-0.06	-0.15	-0.27	-0.32	-0.32	-0.31	-0.28	-0.25	-0.22	-0.21
Import deflator	(1)	0.00	-0.02	-0.06	-0.12	-0.15	-0.16	-0.14	-0.10	-0.07	-0.04
Export deflator	(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic supply prices index	(1)	0.00	-0.01	-0.04	-0.07	-0.11	-0.12	-0.11	-0.09	-0.06	-0.04
Gross employee compensation	(1)	0.00	-0.01	-0.07	-0.18	-0.30	-0.36	-0.33	-0.24	-0.16	-0.11
Unit labour cost	(1)	0.01	0.03	0.00	-0.10	-0.21	-0.25	-0.19	-0.09	-0.01	0.03
Competitiveness	(1)	0.00	0.01	0.04	0.08	0.11	0.12	0.11	0.09	0.06	0.04
Trade balance (% of GDP)	(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total employment	(1)	-0.01	-0.05	-0.10	-0.12	-0.09	-0.02	0.04	0.06	0.05	0.03
Unemplyoment rate	(2)	0.01	0.04	0.08	0.10	0.07	0.02	-0.03	-0.05	-0.04	-0.02

(1) Percentage deviation from the baseline.

(2) Absolute deviation from the baseline.

Table B2. Model elasticities: foreign demand shock (1%)

		1	2	3	4	5	6	7	8	9	10
GDP	(1)	0.04	0.14	0.22	0.24	0.24	0.22	0.19	0.17	0.18	0.18
Household consumption	(1)	0.01	0.06	0.14	0.20	0.24	0.25	0.26	0.25	0.24	0.23
Gross fixed investment	(1)	0.01	0.10	0.21	0.26	0.22	0.17	0.10	0.03	0.05	0.09
Exports (goods and services)	(1)	0.41	0.92	1.02	0.94	0.88	0.87	0.84	0.88	0.82	0.80
Imports (goods and services)	(1)	0.09	0.21	0.32	0.37	0.42	0.46	0.45	0.45	0.46	0.46
CPI	(1)	0.09	0.21	0.32	0.37	0.42	0.46	0.45	0.45	0.46	0.46
Import deflator	(1)	0.00	0.03	0.08	0.15	0.21	0.25	0.26	0.25	0.24	0.23
Export deflator	(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic supply prices index	(1)	0.00	0.01	0.05	0.10	0.15	0.18	0.21	0.20	0.20	0.20
Gross employee compensation	(1)	0.00	0.00	0.06	0.21	0.39	0.47	0.49	0.49	0.47	0.42
Unit labour cost	(1)	-0.01	-0.05	-0.03	0.12	0.30	0.36	0.34	0.34	0.32	0.25
Competitiveness	(1)	0.00	-0.01	-0.05	-0.10	-0.15	-0.18	-0.21	-0.20	-0.20	-0.20
Trade balance (% of GDP)	(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total employment	(1)	0.00	0.04	0.12	0.16	0.13	0.07	0.04	0.02	0.00	0.01
Unemplyoment rate	(2)	0.00	-0.03	-0.10	-0.14	-0.11	-0.06	-0.04	-0.02	0.00	-0.01

(1) Percentage deviation from the baseline.

(2) Absolute deviation from the baseline.

Table B3. Model elasticities: exchange rate shock (depreciation 1%)

		1	2	3	4	5	6	7	8	9	10
GDP	(1)	0.10	0.18	0.19	0.16	0.16	0.16	0.14	0.09	0.12	0.14
Household consumption	(1)	0.04	0.08	0.09	0.09	0.10	0.09	0.09	0.07	0.05	0.05
Gross fixed investment	(1)	0.04	0.26	0.28	0.16	0.08	0.07	-0.01	-0.08	-0.05	0.00
Exports (goods and services)	(1)	0.74	0.45	0.02	-0.03	0.09	0.13	0.21	0.18	0.31	0.37
Imports (goods and services)	(1)	0.14	0.03	-0.15	-0.21	-0.17	-0.14	-0.14	-0.17	-0.13	-0.11
CPI	(1)	0.14	0.03	-0.15	-0.21	-0.17	-0.14	-0.14	-0.17	-0.13	-0.11
Import deflator	(1)	0.08	0.24	0.39	0.49	0.54	0.57	0.58	0.57	0.56	0.56
Export deflator	(1)	0.45	0.75	0.86	0.90	0.91	0.91	0.91	0.91	0.91	0.91
Domestic supply prices index	(1)	0.05	0.21	0.37	0.49	0.56	0.60	0.62	0.63	0.61	0.61
Gross employee compensation	(1)	0.00	0.03	0.32	0.68	0.77	0.70	0.72	0.79	0.77	0.68
Unit labour cost	(1)	-0.02	-0.02	0.29	0.66	0.64	0.46	0.48	0.59	0.55	0.43
Competitiveness	(1)	0.95	0.79	0.63	0.51	0.44	0.39	0.38	0.37	0.39	0.39
Trade balance (% of GDP)	(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total employment	(1)	0.02	0.15	0.21	0.06	-0.09	-0.10	-0.06	-0.10	-0.15	-0.12
Unemplyoment rate	(2)	-0.02	-0.12	-0.17	-0.05	0.08	0.08	0.05	0.09	0.13	0.10

(1) Percentage deviation from the baseline.

(2) Absolute deviation from the baseline.

Table B4. Model elasticities: public consumption shock (1% of GDP)

		1	2	3	4	5	6	7	8	9	10
GDP	(1)	0.86	1.58	1.81	1.59	1.31	0.97	0.82	0.83	0.83	0.81
Household consumption	(1)	0.12	0.63	1.11	1.39	1.54	1.47	1.41	1.33	1.22	1.17
Gross fixed investment	(1)	0.22	1.62	2.08	1.66	1.10	0.58	0.03	-0.06	0.22	0.28
Exports (goods and services)	(1)	-0.01	-0.21	-0.53	-0.74	-0.88	-0.76	-0.83	-0.53	-0.87	-0.97
Imports (goods and services)	(1)	0.53	1.20	1.54	1.77	1.87	1.88	1.82	1.77	1.58	1.45
CPI	(1)	0.53	1.20	1.54	1.77	1.87	1.88	1.82	1.77	1.58	1.45
Import deflator	(1)	0.06	0.47	1.02	1.49	1.74	1.74	1.56	1.37	1.24	1.15
Export deflator	(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic supply prices index	(1)	0.02	0.26	0.63	1.00	1.28	1.34	1.29	1.14	1.07	1.01
Gross employee compensation	(1)	0.00	0.07	1.30	3.08	3.75	3.44	3.13	2.86	2.52	2.29
Unit labour cost	(1)	-0.22	-0.56	0.74	2.79	3.22	2.62	2.30	2.06	1.74	1.58
Competitiveness	(1)	-0.02	-0.26	-0.63	-0.99	-1.26	-1.32	-1.27	-1.13	-1.06	-1.00
Trade balance (% of GDP)	(2)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Total employment	(1)	0.09	0.96	1.62	1.18	0.43	0.15	0.07	0.05	0.10	0.19
Unemplyoment rate	(2)	-0.07	-0.80	-1.37	-1.00	-0.37	-0.13	-0.06	-0.04	-0.08	-0.16

(1) Percentage deviation from the baseline.

(2) Absolute deviation from the baseline.

Table B5. Model elasticities: public investment shock (1% of GDP)

		1	2	3	4	5	6	7	8	9	10
GDP	(1)	0.37	0.82	1.03	0.98	0.93	0.82	0.87	0.94	1.00	1.02
Household consumption	(1)	0.09	0.43	0.73	0.92	1.04	1.02	1.01	1.00	0.97	0.97
Gross fixed investment	(1)	2.04	3.34	3.55	3.42	3.22	3.24	3.44	3.51	4.10	4.08
Exports (goods and services)	(1)	0.00	-0.08	-0.21	-0.30	-0.35	-0.29	-0.30	-0.17	-0.28	-0.29
Imports (goods and services)	(1)	0.70	1.21	1.47	1.60	1.65	1.66	1.71	1.71	1.63	1.57
CPI	(1)	0.70	1.21	1.47	1.60	1.65	1.66	1.71	1.71	1.63	1.57
Import deflator	(1)	0.02	0.18	0.41	0.59	0.68	0.65	0.56	0.46	0.39	0.33
Export deflator	(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic supply prices index	(1)	0.01	0.10	0.25	0.40	0.50	0.51	0.47	0.39	0.35	0.30
Gross employee compensation	(1)	0.00	0.03	0.48	1.21	1.57	1.45	1.26	1.12	0.99	0.90
Unit labour cost	(1)	-0.09	-0.32	0.00	0.75	0.96	0.66	0.37	0.16	-0.02	-0.16
Competitiveness	(1)	-0.01	-0.10	-0.25	-0.40	-0.50	-0.51	-0.47	-0.39	-0.34	-0.30
Trade balance (% of GDP)	(2)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Total employment	(1)	0.03	0.31	0.58	0.45	0.12	-0.04	-0.08	-0.08	-0.06	-0.04
Unemplyoment rate	(2)	-0.03	-0.26	-0.49	-0.38	-0.10	0.04	0.07	0.07	0.05	0.03

(1) Percentage deviation from the baseline.

(2) Absolute deviation from the baseline.

Table B6. Model elasticities: transfers to households shock (1% of GDP)

		1	2	3	4	5	6	7	8	9	10
GDP	(1)	0.06	0.29	0.50	0.59	0.62	0.54	0.51	0.48	0.43	0.38
Household consumption	(1)	0.14	0.57	0.88	1.12	1.30	1.36	1.43	1.45	1.40	1.37
Gross fixed investment	(1)	0.01	0.18	0.47	0.62	0.58	0.47	0.25	0.13	0.17	0.13
Exports (goods and services)	(1)	0.00	-0.02	-0.08	-0.17	-0.27	-0.30	-0.39	-0.31	-0.48	-0.52
Imports (goods and services)	(1)	0.10	0.40	0.64	0.83	0.94	1.01	1.08	1.10	1.04	0.98
CPI	(1)	0.10	0.40	0.64	0.83	0.94	1.01	1.08	1.10	1.04	0.98
Import deflator	(1)	0.00	0.05	0.17	0.34	0.50	0.61	0.66	0.67	0.65	0.61
Export deflator	(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic supply prices index	(1)	0.00	0.02	0.10	0.21	0.35	0.44	0.51	0.52	0.54	0.53
Gross employee compensation	(1)	0.00	0.00	0.11	0.50	0.96	1.22	1.32	1.32	1.31	1.27
Unit labour cost	(1)	-0.01	-0.09	-0.05	0.35	0.80	1.01	1.05	1.01	1.01	0.97
Competitiveness	(1)	0.00	-0.02	-0.10	-0.21	-0.34	-0.44	-0.51	-0.52	-0.54	-0.53
Trade balance (% of GDP)	(2)	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01
Total employment	(1)	0.00	0.10	0.33	0.46	0.41	0.29	0.20	0.16	0.13	0.09
Unemplyoment rate	(2)	0.00	-0.09	-0.28	-0.39	-0.35	-0.25	-0.17	-0.14	-0.11	-0.08

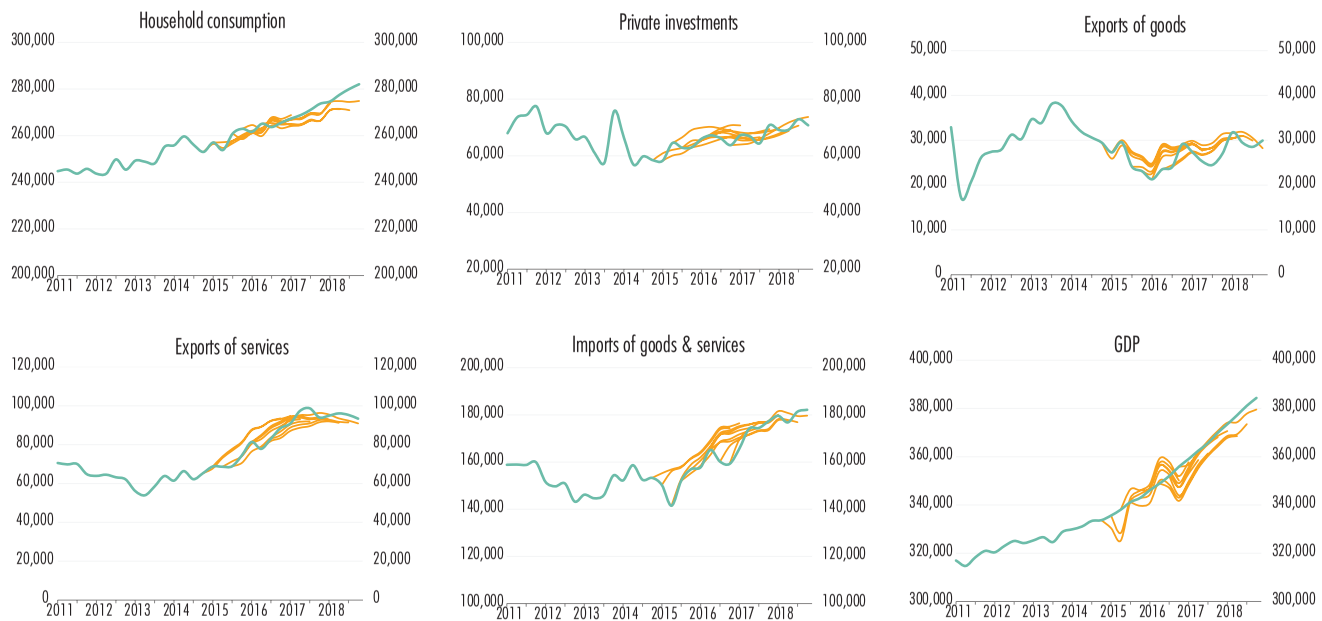
(1) Percentage deviation from the baseline.

(2) Absolute deviation from the baseline.

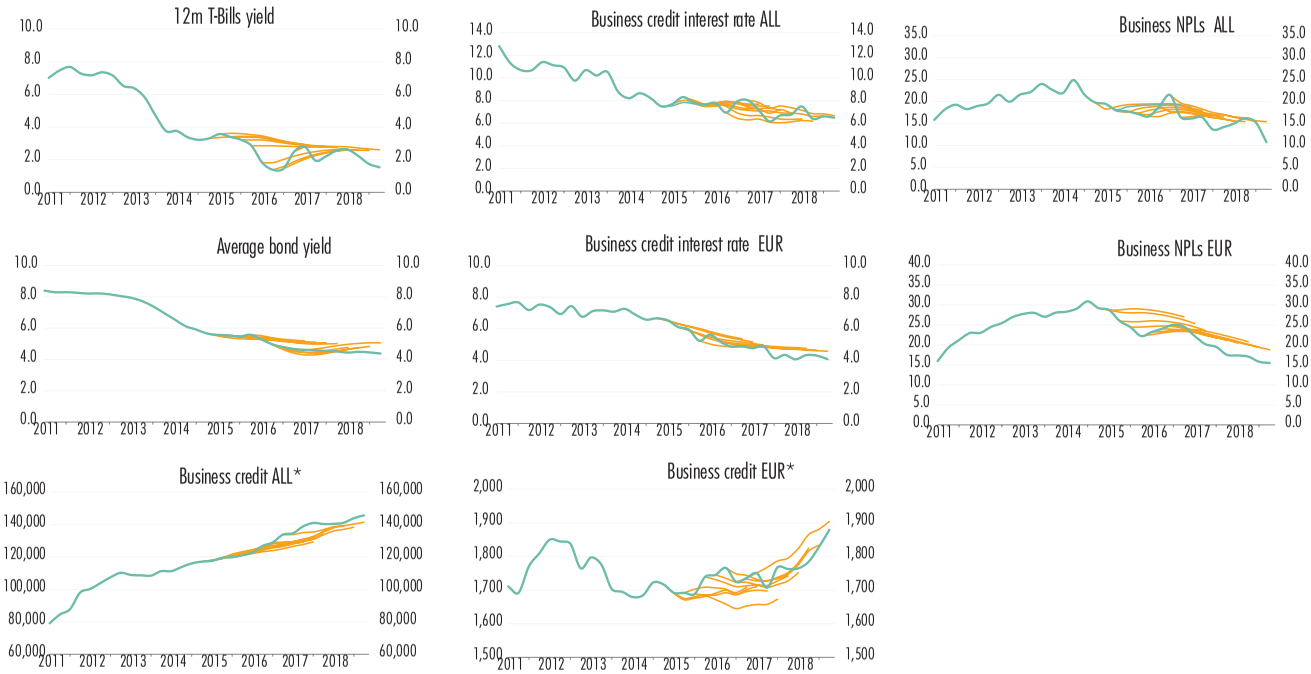
APPENDIX C: MODEL DIAGNOSTICS

C1. In-sample simulations

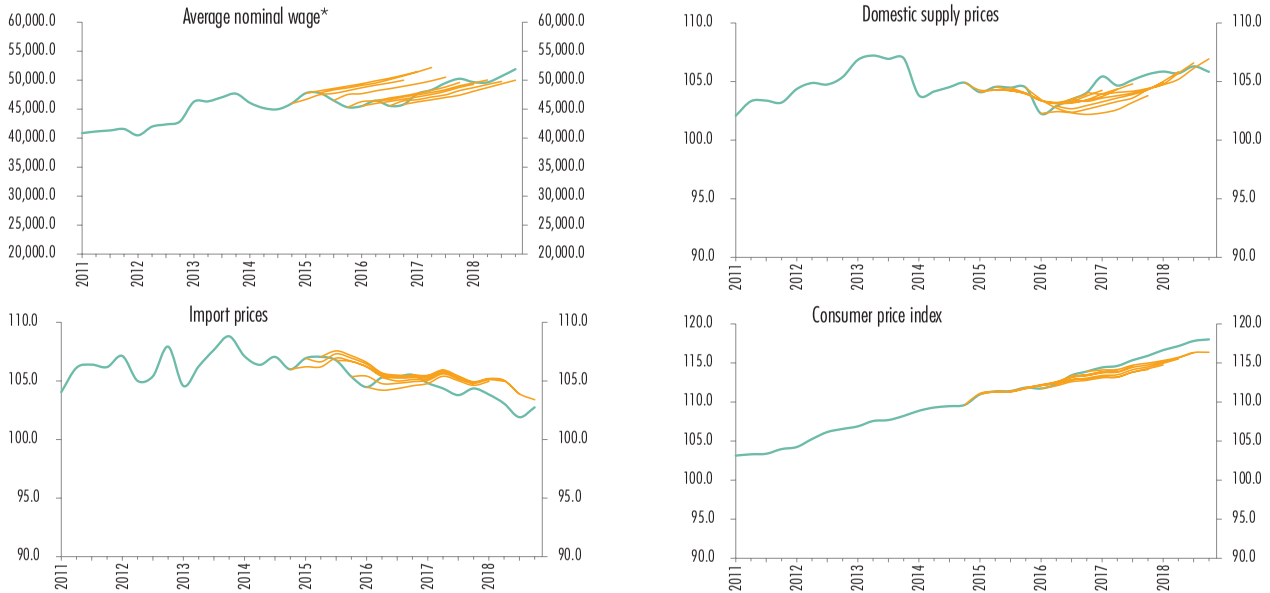
Graph 17. Model results vs actual data: real economy block. Variables are in million Lek.



Graph 18. Model results vs actual data: financial sector block. Variables are in per cent rate, (*) variables are in million Lek.



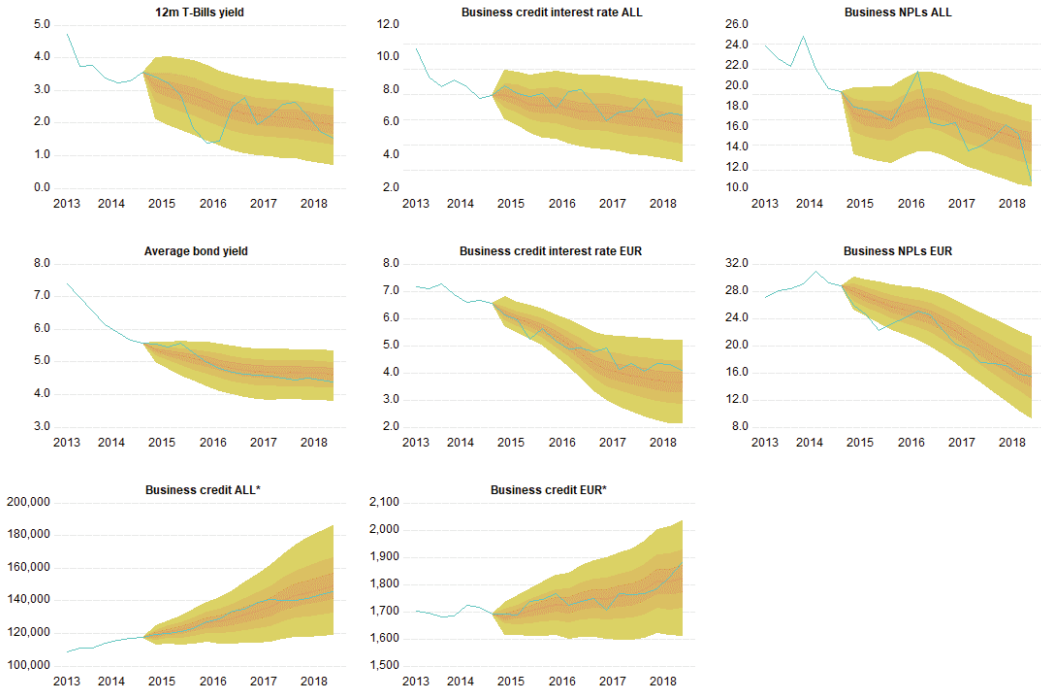
Graph 19. Model results vs actual data: price formation block. Variables are in index, (*) variable is in Lek.



C2. Fan-charts around point forecasts

Graph 20. Fan_charts around point forecast: real economy block. Variables are in million Lek.

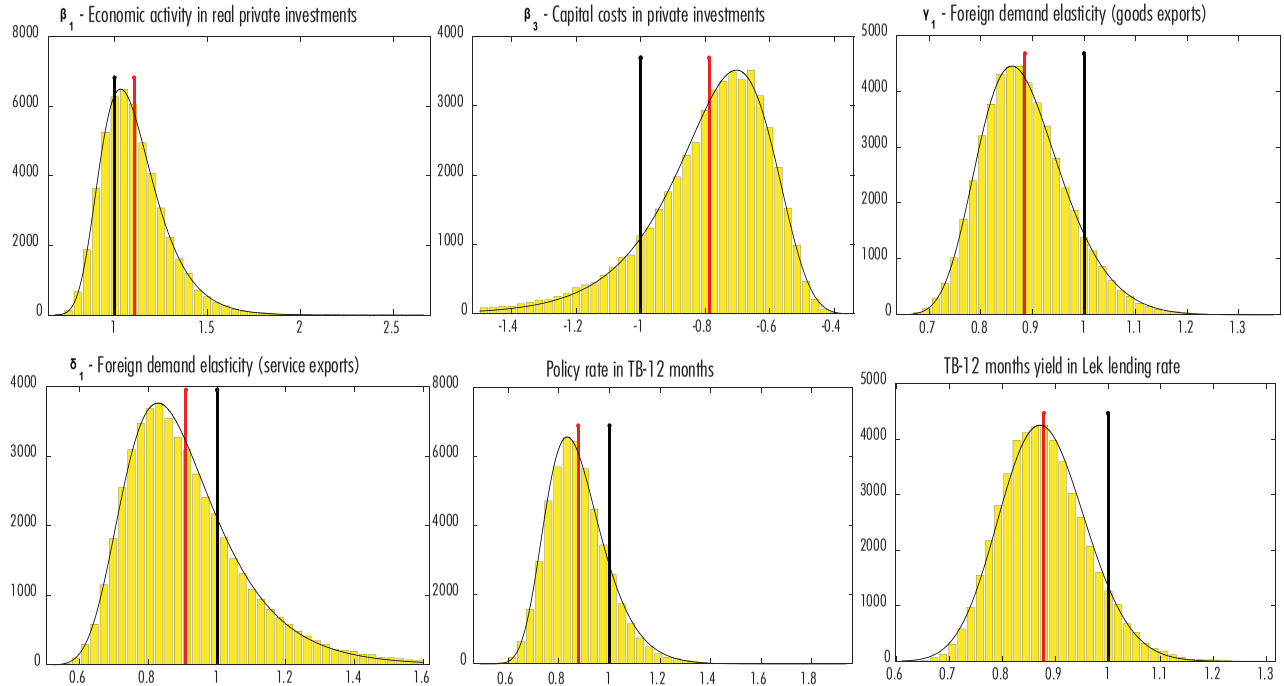
Graph 21. Fan_charts around point forecast: financial sector block. Variables are in per cent rate, (*) variables are in million Lek.



Graph 22. Fan_charts around point forecast: price formation block. Variables are in index, (*) variable is in Lek.

C3. Probability distribution for estimates of calibrated parameters

Graph 23. Probability distribution for estimates of calibrated parameters. Parameter estimate mean red stem, calibrated parameter black stem.



C4. Comparative forecast error performance

Table C1. Forecast performance: real economy indicators

		MEAM		VAR-1LAG	VAR-2 LAGS		RANDOM WALK	
HOUSEHOLD CONSUMPTION								
Mape	(1)	1.09	*	1.66	2.00		1.75	
Mae	(1)	-0.98	*	1.66	2.00		1.75	
Mape	(2)	1.43	*	3.56	4.08		3.72	
Mae	(2)	-1.27	*	3.56	4.08		3.72	
GROSS FIXED PRIVATE INVESTMENT								
Mape	(1)	2.78	*	12.00	3.90		3.95	
Mae	(1)	1.03	*	5.44	-1.20		-1.98	
Mape	(2)	3.08	*	23.41	3.47		3.64	
Mae	(2)	1.81	*	17.84	-2.85		-2.50	
EXPORTS OF GOODS								
Mape	(1)	9.85	*	14.29	17.03		16.67	
Mae	(1)	7.47	*	13.55	17.03		13.57	
Mape	(2)	7.36	*	25.38	29.98		23.36	
Mae	(2)	4.65	*	25.38	29.98		20.87	
EXPORTS OF SERVICES								
Mape	(1)	4.41	*	7.10	4.14		7.45	
Mae	(1)	0.62		4.54	2.06		0.08	*
Mape	(2)	3.95		11.26	3.69	*	8.27	
Mae	(2)	-1.78	*	7.80	2.09		-2.60	
IMPORTS OF GOODS & SERVICES								
Mape	(1)	2.85	*	5.33	5.18		3.94	
Mae	(1)	1.95	*	-4.42	-4.17		2.88	
Mape	(2)	2.30	*	9.46	9.00		5.97	
Mae	(2)	1.42	*	-8.34	-7.69		5.51	

(1) Percentage deviation from actual data 4 quarters ahead.

(2) Percentage deviation from actual data 8 quarters ahead.

(*) Best forecast performance.

Table C2. Forecast performance: financial market indicators

		MEAM		VAR-1LAG		VAR-2 LAGS		RANDOM WALK	
TB-12 MONTHS YIELD									
Mae	(1)	0.72	*	0.88		0.86		0.87	
Me	(1)	0.65		-0.24	*	-0.26		-0.25	
Mae	(2)	0.52	*	1.06		1.04		1.01	
Me	(2)	0.52	*	-1.02		-1.01		-1.00	
AVERAGE BOND YIELD									
Mae	(1)	0.19	*	0.29		0.28		0.36	
Me	(1)	0.05	*	-0.07		-0.06		-0.11	
Mae	(2)	0.21	*	0.46		0.41		0.63	
Me	(2)	0.09	*	-0.20		-0.20		-0.29	
LENDING RATE (ALL)									
Mae	(1)	0.54		0.60		0.44	*	0.53	
Me	(1)	-0.26		-0.09		-0.02	*	-0.10	
Mae	(2)	0.45	*	0.69		0.51		0.54	
Me	(2)	-0.24		-0.07		0.07		-0.01	*
LENDING RATE (EUR)									
Mae	(1)	0.23	*	0.33		0.34		0.35	
Me	(1)	0.20		0.12	*	0.13		0.24	
Mae	(2)	0.28	*	0.44		0.44		0.48	
Me	(2)	0.24		0.17	*	0.18		0.41	
NPLs RATE (ALL)									
Mae	(1)	1.81	*	2.14		1.89		2.73	
Me	(1)	-0.16	*	-1.48		-0.92		2.13	
Mae	(2)	1.56	*	1.98		1.65		5.01	
Me	(2)	-0.50	*	-1.98		-0.87		5.01	
NPLs RATE (EUR)									
Mae	(1)	2.05	*	2.93		2.90		4.05	
Me	(1)	1.06	*	2.37		1.80		3.57	
Mae	(2)	1.22	*	6.63		5.85		7.71	
Me	(2)	1.06	*	6.63		5.85		7.71	
CREDIT TO GDP (ALL)									
Mae	(1)	0.20	*	0.32		0.31		0.32	
Me	(1)	0.04	*	0.25		0.21		0.26	
Mae	(2)	0.15	*	0.45		0.41		0.45	
Me	(2)	0.06	*	0.45		0.37		0.45	

(1) Percentage deviation from actual data 4 quarters ahead.

(2) Percentage deviation from actual data 8 quarters ahead.

(*) Best forecast performance.

Table C3. Forecast performance: financial market dicators: price formation indicators

		MEAM	VAR-1LAG	VAR-2 LAGS	RANDOM WALK
AVERAGE NOMINAL WAGE					
Mape	(1)	4.37 *	5.12	5.19	5.66
Mae	(1)	2.30 *	4.42	4.58	5.33
Mape	(2)	3.94 *	7.22	7.41	8.84
Mae	(2)	2.27 *	7.22	7.41	8.84
DOMESTIC SUPPLY PRICES					
Mape	(1)	0.92 *	1.09	1.07	1.21
Mae	(1)	-0.44	-0.21 *	-0.22	0.56
Mape	(2)	0.62 *	1.39	1.38	1.20
Mae	(2)	-0.11 *	-1.20	-1.22	0.52
IMPORT PRICES					
Mape	(1)	0.92 *	2.38	2.30	2.50
Mae	(1)	0.82 *	2.38	2.30	2.50
Mape	(2)	1.07 *	4.52	4.46	4.70
Mae	(2)	1.02 *	4.52	4.46	4.70
CONSUMER PRICE INDEX					
Mape	(1)	0.70 *	1.05	0.84	0.70
Mae	(1)	-0.60 *	1.05	0.84	0.70
Mape	(2)	0.93 *	2.09	1.68	1.36
Mae	(2)	-0.93 *	2.09	1.68	1.36

(1) Percentage deviation from actual data 4 quarters ahead.

(2) Percentage deviation from actual data 8 quarters ahead.

(*) Best forecast performance.

APPENDIX D: PARAMETER DISTRIBUTION AND CONDITIONAL PROBABILITY DISTRIBUTIONS

D1. Conditional probability distributions around point forecasts

The construction of conditional probability distributions around central forecasts for specific indicators in the MEAM model and their graphical representation within a pre-specified time horizon is an effective exercise in illustrating the uncertainty in the intrinsic forecasting precision of the model. This form of simulation is distinct from the in-sample approach in concept and application, whereby the forecast horizon is of a longer time span and the objective is the uncertainty surrounding the forecast. The graphical representation of uncertainty is done through "fan-charts", which is an effective way in giving form not only to the size of uncertainty, but also to the density of implicit internal layers at specific intervals.

The unique solution of the MEAM model ends in 2014 and thereafter conditional probability distributions of the central forecast are constructed for the next 4 years, until the last quarter of 2018. Technically, out-of-sample conditional forecasts are generated for each endogenous variable of interest, where the trajectory of exogenous variables is known for the whole forecast horizon. Since the actual path of the endogenous variable throughout the forecast horizon is known, we plot the latter to compare it to the full range of the conditional probability distribution of the forecast represented through the fan-chart.

To populate the fan-chart, we draw from the conditional distribution of the errors within the solution sample using a bootstrapping technique (Efron & Tibshirani (1986); Efron & Tibshirani (1993); Sims & Zha (1995)). There are several advantages to this technique. Firstly, the technique is widely applicable under a wide range of settings. Furthermore, there is no need to restrict the sampling algorithm to a specific theoretical distribution but rather one can infer from the actual sampling distribution of the existing data generation process, in this case the intrinsic process that generates the errors

for each behavioural equation in the full MEAM model (Davison & Hinkley (1997)). Thirdly, through this form of bootstrap, a sufficient number of random draws with an equal length to the actual object of the resampling technique can be carried out by drawing with replacement from the sample of errors (Lahiri (2003)). In practice, these two conditions imply that there is a probability that any single value of the actual error can be drawn several times within the same bootstrap sample. Furthermore, in constructing the fan-charts, we do not impose any restrictions on the bootstrap to resample a specific parameter of interest. 20000 bootstraps are conducted in order to allow for the algorithm to converge and to minimise the overall relevance of outliers in the conditional distribution (Bianchi (1995); Antal & Tille (2011)). Bands of the "fan-charts" are set at 1%, 30%, 60% and 90% of the probability distribution around the central forecast.

D2. Parameter distribution methodology

In this exercise, we use a parametric bootstrapping technique with replacement to resample the mean and the standard deviation of each series conditional on the actual data (Hansen (1999); Davison, Hinkley & Young (2003)). The sampling distribution around the mean here is a theoretical construct best suited to fit the parameter estimates of each bootstrapped VECM. In general, we use a generalized extreme value distribution to account for outliers and long tails in the distribution of the bootstrapped parameter estimates (Bali (2003)). The only exception is the "β" parameter, the T-Bills yield elasticity to business credit interest rate in Lek, where we use a gamma distribution.

The final aim is to construct 50000 VECM replicates of the original equations with a calibrated parameter in the long-run relationship and, to generate as many values for the estimate of the calibrated parameter by using the same sample length as in the original VECM.

To generate the resampled vectors that will construct the VECM replicates of the original equations, we first bootstrap the mean and

the standard deviation of each variable and create two vectors of 50000 rows, one for the bootstrapped sample of the mean of each variable and one for the standard deviation. Then, we generate a large array of 50000 columns, with rows equal to the length of the original sample size. We do this by rescaling every data point in the series with the share of the bootstrapped mean to the original variable mean and by adding the share of the bootstrapped standard deviation vector to the original multiplied by the actual series (Benes and Vavra (2004); Christiano, Trabandt and Walentin (2004), Levin and Piger (2004)).

$$(17) \qquad B_{\bar{x}}^{(i)} = \left(\sum_{j=1}^{N} b\,(\bar{x})^{(i)}\right) / \bar{x}^{(i)}$$

$$(18) \qquad B_{\sigma}^{(i)} = \left(\sum_{j=1}^{N} b\,(\sigma)^{(i)}\right) / \sigma^{(i)}$$

$$(19) \qquad A_{(t,50000)}^{(i)} = b_t^{(i)} \odot \sum_{j=1}^{N} B'^{(i)}_{\bar{x}} + b_t^{(i)} \odot \left(1 - \sum_{j=1}^{N} B'^{(i)}_{\sigma}\right)$$

Where for each variable $b\,(\bar{x})^{(i)}$ is the bootstrapped mean; $b\,(\sigma)^{(i)}$ the bootstrapped standard deviation; $\bar{x}^{(i)}$ the sample mean; $\sigma^{(i)}$ the sample standard deviation, $A_{(t,50000)}^{(i)}$ is the final bootstrapped array for each variable.

Since variables are nonstationary the only way to generate full bootstrapped samples is to rescale each original data point through a Hadamard product of a large transposed vector of shares to the mean in order to ensure that the resampled array is again nonstationary and has a shape broadly similar to the original variable (Dehay, Dudek and Leskow (2014); Moniz, Branco and Torgo (2017)). Finally, we estimate each VECM and obtain a large set of parameters for each equation of interest, each with its implicit distribution in parameter space.

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