

Branko Urošević*
Nikola Grga**

APPLICATION OF DYNAMIC STOCHASTIC GENERAL EQUILIBRIUM MODELS TO THE CASE OF THE SERBIAN ECONOMY***

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ABSTRACT: *This paper proposes a dynamic stochastic general equilibrium (DSGE) model for the Serbian economy. It is a modification of the existing models of Goodhart, Osorio and Tsomocos (2009) and Martinez and Tsomocos (2012). The model introduces important features of the Serbian economy, financial dollarization and foreign ownership of the banking system, while retaining the most important element of the reference models, financial friction. To solve the model we use Dynare, a specialized Matlab program for solving*

DSGE models. The model is subject to three different shocks: monetary, productivity, and regulatory, and the results are presented in the form of impulse response functions. It is concluded that the proposed platform has good characteristics, but its complete application to the case of the Serbian economy requires further research.

KEY WORDS: *DSGE model, financial friction, financial dollarization, foreign ownership in banking sector*

JEL CLASSIFICATION: E44, E47, E51, D51

* Faculty of Economics, University of Belgrade and National Bank of Serbia,
e-mail: urosevic@ekof.bg.ac.rs

** Faculty of Economics, University of Belgrade, Serbia, e-mail: grga986@yahoo.com

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1. INTRODUCTION

The recent economic crisis has indicated the inability of DSGE models to adequately address current economic issues. Certain authors (Quadrini 2011, Martinez and Tsomocos 2012) attribute the poor performance of the benchmark DSGE models to the absence of financial friction in their settings. Brunnermeier, Eisenbach, and Sannikov (2012, p. 1) have emphasized the crucial role of financial friction in understanding business cycle fluctuations. Tovar (2009, p. 6) explains that exclusion of the financial markets or financial friction prevents benchmark DSGE models from analyzing financial vulnerability, illiquidity, and procyclicality, and limits their use for stress testing in financial stability exercises.

Although benchmark DSGE models have generally not included financial markets and financial friction, there is a long tradition of dealing with these elements in the macroeconomic theory. One of the earliest works in the field was by Bernanke and Getler (1989). Today, the leading examples of models with financial friction are Bernanke, Gelter, and Gilchrist (1999) and Kiyotaki and Moore (2012). Here asymmetric information in the form of entrepreneur moral hazard and costly state verification results in financial friction. Alternatively, Goodhart, Tsomocos, and Osorio (2009) and Tsomocos and Martinez (2012) introduce financial friction through the existence of money, default, and agent heterogeneity. Since these features are able to capture the first-order effects of financial friction in a parsimonious way, we decided to follow the concept of Tsomocos in the paper.

The aim of this paper is to propose a dynamic stochastic general equilibrium (DSGE) model for the Serbian economy. The focus will be on the introduction of a DSGE model for a small, financially open, dollarized economy. The model proposed in the paper is based on the work of Goodhart et al (2009) and Tsomocos and Martinez (2012). These models are micro-founded models for a closed economy based on a real business cycle paradigm with financial frictions and they follow the framework developed in Dubey and Geanaklopos (2003) and Tsomocos (2003). The models of Goodhart et al (2009) and Tsomocos et al (2012) comprise the liquidity issues and endogenous default, two features present in the Serbian economy. However, due to the specificity of the Serbian economy it is necessary to extend and modify these models. Given that

modelling a small, financially open, dollarized economy in a general equilibrium environment is a very complex issue, this paper should be regarded as a first step in researching the phenomenon.

Our proposed model extends the aforementioned models in the following ways. First, it introduces financial dollarization into the setting of the DSGE model. Although dollarization is presented in Castillo, Montoro, and Tuesta (2006), their model is based on the New Keynesian paradigm, there is no endogenous default, and it does not consider financial dollarization. Second, foreign ownership in the banking sector is introduced. Furthermore, in order to model financial dollarization it is necessary to introduce the exchange rate into the model. The exchange rate in the model is assumed to depend only on capital flow with foreign countries. In this way the proposed model extends the work of Tsomocos and Goodhart to the field of financially open economies.

Dollarization refers to the use of foreign currency for all or some functions of domestic currency in the domestic economy. The focus will be only on partial financial dollarization,¹ where foreign currency becomes the preferred denomination for savings and loans. The literature (Levy Yeyati 2006, Alvarez-Plata and Garcia-Herrero 2008, Aleksić, Đurđević, Palić and Tasić 2008) concentrates on the negative side of financial dollarization. A high level of financial dollarization has a negative effect on the monetary authority conducting monetary policy and on debtors' ability to meet their obligations when the debt is in foreign currency and when there is exchange rate depreciation. In this paper the focus will be predominantly on these effects, while the mechanism of how dollarization affects economic life will be explained further in the part of the paper that deals with motivation.

Another important feature that the previously mentioned models lack is that foreign banking groups own the majority of the Serbian banking sector. As part of international banking groups Serbian banks have access to funds with conditions they would not have otherwise. A similar case is described in

¹ Dollarization can be complete, when foreign currency is a legal tender, and partial, when foreign currency is used along with domestic currency. Partial dollarization can be: transaction dollarization, price dollarization, or financial dollarization. For details see Castillo, Montoro and Tuesta (2006)

Tsenova (2012). According to Dragutinović (2008, p. 18) the existence of an alternative source of finance makes banks less dependent on the liquidity provided by the Central Bank. Therefore foreign ownership might additionally affect transmission of monetary policy and its efficiency. Finally, since the Serbian economy is small compared to the size of the European Union economy, changes in Serbia in demand for funds from abroad would have a negligible effect on the financial markets of the European Union.

The paper is organized as follows. The first section explains the motivation of our paper. The model is defined in the second section. The third part contains a numerical example of the model, and the last section concludes.

2. MOTIVATION

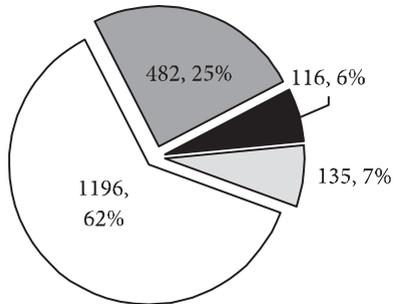
DSGE models are a very useful tool for economic policy analysis. However, as yet no DSGE model has been developed to analyse Serbian economic policy. This paper is motivated by the desire to start a discussion on the topic, and to contribute to the development of a DSGE model for the Serbian economy and the development of DSGE models for developing countries with dollarization issues in general.

The following statistics show the extent of financial dollarization and foreign ownership in the Serbian banking sector, the consequences of which determined the introduction of these features in our proposed model.

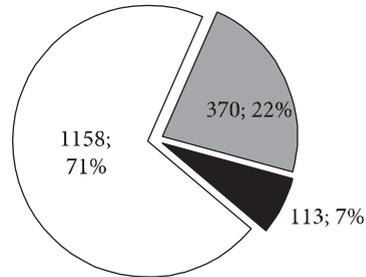
On the Serbian banking sector's balance sheet, loans constitute almost 75% of total assets and securities just 9%². On the other hand, deposits make up almost 70% of liabilities³. Thus loans and deposits play a dominant role in the balance sheets of Serbian banks. In this paper we will only focus on the currency structure of the loans and deposits to show the extent of the financial dollarization of the Serbian economy. The structure of loans and deposits in the Serbian economy in terms of denomination is presented in Figure 1 and Figure 2:

² National Bank of Serbia (2012) BANKING SECTOR IN SERBIA: Third Quarter Report 2012, page 7.

³ National Bank of Serbia (2012) BANKING SECTOR IN SERBIA: Third Quarter Report 2012, pages 20-23.

Figure 1: Currency structure of loans
(in billions of RSD)

□ EUR ■ RSD ■ OTHER □ CHF

Figure 2: Currency structure of deposits
(in billions of RSD)

□ EUR ■ RSD ■ OTHER

Source: National Bank of Serbia (2012), pp 9 and 21

Euro-denominated loans and deposits strongly dominate loans and deposits in dinars (as well as other foreign currencies). Furthermore, the currency structure of deposits is harmonized with the currency structure of loans. Nevertheless, banks are not protected against the negative impact of unexpected changes in exchange rates. Exchange rate risk is transformed into default risk: when debtors' revenue is in domestic currency and their credit obligations are in foreign currency, a change in the exchange rate will directly affect the amount of credit obligation. If the exchange rate depreciates the debtor will need more domestic currency to honour the debt, which increases in terms of domestic currency. Given that revenues stay relatively constant, a change in the exchange rate affects the debtor's ability to honour the credit obligation in its entirety. This phenomenon is described, e.g. in Levy Yeyato (2006) and Božović, Urošević and Živković (2009).

When such a large proportion of assets and liabilities is denominated in a foreign currency it affects the ability of the Central Bank to conduct monetary policy. In a regime of inflation targeting, the interest rate is supposed to be the most important channel for transmission of monetary policy. The interest rate channel implies that a change in the key rate is transmitted to other rates, which, under certain conditions, will later affect aggregate demand. However, a change in the key domestic rate will only affect the rates on loans in domestic currency. However, most of the loans are denominated in or indexed to a foreign

currency, primarily the euro, and depend on the international interest rate, mainly EURIBOR, while domestic key interest rates do not affect them. Therefore the efficiency of the interest rate channel in conditions of high financial dollarization is significantly reduced. This statement is in accordance with the findings of Aleksić, Đurđević, Palić and Tasić (2008, pp. 28, 29), which argue that the effectiveness of this channel depends on the level of dollarization, and at the current level of dollarization its effectiveness is shaded.

The ownership structure of Serbian banks is as follows: foreign-owned banks account for 74% of total assets, 74% of total capital, and 71% of employment in the banking sector, and post profits of RSD 17.5bn⁴. The majority of the foreign owners of banks in the Serbian economy are from Eurozone countries⁵. This fact might have encouraged dollarization (euroization) in Serbia. According to Dragutinović (2008), foreign ownership means that the banking sector is able to get foreign capital easily and is less sensitive to liquidity provided by the Central Bank. Therefore foreign ownership affects monetary policy and its efficiency.

3. THE MODEL

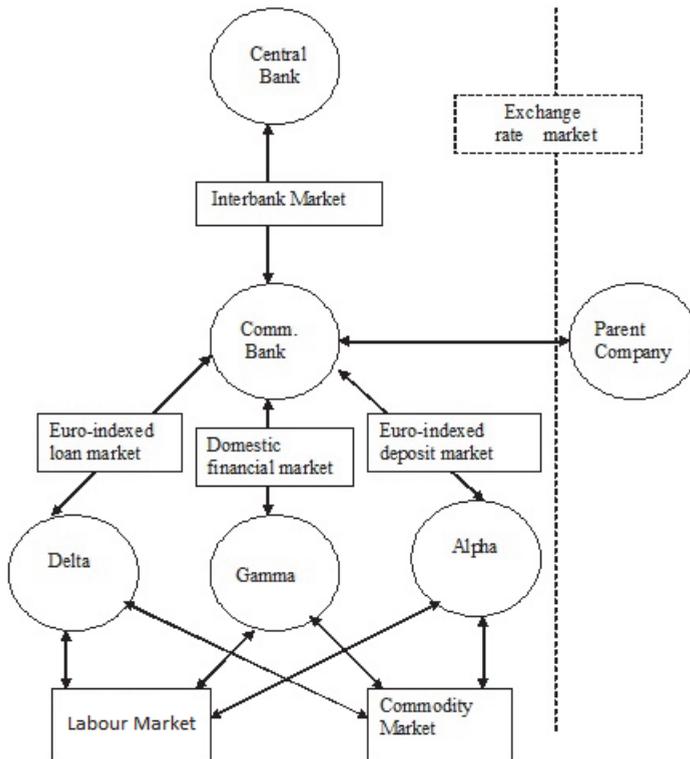
The model consists of one household, two yeoman farmers, a commercial and a Central Bank. ‘Yeoman farmer’ is a generic term in macroeconomics for the producer who partially consumes the goods he produces. The central place in the model belongs to the commercial bank, which acts as an intermediary between sectors with a deficit and sectors with a surplus of funds. The household is the labour provider and acts as a net depositor in the financial market, while the yeoman farmers provide consumer goods and act as net borrowers. The yeoman farmers differ in their ability to access different financial markets. The Central Bank, on the other hand, is a strategic dummy (i.e., its behaviour is not conditional on the state of the system), which partially provides liquidity to the system. In the model the commercial bank has a parent company, which is an alternative provider of liquidity to the commercial bank, but its behaviour is not the object of interest in this paper. It is only important

⁴ Source: National Bank of Serbia, BANKING SECTOR IN SERBIA: Third Quarter Report 2012,, page 3.

⁵ Source: National Bank of Serbia, BANKING SECTOR IN SERBIA: Third Quarter Report 2012,, page 3.

that the parent company provides the commercial bank with the funds it requires at an interest rate determined outside of the model. Finally, the agents in the system are interconnected by a system of markets. The structure of the model is presented in Figure 3.

Figure 3: Structure of the Model



Source: Author's illustration

Financial dollarization is introduced through partial deposit and loan dollarization. In other words, a part of deposits and loans are in foreign currency. For the sake of simplicity, instead of having deposits and loans in foreign currency, foreign-currency-indexed loans and deposits are introduced (hereinafter euro-indexed deposits and credits). Euro-indexed credits and deposits are regular credits and deposits with an exchange rate clause, i.e., the amount of outstanding debt in euro-indexed deposit and credit markets changes

with changes in the exchange rate. In this way the same effect is achieved, but more simply, each time money relating to euro-indexed loans and deposits is changed. The exchange rate clause makes agents sensitive to changes in the exchange rate, while the quantity of euro-indexed loans and deposits means that the role of the exchange rate is very important in decision-making.

The economy contains four different types of market: the financial market, the commodity market, the labour market, and the exchange rate market. The financial markets are the interbank market (between the Central Bank and the commercial bank), the domestic currency financial market (between the commercial bank and yeoman farmer γ), the euro-indexed deposit market (between the commercial bank and household α), and the euro-indexed loan market (between the commercial bank and yeoman farmer δ). Furthermore, the commodity market and the labour market both connect household α with yeoman farmer γ and yeoman farmer δ . In the labour market, the commodity market, the interbank market, the foreign exchange market, and the domestic financial market, the price or interest rate is determined by equating respective supply and demand, in the same way as in Goodhart et al (2009) and Martinez et al (2012).

By contrast, interest rates in the euro-indexed loan and deposit markets are determined outside of the model. In the case of the Serbian economy, due to the currency structure of deposits and loans (see Figures 1 and 2), international interest rates such as Libor and Euribor play a dominant role. To implement this feature of the Serbian economy in the model the following assumption has been made: the commercial bank takes as many deposits as household α is willing to invest in the commercial bank at an interest rate level that is determined outside of the model. Furthermore, yeoman farmer δ accepts as many funds as the commercial bank is willing to invest in the euro-indexed loan market at the rate determined outside of the model. Thus, interest rates on euro-indexed loans and deposits are equal to the sum of the interest rates in the international financial market, which is represented in the model by the interest rate on the loans from the parent company and premiums, which are all assumed to be constant in the model.

The agents also differ according to which financial market they have access to. Yeoman farmer δ can only get a euro-indexed loan, while yeoman farmer γ can only get a loan in domestic currency. Furthermore, household α can only invest money in euro-indexed deposits. The division of yeoman farmers is conditioned by the need to have assets in different currencies in one model. On the other hand, from the currency structure of deposits (see Figure 2) it seems that the limitation on household investment does not diverge much from reality but makes the model more parsimonious.

Financial openness is achieved because the commercial bank can borrow from abroad. Foreign ownership provides Serbian banks that belong to international banking groups with an option to borrow from the parent company. We treat Serbian economy as a small open economy. Thus, the interest rate on loans from the parent company does not vary with the amount of funds demanded by the commercial bank. Because the commercial bank has an alternative source of funding it is less dependent on the liquidity that the Central Bank provides.

Our model extends the models of Goodhart et al (2009) and Martinez and Tsomocos (2012). We expand these models in terms of participants (a parent company and another yeoman farmer are added), markets (foreign exchange rate market and euro-indexed loan and deposit markets are added), and assets (euro-indexed loans and euro-indexed deposits are added). In regard to Goodhart et al (2009) the model is simplified so that there is no bank heterogeneity. The omission of bank heterogeneity has little effect on the main findings of the paper while facilitating both tracking of shock propagation throughout the model and explanation of the results. The model differs from Martinez and Tsomocos (2012), as there is production and deposit of funds while the agents are not endowed with consumer goods.

3.2 Financial Friction

In the model, financial friction is represented by money, default, market liquidity, and agent heterogeneity. These frictions are the key ingredients of the models of Martinez and Tsomocos (2012) and Goodhart et al (2009), and as the proposed model is based on their papers these frictions are also part of our model. The following paragraphs explain the role of financial friction in the model.

Default arises as an equilibrium phenomenon, since agents can choose the amount of outstanding debt they pay. Similar to in Martinez and Tsomocos (2012), the cost of default is given by a penalty that reduces utility and which can be regarded as a reputation sanction as the loan obligation is not fulfilled in its entirety and which is proportional to the unpaid amount of loan obligation.

On the other hand, money is introduced via cash-in-advance constraint. It is a requirement that every consumer or firm must have sufficient money before they can buy a good. In the model, commodities and assets can only be traded for money, while all assets are only delivered in money. Since the yeoman farmers do not have the required money at the time of the trade, they have to borrow prior to the purchase. Some of the money already exists in the system due to household deposits in the bank, but the other part has to come from outside. Money enters the system in three ways: through open market operations, borrowing from abroad, and small government subsidies. Open market operations (OMO) represent the Central Bank lending to the commercial bank via the interbank market (Repo Market). Borrowing from abroad is represented by the commercial bank borrowing from its parent company. Finally, small government subsidy is the constant amount of money that both yeoman farmers get at the beginning of each period to reduce the level of default on their loan obligations.

Market liquidity is represented by the proportion of proceedings from sales that is available to the agents at the moment of purchase. In the model a very high level of illiquidity is assumed; hence the sales' proceedings are available to the agent only at the end of the period and so cannot be used to make purchases in the current period. If the agents do not have other sources of finance they will have to borrow from the commercial bank in order to consume. Contrary to Goodhart et al (2009) where low level of liquidity refers only to the commodity market, the low level of liquidity in this model refers to both commodity and labour markets.

Although the assumption of a representative agent facilitates the process of solving the model it prevents the model from addressing some relevant issues in economic theory. Without agent heterogeneity there will be no trading between agents, and consequently no default. Absence of default is in stark contrast to

reality and the need in a state of crisis to model financial stability. In the proposed model there are three classes of agent: the producers, the consumer, and the intermediary. Since they differ in goals and endowment their decisions and consequently their reaction to shocks will also differ. In this way the model is suitable for analysing complex economic phenomena.

The existence of financial frictions, particularly liquidity and default, allows monetary policy to be non-neutral in the short run. On the other hand, financial frictions do not prevent monetary policy from being neutral in the long run. In this way the proposed model is able to overcome the classic dichotomy in the short run. The model is in accordance with New Keynesian literature, where monetary neutrality holds only in the long run, albeit short-run neutrality is obtained through other means. In addition, it is in accordance with RBC literature, but only in the long run, since money neutrality in RBC models holds in both the short and long run.

3.3 Timing Convention

Every period starts with a realization of the state of nature, defined by a shock or its absence. After the shock has occurred the agents decide on their action. In the process of decision-making the agents take prices as given. Once they have made their decision the following chain of events occurs.

Firstly, the Central Bank lends money to the commercial bank (i.e., the domestic interbank meets). Then the commercial bank borrows money from abroad and repays its previous-period loan obligations to the foreign lender. Simultaneously, the foreign exchange market meets. Furthermore, the yeoman farmers repay the previous-period loans with revenue from commodity sales. Due to liquidity issues the revenue from commodity sales and the revenue from the labour market come to the commodity seller or labour provider with one period lag in regards to the period that the commodity or labour was purchased. With the money obtained, the commercial bank can now repay its previous-period loans to the household and the Central Bank. The debt obligation to the foreign lender has already been honoured, since it was one of the conditions of determining the exchange rate. Afterwards the household deposits some of the money from the commercial bank and the labour market into the bank and sends the rest to the commodity market. Also, the household sends part of its

labour endowment to the labour market. The commercial bank uses money from the Central Bank and the household and money borrowed from abroad to lend to the yeoman farmers. The yeoman farmers use money to hire labour (i.e., the labour market meets) and produce the commodity. Next, the yeoman farmers send part of the produced goods to the commodity market. Finally, the commodity market meets and agents consume the goods.

We assume that the Central Bank is willing to make a new loan to the commercial bank before it has repaid its previous-period loan to that institution. However, this assumption does not affect the decision-making of the commercial bank, though it does allow the exchange rate to be determined before other agents repay their previous-period loan obligations. In other words, the commercial bank does not use money borrowed from the Central Bank to repay its previous-period loan obligation to that institution. On the contrary, these funds are taken from the Central Bank with the intention of lending them to the yeoman farmer and they will be used for that purpose, but the commercial bank temporarily uses part of them to repay the previous-period loan obligation to the lender abroad. Once the yeoman farmers have repaid their previous-period loan obligations, the money that should be used to repay the commercial bank loan obligation to the foreign lender is used for lending to domestic agents, since the obligation to the foreign lender has already been honoured.

3.4 Household α

Household α is a risk-averse agent that maximizes the discounted sum of lifetime utility with decision vector $\sigma^\alpha = \{b_t^\alpha, w_t^\alpha, d_t^{eu}\}_{t=0}^{\text{inf}}$. It obtains utility by consuming goods and by leisure time. Household α is endowed with some amount of time that can be spent either in leisure or working. Work provides it with money that can be used to buy consumer goods. On the other hand, leisure also has a positive effect on utility. Hence, household α always faces a trade-off between consumption and leisure. Furthermore, since household α has access to the financial market, it can deposit a certain amount of money with the commercial bank. In this way α can smooth its consumption, because it can carry over a part of today's consumption to some future period when economic factors might prevent household α from consuming at its desired level. The same applies to the situation where economic factors prevent household α from

obtaining its desired level of consumption today: it can lower savings and increase consumption today at the expense of future periods. Household α differs from the household in Goodhart et al (2009) because it is not the owner of the bank and it invests in euro-indexed deposits. The optimization problem α faces is given below:

$$\max_{\sigma^\alpha} E_0 \sum_0^{\infty} \beta^t \left\{ U\left(\frac{b_t^\alpha}{p_t^Y}\right) + U(h^\alpha - w_t^\alpha) \right\} \quad (1)$$

subject to:

$$b_t^\alpha + d_t^{eu} = p_{t-1}^l w_{t-1}^\alpha + d_{t-1}^{eu} v_t^\theta (1 + r_{t-1}^{eu}) \frac{f_t}{f_{t-1}} \quad (2)$$

(i.e., good expenditure + investment in euro-indexed deposits at time t = labour income carried forward from period $t-1$ + repayment of euro-indexed deposit from period $t-1$)

where:

U - utility function

b_t^α - amount of money sent by α to purchase consumer goods at time t

d_t^{eu} - euro-indexed deposits made by α at time t

p_t^Y - price of consumer goods at time t

p_t^l - wage paid for unit of labour at time t

f_t - exchange rate at time t

h^α - α 's time endowment

w_t^α - amount of time α chooses to work in period t

$(h^\alpha - w_t^\alpha)$ - amount of time α chooses to spend in leisure in period t

(b_t^α / p_t^Y) - consumption of household α at time t

r_t^{eu} - interest rate in euro-indexed deposit market in period t

v_t^θ - deposit repayment rate by commercial bank in period t

β - discount factor

3.5 Yeoman Farmer γ

Yeoman farmer is a generic term in macroeconomics for the producer who partially consumes the goods he produces. Yeoman farmer γ maximizes the sum of lifetime utility with decision vector $\sigma^\gamma = \{b_t^\gamma, q_t^\gamma, v_t^\gamma, \mu_t^\gamma\}_{t=0}^{\text{inf}}$. He obtains utility by consuming consumer goods and suffers penalties for defaulting on loan obligations. Yeoman farmer γ has the same discount factor as household α . Yeoman farmer γ resembles the yeoman farmer in the paper by Goodhart et al (2009), but they differ in that the yeoman farmer in this paper pays a non-pecuniary default penalty.

To produce consumer goods, yeoman farmer γ uses a production function which depends on technology and labour. He hires labour on the labour market from household α . Since γ 's utility depends on the consumption of the consumer good, part of the production he holds for himself while selling the other part on the consumer goods market. Furthermore, the cash-in-advance constraint requires that the agent has sufficient funds prior to making the purchase. In the case of yeoman farmer γ this means he needs to borrow from the commercial bank on the domestic currency loan market. Later he repays his debt with profits accumulated from the proceeds of the last-period consumer goods sale and a small amount of government aid (subsidy). Partial or complete default on his loan is an option, although γ suffers a default penalty proportional to the amount of the loan he did not honour. Hence, the default penalty is non-pecuniary and it lowers his utility. The optimization problem that yeoman farmer γ faces is given below:

$$\max_{\sigma^\gamma} E_0 \sum_0^{\text{inf}} \beta^t \{U(Y_t^\gamma - q_t^\gamma) - \tau_t^\gamma (1 - v_t^\gamma) \mu_{t-1}^\gamma\} \quad (3)$$

subject to:

$$Y_t^\gamma = A_t \left(\frac{b_t^\gamma}{P_t} \right); \quad (4)$$

(i.e., amount of the consumer good produced in period t = total productivity factor * the amount of labour γ used to produce the consumer good in period t)

$$v_t^\gamma \mu_{t-1}^\gamma = m^\gamma + p_{t-1}^\gamma q_{t-1}^\gamma ; \quad (5)$$

(i.e., loan repayment to the domestic financial market at time t = subsidy + sales revenue carried forward from period t-1)

$$b_t^\gamma = \frac{\mu_t^\gamma}{1 + r_t^{rsd}} \quad (6)$$

(i.e., payroll payment at time t = borrowing from domestic financial market at time t)

Furthermore, mutual technological factor A_t and γ 's default penalty are represented by the AR(1) process because they will be the subject of the exogenous shock in the simulation section.

$$\ln(A_t) = 0.5\ln(\bar{A}) + 0.5\ln(A_{t-1}) + e_t^A ; e_t^A = N(0, \sigma_A^2) \quad (7)$$

$$\ln(\tau_t^\gamma) = 0.5\ln(\bar{\tau}^\gamma) + 0.5\ln(\tau_{t-1}^\gamma) + e_t^\tau ; e_t^\tau = N(0, \sigma_\tau^2) \quad (8)$$

where:

U - utility function

Y_t^γ - production of consumer goods by γ in period t

q_t^γ - amount of goods offered for sale by γ in period t

$(Y_t^\gamma - q_t^\gamma)$ - γ 's consumption of consumer goods in period t

p_t^γ - price of consumer goods at time t

μ_t^γ - debt acquired by γ on the domestic financial market in period t

v_t^γ - γ 's repayment rate on his outstanding loan in period t

r_t^{rsd} - interest rate on loans from domestic financial market extended in period t

b_t^γ - amount of money sent by γ to hire labour at time t

p_t^l - wage paid for unit of labour at time t

(b_t^γ / p_t^l) - quantity of labour that γ hires

A_t - total productivity factor in period t

\bar{A} - total productivity factor parameter

m^γ - government subsidy

f_t - exchange rate at time t

τ_t^γ - default penalty on outstanding debt in period t

$\bar{\tau}^\gamma$ - γ 's default penalty parameter

3.6 Yeoman Farmer δ

Yeoman farmer δ differs from yeoman farmer γ in two major characteristics. Firstly, yeoman farmer δ only has access to the euro-indexed loan market, while yeoman farmer γ only has access to the domestic currency financial market. Secondly, yeoman farmer δ is modelled to be willing to accept as much money as the commercial bank is willing to invest in the euro-indexed loan market. In other words, the yeoman farmer is assumed to have perfectly elastic demand for funds on the euro-indexed loan market at the given rate $r^{B,eu}$. Therefore, he maximizes the sum of his lifetime utility with respective decision vector $\sigma^\delta = \{q_t^\delta, v_t^\delta\}_{t=0}^{\text{inf}}$.

$$\max_{\sigma^\delta} E_0 \sum_0^{\text{inf}} \beta^t \{U(Y_t^\delta - q_t^\delta) - \tau^\delta (1 - v_t^\delta) d_{t-1}^{eu} (1 + r_{t-1}^{B,eu}) \frac{f_t}{f_{t-1}}\} \quad (9)$$

subject to:

$$Y_t^\delta = A_t \left(\frac{b_t^\delta}{p_t} \right) \quad (10)$$

(i.e., δ 's production at time t = total productivity factor * amount of the labour bought on the labour market at time t)

$$v_t^\delta d_{t-1}^{eu} (1 + r_{t-1}^{B,eu}) \frac{f_t}{f_{t-1}} = m^\delta + p_{t-1}^Y q_{t-1}^\delta \quad (11)$$

(i.e., loan repayment to euro-indexed loan market at time t = subsidy + sales revenue carried forward from period $t-1$)

$$b_t^\delta = d_t^{eu} ; \quad (12)$$

(i.e., meeting payroll at time t = borrowing from euro-indexed loan market at time t)

where:

U - utility function

Y_t^δ - production of consumer goods by δ in period t

q_t^δ - amount of consumer goods offered for sale by δ in period t

v_t^δ - δ 's repayment rate on his outstanding debt in period t

- p_t^Y – price of consumer goods at time t
 μ_t^δ – debt acquired by δ on the euro-indexed loan market in period t
 $r_t^{B,eu}$ – interest rate in euro-indexed loan market in period t
 b_t^δ – amount of money sent by δ to hire labour at time t
 A_t – total productivity factor in period t
 τ^δ – δ 's default penalty on outstanding debt
 m^δ – government subsidy
 f_t – exchange rate at time t
 p_t^l – wage paid for unit of labour at time t

3.7 Commercial Bank θ

The commercial bank acts as an intermediary that connects sectors with surplus and sectors with deficit in funds. It takes deposits from household α and loans from the Central Bank and its parent company. On the other hand, it extends credit in the domestic financial market and euro-indexed loan market. Deposits from euro-indexed loans are only used for euro-indexed loans, while loans from the Central Bank and parent company are used for loans in the domestic financial market.

The commercial bank is hedged against a change in the exchange rate. Primarily, the total amount of the funds the commercial bank invests in the euro-indexed loan market is equal to the amount that it gathers in the euro-indexed loan market. This loan and deposit structure does not differ much from the reality, presented in Figures 1 and 2. In this way the commercial bank transfers the exchange rate risk to the other participants in the model. On the other hand, the loans the commercial bank gets from its parent company are modelled not to vary with the change in exchange rate. Hence, the commercial bank is hedged against exchange rate risk.

However, the fact that the commercial bank transferred the exchange rate risk to the other participants does not mean it has solved the problems related to dollarization. Given that the agent's costs are affected by the change in the exchange rate while revenues are not, the risk of exchange rate change is converted to default risk. In the model liquidity issues cause the phenomenon mentioned above, albeit that in reality there are many other reasons that can have same effect.

The commercial bank maximizes the net present value of the flows of the expected profit with decision vector $\sigma^\theta = \{\Pi_t^\theta, l_t^\theta, \mu_t^{IB}, \mu_t^{IB,eu}, v_t^\theta\}_{t=0}^{\text{inf}}$. It suffers a non-pecuniary reputation penalty for defaulting on its debt obligations proportional to the size of the non-repaid amount of the obligation. Furthermore, it is assumed that the commercial bank can default on the loan from the Central Bank and deposit from household α , but cannot default on the loan from its parent company. Besides the default penalty, the commercial bank suffers a penalty for borrowing money from its parent company. Loans from the parent company have the status of an additional source of funding that the commercial bank uses when it cannot gather enough funds from other sources, primarily households. In this way, anytime the commercial bank borrows from its parent company it sends a negative message to the public that the commercial bank is not able to attract the funds it needs, or, even more general, that agents do not sufficiently trust the banking system. Therefore, the ratio of the funds borrowed from the parent company to the funds gathered from households can be an indicator of the power the commercial bank has in the economy. The decreased power of the commercial bank has a negative effect on its image: in the same way as default, a bad image negatively affects a bank's reputation. A lower reputation should lower the utility function of the commercial bank, because the commercial bank's utility function, loosely speaking, depends on the profit and reputation of the bank. The bank differs from the banks in Goodhart et al (2009) and Martinez and Tsomocos (2012) since it has access to funds abroad but suffers penalties by borrowing abroad, and it gives different types of loans to different agents.

The optimization problem that the commercial bank faces is given below:

$$\max_{\sigma^\theta} E_0 \sum_0^{\text{inf}} \beta^{B,t} \{U(\Pi_t^\theta) - \tau^{\theta,1} (1 - v_t^\theta) [\mu_{t-1}^{IB} + \frac{f_t}{f_{t-1}} d_{t-1}^{eu} (1 + r_{t-1}^{eu})] - \tau^{\theta,2} (\frac{f_t \mu_t^{IB,eu}}{d_t^{eu}})\} \quad (13)$$

subject to:

$$\Pi_t^\theta = v_t^\gamma (1 + r_{t-1}^{rsd}) l_{t-1}^\theta + v_t^\delta d_{t-1}^{eu} (1 + r_{t-1}^{B,eu}) \frac{f_t}{f_{t-1}} - v_t^\theta [\mu_{t-1}^{IB} + \frac{f_t}{f_{t-1}} d_{t-1}^{eu} (1 + r_{t-1}^{eu})] - f_{t-1} \mu_{t-1}^{IB,eu} \quad (14)$$

(i.e., bank's profit = revenue from domestic financial and euro-indexed credit market for loans made at time t-1 – repayments on the loans and deposits taken at time t-1)

$$l_t^\theta = \frac{\mu_t^{IB}}{(1+r_t^{IB})} + \frac{f_t \mu_t^{IB,eu}}{(1+r_t^{IB,eu})} \quad (15)$$

(i.e., extensions to the domestic financial market at time t = loans from the interbank market and from the parent company at time t)

where:

U - utility function

μ_t^{IB} - debt that commercial bank acquires in the interbank market in period t

$\mu_t^{IB,eu}$ - commercial bank's debt to parent company (in foreign currency) in period t

d_t^{eu} - euro-indexed deposits made by α at time t

$r_t^{IB,eu}$ – interest rate on the loans from parent company at time t

r_t^{IB} – interbank interest rate at time t

Π_t^θ – commercial bank's profit

v_t^γ - γ 's repayment rate on his outstanding debt in period t

l_t^θ - loans to domestic financial market

v_t^θ – θ 's repayment rate on its outstanding debt in period t

$\tau^{\theta,1}$ – reputation penalty for defaulting on outstanding debt

$\tau^{\theta,2}$ – reputation penalty for borrowing from the parent company

β^B – discount factor for commercial bank

3.8 Interbank Market

The interbank market clears when the amount of money the commercial bank promises to repay in the next period is exchanged for the credit extension the Central Bank offers in the current period.

$$1+r_t^{IB} = \frac{\mu_t^{IB}}{M_t} \quad (16)$$

3.9 Domestic Financial Market

The domestic financial market clears when the amount of money yeoman farmer γ promises to repay in the next period is exchanged for the credit extension in domestic currency that the commercial bank offers in the current period.

$$1 + r_t^{rsd} = \frac{\mu_t^\gamma}{l_t^\delta} \quad (17)$$

3.10 Consumer Goods Market

In every period, the consumer goods market clears when the amount of money household α offered for consumer goods is exchanged for the quantity of consumer goods yeoman farmers γ and δ offered for sale.

$$p_t^\gamma = \frac{b_t^\alpha}{q_t^\gamma + q_t^\delta} \quad (18)$$

3.11 Labour Market

In every period, the labour market clears when labour expenditures by yeoman farmers γ and δ are exchanged for the amount of hours that household α is willing to work.

$$p_t^l = \frac{b_t^\gamma + b_t^\delta}{w_t^\alpha} \quad (19)$$

3.12 Exchange Rate Market

In every period, the foreign exchange rate equates supply and demand for foreign exchange. The amount of credit that the commercial bank borrows from its parent company and the constant amount of foreign exchange that the parent company has to pay to the authority (M^{eu}) form a supply of foreign exchange. On the other hand, repayment of the previous-period debt obligation to the parent company by the commercial bank and the previous-period profits of the commercial bank form demand for foreign exchange. Here, it is assumed that repayment of the commercial bank's previous-period debt to the parent

company happens simultaneously with the new loan the commercial bank gets from its parent company.

$$f_t = \frac{f_{t-1} \mu_{t-1}^{IBeu} + \Pi_{t-1}^\theta}{\frac{\mu_t^{IBeu}}{(1+r_t^{IBeu})} + M^{eu}} \quad (20)$$

3.13 Euro-indexed Deposit and Loan Market

The euro-indexed loan and deposit market differs from the other markets because interest rates are not determined through the interaction of supply and demand but are given exogenously. Therefore, so that both markets clear (clearing of all the markets is one of the conditions of equilibrium in DSGE models), it is necessary to assume that the commercial bank is willing to accept as much money as household α is willing to deposit at a given level of the euro-indexed deposit interest rate. The commercial bank is willing to do so, since yeoman farmer δ is modelled to be willing to accept as many funds as the commercial bank offers on that market.

3.14 Monetary Policy

The monetary policy follows Goodhart et al (2009) and Martinez and Tsomocos (2012). In every period the Central Bank injects a certain amount of money into the system. It does so through open market operations (OMO). When it wants to decrease the amount of money in the system and increase the interest rate on loans in domestic currency, the Central Bank decreases the level of OMOs.

$$M_t = \eta_t^{CB} \bar{M} \quad (23)$$

$$\ln(\eta_t^{CB}) = 0.5 \ln(\bar{\eta}^{CB}) + 0.5 \ln(\eta_{t-1}^{CB}) + e_t^{CB} ; e_t^{CB} = N(0, \sigma_{CB}^2) \quad (24)$$

where:

M_t – amount of money injected into the system by the Central Bank at time t

\bar{M} – amount of the money injected into the system by the Central Bank in steady state

η_t^{CB} – the monetary operations' gross growth at time t

$\bar{\eta}^{CB}$ – the monetary operations' gross growth parameter

3.15 Equilibrium

According to the definition of DSGE models, a system is always in equilibrium. Equilibrium can come in two different modalities, long-run equilibrium and short-run equilibrium. Long-run equilibrium is a static equilibrium and is referred to as a steady state.

Short-run equilibrium is achieved if:

1. agents optimize their utility functions given their budget set;
2. all markets clear;
3. expectations are rational.

The system is always in short-run equilibrium. However, in order to have long-run equilibrium as well, two additional conditions are required. The system is in long-run equilibrium (steady state) if:

1. agents optimize their utility functions given their budget set;
2. all markets clear;
3. expectations are rational;
4. all variables do not grow;
5. the economy is not subject to any current or expected shock.

4. NUMERICAL EXAMPLE

The numerical example aims to give a basic intuition of how the model works. However, the calibration that will allow deeper analysis of the Serbian economy is a task for further development of the model. The tables below show the parameter values and steady-state values of endogenous values used in simulations.

Table 1: Parameters

Parameters	Value
\bar{A}	2.10
h^{α}	1.00
$1+r^{IB,eu}$	1.030
τ^{δ}	3.753160441047400
$\bar{\tau}^{\gamma}$	15.00
$\tau^{\theta,1}$	43.200276481769485
$\tau^{\theta,2}$	5.362446084360822
m^{γ}	0.028875
m^{δ}	0.0289667575
β	1/1.0296
β^B	1/1.02
\bar{M}	0.2651
M^{eu}	2.695909090909087e-004
$1+r^{B,eu}$	1.070
$1+r^{eu}$	1.040
$\bar{\eta}^{CB}$	1.00

Source: Author's calculation

Table 2: Endogenous variables

Endo. var.	Value
p^Y	2.262398516297142
p^I	3.959197403520000
f	110.00
$1+r^{RSD}$	1.20
$1+r^{IB}$	1.1175
M	0.2651
A	2.10
η^{CB}	1.00
d^{eu}	1.447
b^{α}	1.9718312
η^{α}	-0.507142802081639
w^{α}	0.487219959854739
μ^{γ}	0.5784
b^{γ}	0.482
η_1^{γ}	-15.00
η_2^{γ}	-17.482517482517480
q^{γ}	0.225318393876213
v^{γ}	0.93125
τ^{γ}	15.00
η^{δ}	-3.753160441047400
q^{δ}	0.646248302174882
v^{δ}	0.963022403748652
Π^{θ}	0.023148
μ^{IB}	0.29624925
$\mu^{IB,eu}$	0.002030972727273
η_1^{θ}	-43.200276481769485
η_2^{θ}	-47.329714674879803
l^{θ}	0.481999939995261
v^{θ}	0.99

Source: Author's calculation

4.2 Simulations

The purpose of this section is to describe the change of the endogenous variables due to the set of exogenous shocks. Simulations are run for three different shocks: monetary shock, productivity shock, and regulatory shock. All

of the simulations are run for a small shock, i.e., 1% change in the respective steady-state value. In all cases, shock unexpectedly hits the system at beginning of the first period and provokes the reaction of the agents, who adjust their behaviour accordingly. In simulations, all the agents have logarithmic utility functions. The model is simulated using Dynare software⁶.

4.3 Monetary Shock

Monetary shock stands for a change in the OMO growth rate (η_t^{CB}) in the initial period. From equation (23) it is clear that a change in the OMO determines the amount of liquidity the Central Bank injects into the system. Thus, the following simulation shows the reaction of the participants in the model to the unexpected 1% decrease in the amount of liquidity the Central Bank injects into the system. Graphs 5.1 to 5.18 summarize the effects of the monetary shock at the beginning of the first period.

As might be expected, a negative monetary shock increases domestic currency interest rates. However, the impulse response function of the interest rates on domestic currency loans (r_t^{RSD}) differs from that of the interest rate on the interbank market (r_t^{IB}), because the commercial bank has the possibility to borrow money from its parent company. In this way the possibility of borrowing from abroad negatively affects the transmission of monetary policy and the usefulness of the interest rate channel.

Although the system is modelled in such a way that a change in domestic monetary policy does not change interest rates on euro-indexed loans and deposits ($r_t^{B,eu}, r_t^{eu}$), monetary policy does change the level of default in the economy. Since the commercial bank can borrow from abroad if the Central Bank runs a restrictive monetary policy, a negative monetary shock implicitly leads to an increased supply of foreign currency and decreases the foreign exchange rate. Because yeoman farmer δ 's debt obligation depends on the exchange rate, a decrease in the exchange rate means lower debt obligation for yeoman farmer δ and consequently a lower level of default. Given that the negative monetary shock has almost no effect on the default of yeoman farmer

⁶ In the paper, first-order approximation is used. For details, see Julliard (2001) and Adjemian et al. (2011).

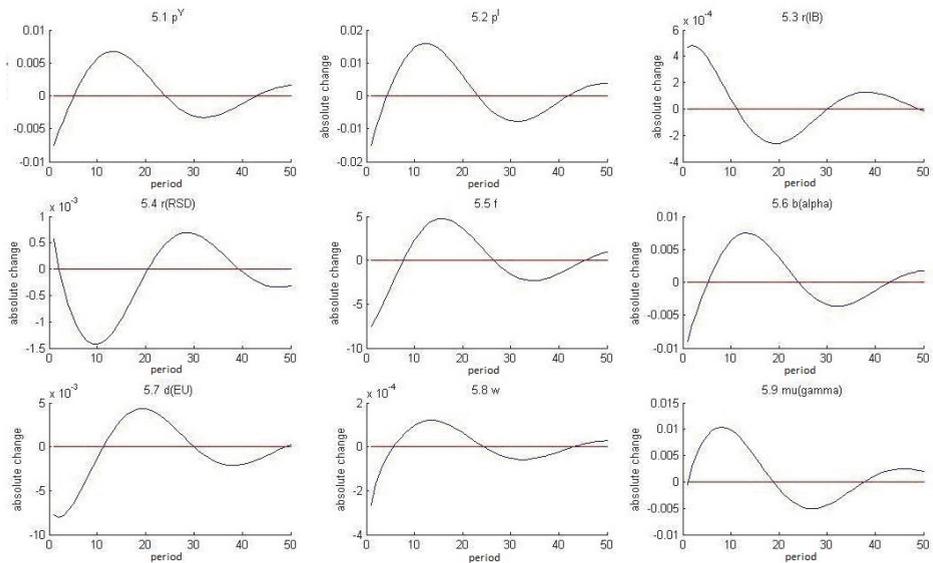
γ , the decreased default of yeoman farmer δ also affects the default rate of the commercial bank.

Negative monetary shock has a negative effect on the price of consumer goods and labour. Due to the lower level of funds available to the yeoman farmers for hiring labour, wages decrease and household α offers less units of labour on the labour market. Since the commercial bank does not compensate for the negative monetary shock entirely and household α reduces investment in deposits, the yeoman farmers have less funds available for hiring labour. The decrease in the exchange rate reduces the return of household α on its deposit investment prior to the occurrence of the shock and the amount of funds it has at its disposal, affecting negatively its deposit investments in the current period. Furthermore, the smaller amount of labour available on the labour market reduces overall production and consumption. This is proof that monetary policy has real effects, since the change in monetary policy leads to a change in agents' production and consumption. On the other hand the price of consumer goods also decreases. It is reduced because household α spends less in the consumer market due to its reduced budget.

After the initial period the effect of the shock starts to vanish and the variables slowly return to a steady state. Some of the variables diverge from their steady-state values for a few periods after the initial period, but after that they start to converge back to the steady state. This is because borrowing from the parent company decreases slower than the borrowing from the Central Bank recovers.

Finally, this simulation proves the importance of the exchange rate to the transmission of monetary policy. This is because most of the changes in the system result from the change in the exchange rate. On the other hand, the interest rate channel has relatively low impact in the given setting. Furthermore, it is proved that the ability of the commercial bank to borrow from abroad prevents the Central Bank from controlling the amount of liquidity in the system. Default also follows the expected pattern. In the end, the dominant effect of default on euro-indexed loans on default in the whole system might be expected, bearing in mind the currency structure in the model.

- Graph 5.1** – change of p^Y due to the change of M
- Graph 5.2** - change of p^I due to the change of M
- Graph 5.3** - change of r^{IB} due to the change of M
- Graph 5.4** - change of r^{RSD} due to the change of M
- Graph 5.5** - change of f due to the change of M
- Graph 5.6** - change of b^α due to the change of M
- Graph 5.7** - change of d^{EU} due to the change of M
- Graph 5.8** - change of w due to the change of M
- Graph 5.9** - change of μ^Y due to the change of M



Source: Author's calculation

Graph 5.10 – change of b^y due to the change of M

Graph 5.11 - change of v^y due to the change of M

Graph 5.12 - change of q^y due to the change of M

Graph 5.13 - change of v^δ due to the change of M

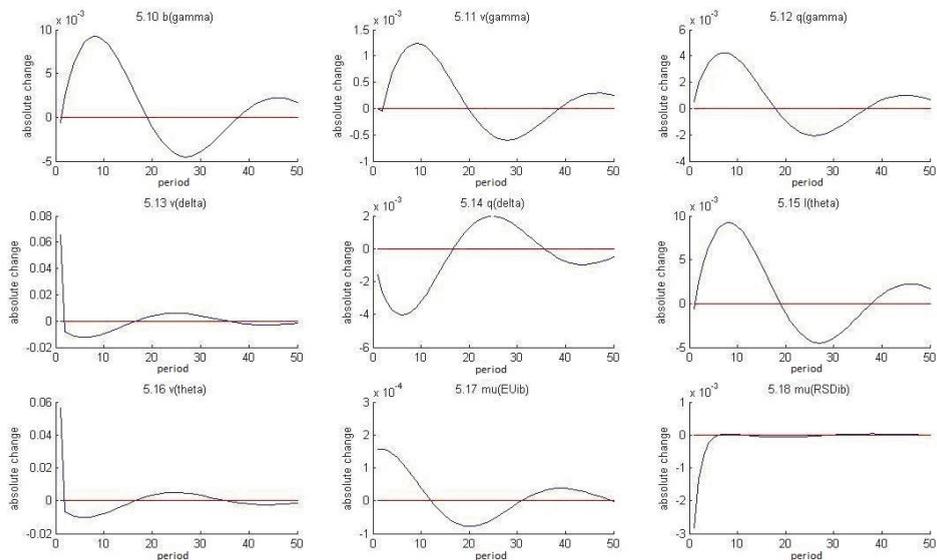
Graph 5.14 - change of q^δ due to the change of M

Graph 5.15 - change of l^0 due to the change of M

Graph 5.16 - change of v^θ due to the change of M

Graph 5.17 - change of $\mu^{IB,eu}$ due to the change of M

Graph 5.18 - change of μ^{IB} due to the change of M



Source: Author's calculation

4.4 Productivity Shock

Productivity shock stands for a change in the technological factor (A_t) in the initial period. Shock is supposed to affect the production functions of both yeoman farmers, because they do not differ in terms of production technology. Thus, the following simulation shows the reaction of the participants in the model to the unexpected 1% increase of productivity of technology in the initial period. Graphs 6.1 to 6.3 summarize the effects of the productivity shock at the beginning of the first period.

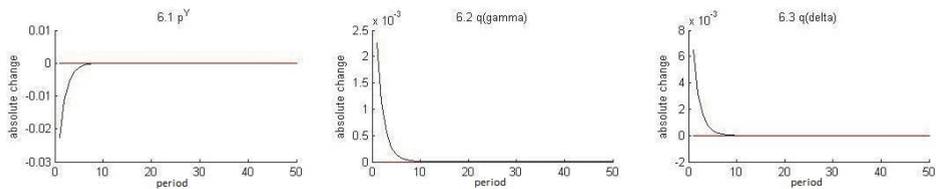
As might be expected, increase in productivity increases overall production. It also has a positive effect on the amount of consumer goods farmers supply to the consumer goods market. Due to increased supply the price of consumer goods decreases. Finally, the productivity shock affects the other variables such as interest rates and exchange rate, but the effect is so small that it can be ignored.

The productivity shock reveals the importance of interest rates and especially exchange rate to the duration of the effect of the shock. Since it has very little effect on these variables the shock affects the system for a very short period.

Graph 6.1 – change of p^Y due to the change of A

Graph 6.2 - change of q^Y due to the change of A

Graph 6.3 - change of q^δ due to the change of A



Source: Author's calculation

4.5 Regulatory Shock

The following simulation shows the effect of an unexpected 1% increase of the default penalty to yeoman farmer γ (τ^Y) in the initial period. Graphs 7.1 to 7.18 summarize the effects of the regulatory shock at the beginning of the first period.

As might be expected, an increase in the default penalty enhances the debt repayment rate of yeoman farmer γ . However, in the initial period the repayment rate stays at the steady-state level and increases only after the initial period. This is because yeoman farmer γ does not have strategic space to increase his repayment rate, due to the decisions he made in the previous period. Only after the occurrence of the shock can he change his previous decision and decrease the level of default. This is the reason yeoman farmer γ 's default starts to decrease after the first period.

Due to the prospective increase in γ 's repayment rate, the commercial bank is willing to borrow more from the Central Bank and parent company. Hence, it provokes an increase in the interbank market interest rate and a decrease in the exchange rate. It also has a negative effect on the domestic financial market interest rate, because the amount of funds available for lending increases.

Similarly to the case of negative monetary shock, exchange rate decrease drives down wages, the amount of labour household α sends to the labour market, and overall production and consumption. The reduced budget of household α has a negative effect on the price of consumer goods. Furthermore, the lower exchange rate increases the repayment rate of yeoman farmer δ and the commercial bank. Since the amount of euro-indexed loans is much greater than the amount of loans in domestic currency, the repayment rate of the commercial bank follows the pattern of yeoman farmer δ 's repayment rate.

Finally, after the initial shock the variables converge slowly to a steady state. However, some of the variables do not start to converge immediately after the first period. Because the foreign exchange rate increases faster than the amount of money that the commercial bank borrows from its parent company decreases, the amount of money the commercial bank offers on the domestic financial market increases. This is the reason why some of the variables, e.g., r^{RSD} and b^y , diverge from the steady state after the initial shock, and then start to converge.

Regulatory shock proves the findings from the monetary shock. The importance of the exchange rate is shown once again, since the level of production decreases despite the decrease in the interest rate in the domestic financial market. Also, it is shown that default in the whole system strongly depends on the level of default on the euro-indexed loans.

Graph 7.1 – change of p^Y due to the change of τ^Y

Graph 7.2 - change of p^I due to the change of τ^Y

Graph 7.3 - change of r^{IB} due to the change of τ^Y

Graph 7.4 - change of r^{RSD} due to the change of τ^Y

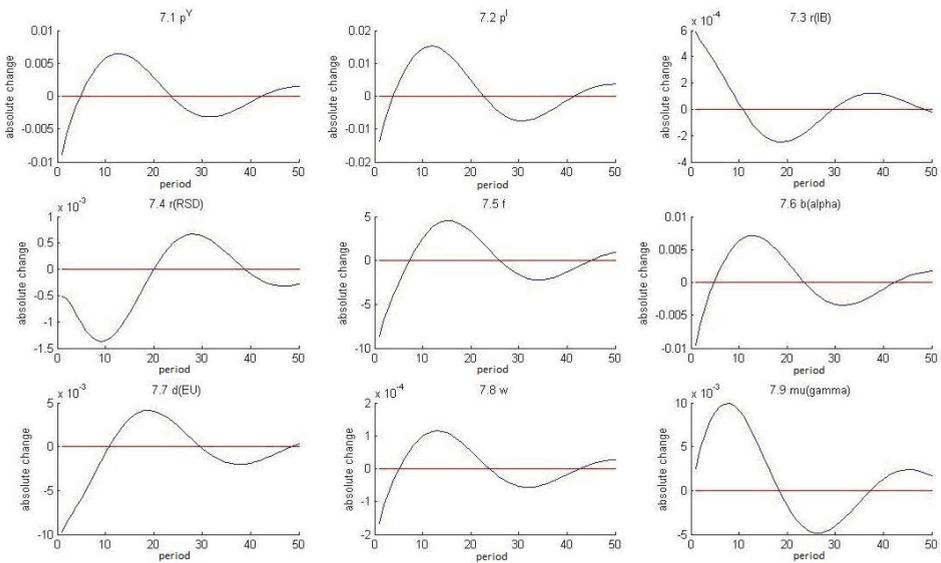
Graph 7.5 - change of f due to the change of τ^Y

Graph 7.6 - change of b^α due to the change of τ^Y

Graph 7.7 - change of d^{EU} due to the change of τ^Y

Graph 7.8 - change of w due to the change of τ^Y

Graph 7.9 - change of μ^Y due to the change of τ^Y



Source: Author's calculation

Graph 7.10 – change of b^{γ} due to the change of τ^{γ}

Graph 7.11 - change of v^{γ} due to the change of τ^{γ}

Graph 7.12 - change of q^{γ} due to the change of τ^{γ}

Graph 7.13 - change of v^{δ} due to the change of τ^{γ}

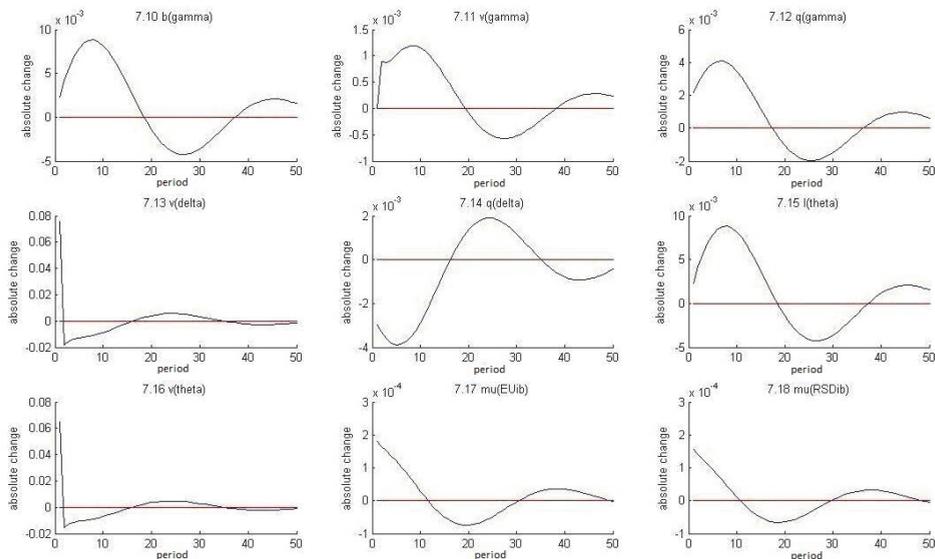
Graph 7.14 - change of q^{δ} due to the change of τ^{γ}

Graph 7.15- change of l^{θ} due to the change of τ^{γ}

Graph 7.16 - change of v^{θ} due to the change of τ^{γ}

Graph 7.17- change of $\mu^{IB,EU}$ due to the change of τ^{γ}

Graph 7.18 - change of μ^{IB} due to the change of τ^{γ}



Source: Author's calculation

5. CONCLUSION

In this paper the inability of existing DSGE models to depict the Serbian economy is emphasized. This inability is attributed to a lack of specific features that significantly impact the operation of the Serbian economy, such as financial dollarization and foreign ownership of the banks. Here these features are applied, producing a model that can be applied to the Serbian economy.

The proposed model shows that the interest rate channel has relatively low impact on economic activity, firstly because most of the assets are denominated

in foreign currency and change of the reference rate does not affect the international interest rate on which they rely, and secondly because the alternative source of funding hinders the transmission of the impulse from reference rate to interest rates on commercial loans.

On the other hand, the foreign exchange rate is shown to have a very important role. Firstly, its change affects the level of the default and its transmission throughout the system. Hence there is a link between exchange rate risk and default risk. Secondly, it has an effect on the level of activity in the economy through its effect on the wealth of the agents in the model.

Finally, it is shown that banks are less sensitive to the amount of liquidity the Central Bank provides to the system when they have an alternative source of funding. However, it also leads to the conclusion that the Central Bank has difficulty regulating the level of liquidity in the system when banks have an alternative source of financing.

The application of the additional features did not affect the main characteristics of the reference models. Firstly, the structure of the model has not changed drastically. Secondly, financial frictions still exist and still play a crucial role in the functioning of the system. Finally, the system is still non-dichotomous in the short run.

However, these results are obtained by making some assumptions and simplifications. These assumptions and simplifications represent the limitations of the model, although they are crucial for the existence of the same. Furthermore, the parameters have a degree of subjectivity, so the strength of the reaction to the shock and the process of return to the steady state have a dose of arbitrariness. On the other hand, methods based on Bayesian interference or maximum likelihood can be used for finding parameters. However, their application might be hindered by the lack of relevant data.

The proposed model incorporates elements of the Serbian economy and its findings are in accordance with the characteristics of the Serbian economy outlined at the beginning of the paper and basic economic logic. Hence, it can be said that the reference model, with the modifications made, is applicable to the Serbian economy. However, further research is still needed. One direction

for further research should be related to overcoming the assumptions and simplifications which are the limitations of the model. Another possible direction is the calibration and parameterization of the model. Given that DSGE models that rely on the work of Goodhart and Tsomocos are still in the development stage, calibration and parameterization could be the field for further development of all these models.

In the end it can be concluded that, although the proposed model has good characteristics, it should be regarded just as a first step in the application of DSGE models to the Serbian economy. Complete application of the DSGE approach to the Serbian economy requires further research in the directions proposed in this paper.

REFERENCES:

Adjemian S., Bastani H., Juillard M., Karame F., Mihoubi F., Perendia G., Pfeifer J., Ratto M. and Villemot S. (2011), *Dynare: Reference Manual, Version 4, Dynare Working Papers*, Paris : CEPREMAP

Aleksić, M., Đurđević, Lj., Palić, M. and Tasić, N. (2008) Interest Rate Transmission in a Dollarized Economy: The Case of Serbia, *NBS Working Paper September 2008*, Belgrade: National Bank of Serbia

Alvarez-Plata P., Garcia-Herrero A. (2008) To Dollarize or De-dollarize: Consequences for Monetary Policy. *Discussion Papers of DIW Berlin 842*, Berlin: German Institute for Economic Research

Bernanke B, and Gertler M (1989) Agency Costs, Net Worth, and Business Fluctuations. *American Economic Review 79 (March)*, Nashville and Pittsburgh: American Economic Association, pp. 14–31

Bernanke, B., Gertler M, and Gilchrist S. (1999) The Financial Accelerator in a Quantitative Business Cycle Framework, in J. Taylor and M. Woodford (eds.) *Handbook of Macroeconomics Volume 1C*, Amsterdam: North Holland Publishing.

Božović M, Urošević B, Živković B. (2009) On the Spillover of Exchange Rate Risk into Default Risk, *Economic Annals 183*, Belgrade: Faculty of Economics, pp. 32–55

Brunnermeier M, Eisenbach T, and Sannikov Y. (2012) Macroeconomics with financial frictions: A survey. *No. w18102. National Bureau of Economic Research*, Cambridge: NBER

- Castillo P., Montoro C. and Tuesta V. (2006) An estimated stochastic general equilibrium model with partial dollarization: a Bayesian approach, *Central Bank of Chile Working Papers No. 381*, Santiago: Central Bank of Chile
- Dragutinović D. (2008) Power and Weakness of Monetary Policy in Striking a Balance Between Balance of Payments and Inflation-Related Objectives, *NBS working paper*, Belgrade: National Bank of Serbia
- Dubey P. and Geanakoplos J. (2003) Monetary Equilibrium with Missing Markets. *Journal of Mathematical Economics* 39, New York: Elsevier, pp. 585-618
- Goodhart C.A.E, Osorio C., Tsomocos D (2009) Analysis of Monetary Policy and Financial Stability: A New Paradigm, *CESifo Working Paper No. 2885*, Munich: CESifo Group Munich
- Juillard M. (2001) DYNARE: A program for the simulation of rational expectation models, *Computing in Economics and Finance 2001*, USA: Society for Computational Economics
- Kiyotaki N, and Moore J (2012) Liquidity, Business Cycles and Monetary Policy, *No. w17934. National Bureau of Economic Research*, Cambridge: NBER
- Levy Yeyati, E. (2006) Financial Dollarization: evaluating the consequences. *Economic Policy* 21, no 45, Malden: John Wiley and Sons, pp. 61-118
- Martinez J-S. and Tsomocos D. (2012) Liquidity Effects on Asset Prices, Financial Stability and Economic Resilience, *mimeo*, Oxford: University of Oxford
- Miguel S. (1996) Dollarization in Latin America: Recent Evidence and Some Policy Issues.. *IMF Working Paper. WP/96/4: iii.*, Washington DC: International Monetary Fund
- National Bank of Serbia (2012) THE BANKING SECTOR IN SERBIA: Third Quarter Report 2012, Belgrade: National Bank of Serbia
- Quadrini V. (2011) Financial Frictions in Macroeconomic Fluctuations. *FRB Richmond Economic Quarterly*, vol. 97, no. 3, Third Quarter 2011, Richmond: FED Richmond, pp. 209-254
- Tovar, C. E. (2009) DSGE models and central banks, *Economics: The Open-Access, Open-Assessment E-Journal*, Kiel, pp. 1-31
- Tsenova Ts. (2012) International Monetary Transmission with Bank Heterogeneity and Default Risk, *Annals of Finance*, Berlin and Heidelberg: Springer
- Tsomocos D. (2003) Equilibrium Analysis, Banking, and Financial Instability. *Journal of Mathematical Economics*, 39 (5-6), New York: Elsevier, pp. 619-655

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