Open DSGE model with firm's owned capital

Ivashchenko Sergey
Saint-Petersburg State University, Saint-Petersburg, Russia.

Abstract

This paper presents open DSGE model with firm's owned capital. This model includes some unusual features except firm's owned capital. The model is estimated by ML method for Russia and USA. Some features of the model a statistically checked. IRFs and variance decomposition are calculated. They show flexibility of the model and huge difference between USA and Russia.

JEL classification: E2-E4

Keywords: DSGE models; firms' dynamics; IRF; variance decomposition; USA; Russia;

Introduction

One of the most popular approaches for analysis of macroeconomic environment is researching of dynamic stochastic equilibrium models. This type of models is the base of modern macroeconomic theory.

How can DSGE models help in macroeconomic analysis? First of all, DSGE models are the telling story instrument. These models explain and understand macroeconomic fluctuations using a coherent theoretical framework [Adolfson, Lindé etc. (2007)]. In the 1990s the view was that it is the main (possible unique) usage of DSGE models [Del Negro and Schorfheide (2006)].

Another usage is forecasting. The new generation of closed economy DSGE models compare very well with vector autoregressive (VAR) models in terms of forecasting accuracy [Adolfson, Lindé etc. (2007)]. More over, these models forecasts are close to surveys results (the Philadelphia Fed Survey of Professional Forecasters) [Rubaszek and Skrzypczyński (2008)].

DSGE models could be used for optimal policy of government forming. There are a lot of articles which concerns optimal monetary policy. They use different criterions of optimality (from inflation targeting till householders optimum). The main reason of such usage is that DSGE models are based on deep parameters of preferences and technology. The micro foundations imply that the structural parameters are more likely to be invariant to various policy interventions the policy makers may want to consider [Smets and Wouters (2004)].

Thus DSGE modeling can be useful in different ways. But the goal of this paper is to better understand the dynamic behavior of aggregate variables (especially inflation). We develop a small open economy DSGE model.

What is the difference between our model and other? There are a lot of common features at majority of DSGE models. One of these features is householders which own real capital. They make decision about real investments. This common assumption doesn't look like realistic. Usually, capital is owned by firms in the real world. They make real investment decisions. Householders make only financial investments. In the model they can buy (or sell) bonds or equities. It is the first feature of our model.

There are some models with such feature. But they aren't common. Articles of Giuli and Tancioni or De Graeve etc. are good examples of models with firms owned capital. Hence, financial investments of householders aren't clear described in Giuli and Tancioni's model (Householders doesn't invest to equities) [Giuli and Tancioni (2009)]. De Graeve etc. are focused on behavior of financial variables. Moreover, De Graeve etc. don't estimate the model [De Graeve, Dossche etc. (2008)]. It happens because of complicity of the model and interest in higher order behavior of model. Thus, papers with the same feature are different in the other one.

Another one common feature is firms which haven't access to bond market. It doesn't look like realistic especially in context of current crises. So, we give such possibility for firms. But probability of bankruptcy isn't added into the model for simplicity reasons. This is the second big difference of the model. There are a lot of smaller differences such as interest rate as discounting factor.

We estimate the DSGE model for Russia and USA. Quarterly data is used for estimation. After that impulse response and variance decomposition are analyzed for each country. A lot of differences between countries were revealed.

Model

The open DSGE model includes 4 types of agents: householders, firms, government and foreign sector. Householders maximize expected sum of discounted utility functions (1) with budget restriction (2). Householders don't own capital but they can buy domestic and foreign stocks and bonds for saving money. It should be noted that householders doesn't like to use foreign assets. Householders consume continuous set of goods (C_t represents consumption basket which definition is based on CES-function (3)).

$$E_0 \sum_{t=0}^{\infty} \beta^t \begin{pmatrix} \ln(C_t) + \frac{Z_{H,t}}{\psi}\left(\frac{C_t}{C_{t-1}}\right)^{\psi} - \frac{(Z_{L,t}L_t)^{1+\omega}}{1+\omega} + Z_{M,t}\ln\left(\frac{M_t}{P_t}\right) - \\ -\frac{\phi_{H,B}}{2}\left(\frac{F_t B_{H,F,t}}{M_t}\right)^2 - \frac{\phi_S}{2}\left(X_{H,F,t}\right)^2 \end{pmatrix} \rightarrow \max_{C;M;B;X;L} \quad (1)$$

$$P_t C_t + \begin{pmatrix} B_{H,D,t} + F_t B_{H,F,t} + \\ + S_{D,t} X_{H,D,t} + \\ S_{F,t} X_{H,F,t} + M_t \end{pmatrix} = (1 - T_{L,t}) W_t L_t + \begin{pmatrix} R_{D,t-1} B_{H,D,t-1} + F_t R_{F,t-1} B_{H,F,t-1} + \\ + (S_{D,t} + D_{D,t}) X_{H,D,t-1} + \\ + (S_{F,t} + D_{F,t}) X_{H,F,t-1} + M_{t-1} \end{pmatrix} \quad (2)$$

, where C_t – value of consumption goods basket at period t, L_t – labor supply at period t, M_t – money stock at period t, P_t – price of goods basket at period t, F_t – exchange rate at period t (number of domestic currency units for one foreign currency unit), $B_{H,F,t}$ – value of foreign bonds bought by householders at period t, $X_{H,F,t}$ – number of foreign equities bought by householders at period t, $B_{H,D,t}$ – value of domestic bonds bought by householders at period t, $S_{D,t}$ – price of domestic equities at period t, $X_{H,D,t}$ – number of domestic equities bought by householders at period t, $S_{F,t}$ – price of foreign equities at period t, $T_{L,t}$ – payroll tax at period t, $R_{D,t}$ – interest rate on domestic bonds at period t, $R_{F,t}$ – interest rate on foreign bonds at period t, $D_{D,t}$ – dividends of domestic equities at period t, $D_{F,t}$ – dividends of foreign equities at period t.

Value of consumption goods determines according to CES function:

$$C_t = \left(\omega_D^{1/\theta} \int_0^1 C_{D,j,t}^{(\theta-1)/\theta} dj + (1-\omega_D)^{1/\theta} \int_0^1 C_{F,j,t}^{(\theta-1)/\theta} dj \right)^{\theta/(\theta-1)} \quad (3)$$

, where $C_{D,j,t}$ – consumption of domestic j-th firms goods at period t, $C_{F,j,t}$ –

consumption of foreign j-th firms goods at period t.

Minimization of expenditure for such goods basket leads to the following demand functions and price level:

$$C_{D,j,t} = \omega_D \left(\frac{P_{D,j.t}}{P_t} \right)^{-\theta} C_t \tag{4}$$

$$C_{F,j,t} = (1-\omega_D)\left(\frac{P_{F,j.t}}{P_t} \right)^{-\theta} C_t \tag{5}$$

$$P_t = \left(\omega_D \int_0^1 P_{D,j,t}^{1-\theta} dj + (1-\omega_D) \int_0^1 P_{F,j,t}^{1-\theta} dj \right)^{1/(1-\theta)} \tag{6}$$

Most features of householder's problem are common for DSGE models. But there are few unusual details. The first of them is absence of real capital under householder's control. The second are financial investments of householders. Householders could own equity of foreign and domestic firms. They are also able to but (or sell) bonds in domestic and foreign currency, but this detail is more common. The third is rigidity of foreign asset position. Householders don't like to have any foreign assets. This feature is forced because foreign sector is fully exogenous.

Firms maximize expected discounted dividend flow (7) with restrictions. Firms are working at the monopolistic competition market. Demand for those product (8) forms according to the optimal basket structure for each agent. Budget restriction (9) and restriction of capital evolution are common. However, production function (10) includes price, output and dividend adjustment costs. It also includes costs of bond position difference from conventional level. Firms also have additional resource at production function. It is semi finished goods $Y_{j,DD,t}$.

$$E_0 \sum_{t=0}^{\infty} \left(\prod_{\tau=0}^{t-1} R_{D,\tau} \right)^{-1} (D_{j,t}) \to \max_{D;L;I;B;Y;Y_{DD};K;P} \tag{7}$$

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\theta} (\omega_D C_t + \omega_D I_t + \omega_D Y_{DD,t}) + \left(\frac{P_{j,t}}{P_{D,t}} \right)^{-\theta} G_t + \left(\frac{P_{j,t}}{P_{F,t}} \right)^{-\theta} (Y_{F,t}) \tag{8}$$

$$D_{j,t} + P_t I_{j,t} + P_t Y_{j,DD,t} + B_{j,t} + W_t L_{j,t} = P_{j,t} Y_{j,t} + R_{t-1} B_{j,t-1} \tag{9}$$

$$Y_{j,t}\left(\begin{aligned}&1+\varphi_P\left(\ln\left(\frac{P_{j,t}}{P_{j,t-1}}\right)-\overline{p}\right)^2+\varphi_Y\left(\ln\left(\frac{Y_{j,t}}{Y_{j,t-1}}\right)-\overline{y}\right)^2+\\&+\varphi_B\left(\frac{B_{j,t}}{P_{j,t}Y_{j,t}}-Z_{D,B,t}\right)^2+\varphi_D\left(\ln\left(\frac{D_{j,t}}{D_{j,t-1}}\right)-\overline{p}-\overline{y}\right)^2\end{aligned}\right)=Z_{Y,t}L_{j,t}^{\alpha_L}K_{j,t-1}^{\alpha_K}Y_{j,DD,t}^{1-\alpha_L-\alpha_K} \quad (10)$$

$$K_{j,t}=(1-\delta)K_{j,t-1}+I_{j,t} \quad (11)$$

, where $D_{j,t}$ – dividends of firm j at period t, $Y_{j,t}$ – output of firm j at period t, $P_{j,t}$ – price for goods of firm j at period t, I_t – demand for investments goods at period t, $Y_{DD,t}$ – demand for semi finished goods at period t, G_t – government expenditure at period t, $P_{D,t}$ – price level for domestic goods at period t, $P_{F,t}$ – price level for foreign goods at period t, $Y_{F,t}$ – foreign demand for domestic goods at period t, $I_{j,t}$ – investments of firm j at period t, $Y_{j,DD,t}$ – demand for semi finished goods from firm j at period t, $B_{j,t}$ – value of domestic bonds bought by firm j at period t, K_j,t – amount of capital used by firm j at period t, $L_{j,t}$ – amount of labor used by firm j at period t.

There are some unusual features in the firm's problem. The first feature is capital owned by firms. Existence of real investment is consequence of this feature. The second is that firms are able to buy (sell) domestic bonds. The third is semi-finished goods as input of production function. The fourth is rigidity in the production function. It's impossible to add rigidity into budget restriction because it eliminates colinearity of budget restrictions. That is why rigidity is added into production function. It should be noted that rigidity of bond position could be interpreted as conventional level of debt pressure.

Government makes its decisions according to policy rules and budget restriction. Government has following budget restriction:

$$P_{D,t}G_t+B_{G,D,t}+F_tB_{G,F,t}=T_{L,t}W_tL_t+\left(\begin{aligned}&R_{D,t-1}B_{G,D,t-1}+\\&+F_tR_{F,t-1}B_{G,F,t-1}+\\&+M_t-M_{t-1}\end{aligned}\right) \quad (12)$$

Monetary policy rule:

$$\ln(R_{D,t})=\gamma_p\ln\left(\frac{P_t}{P_{t-1}}\right)+\gamma_Y\ln\left(\frac{Y_t}{Y_{t-1}}\right)+Z_{R,t} \quad (13)$$

Taxation rule:

$$W_t L_t T_{L,t} = -\gamma_B \left(B_{G,D,t} + F_t B_{G,F,t}\right) + \gamma_G P_{D,t} G_t + P_t Y_t Z_{T,t} \tag{14}$$

Rule of government debts structure:

$$Z_{G,B,t} B_{G,D,t} = F_t B_{G,F,t} \tag{15}$$

Government expenditures are exogenous. AR(1) process describes it. There is one uncommon feature in the government. Government has position in domestic and foreign bonds. This is uncommon for developed countries but common for developing.

Foreign sector is fully exogenous. It has following demand for domestic goods of firm j:

$$\left(\frac{P_{j,t}}{P_{F,t}}\right)^{-\theta} \left(Y_{F,t}\right) \tag{16}$$

$$\frac{Y_{F,t}}{Y_t} = Z_{F,Y,t} \tag{17}$$

Price level for foreign goods is following:

$$\frac{P_{F,t} F_{t-1}}{F_t P_{F,t-1}} = Z_{F,P,t} \tag{18}$$

, where $Z_{F,Y,t}$, $Z_{F,P,t}$ are exogenous process AR(1).

Foreign sector has access and interest on financial markets. It’s position in equities and bond describes by following rules:

$$\frac{B_{F,D,t}}{P_{F,t} Y_{F,t}} = Z_{F,B,t} \tag{19}$$

$$X_{F,D,t} = Z_{F,X,t} \tag{20}$$

, where $Z_{F,B,t}$ and $Z_{F,X,t}$ are exogenous process AR(1).

Prices and dividends of foreign equities are exogenous:

$$\frac{D_{F,t}}{P_{F,t} Y_{F,t}} = Z_{F,D,t} \tag{21}$$

$$\frac{S_{F,t}}{P_{F,t} Y_{F,t}} = Z_{F,S,t} \tag{22}$$

Foreign sector has budget restriction which automatically true (because of budget restrictions of other agents):

$$\begin{pmatrix} P_{F,t}\left(\frac{P_{D,t}}{P_{F,t}}\right)^{-\theta} Y_{F,t} + \\ + D_{F,t} \end{pmatrix} + \begin{pmatrix} S_{D,t}X_{F,D,t} + \\ + S_{F,t}X_{F,F,t} + \\ + B_{F,D,t} + \\ + F_t B_{F,F,t} \end{pmatrix} = \begin{pmatrix} P_{F,t} \cdot \\ \cdot \left(\frac{P_{F,t}}{P_t}\right)^{-\theta} \cdot \\ \cdot (1-\omega_D) \cdot \\ (C_t + I_t + Y_{DD,t}) \end{pmatrix} + \begin{pmatrix} (S_{D,t} + D_{D,t})X_{F,D,t-1} + \\ + (S_{F,t} + D_{F,t})X_{F,F,t-1} + \\ + R_{D,t-1}B_{F,D,t-1} + \\ + F_t R_{F,t-1}B_{F,F,t-1} \end{pmatrix} \quad (23)$$

There are few balance restrictions:

$$Y_t = C_t + I_t + G_t \quad (24)$$

$$P_t = \left(\omega_D P_{D,t}^{1-\theta} + (1-\omega_D)P_{F,t}^{1-\theta}\right)^{1/(1-\theta)} \quad (25)$$

$$X_{H,F,t} + X_{F,F,t} = 1 \quad (26)$$

$$X_{H,D,t} + X_{F,D,t} = 1 \quad (27)$$

$$B_{G,D,t} + B_{F,D,t} + B_{H,D,t} + B_{D,t} = 0 \quad (28)$$

$$B_{G,F,t} + B_{F,F,t} + B_{H,F,t} = 0 \quad (29)$$

Optimal conditions in terms of stationary variables are presented in appendix 1. Linkage between stationary variables and usual one are presented in appendix too.

Results

The DSGE model which is described above is estimated for Russia and USA. Maximum likelihood method with measurement errors is used to estimate linear approximation. The following datasets are used for USA: real and nominal GDP, consumption, investments, government expenditure, export, import growth, nominal compensation for employees, all employees, average nominal wage, money measure M1, LIBOR 3M, MSCI USA, MSCI world ex USA, nominal broad dollar index. The data was from Q1 1975 till Q4 2008 (139 observation). The log-likelihood is equal to 8260,325. The results of estimation are presented in appendix 2.

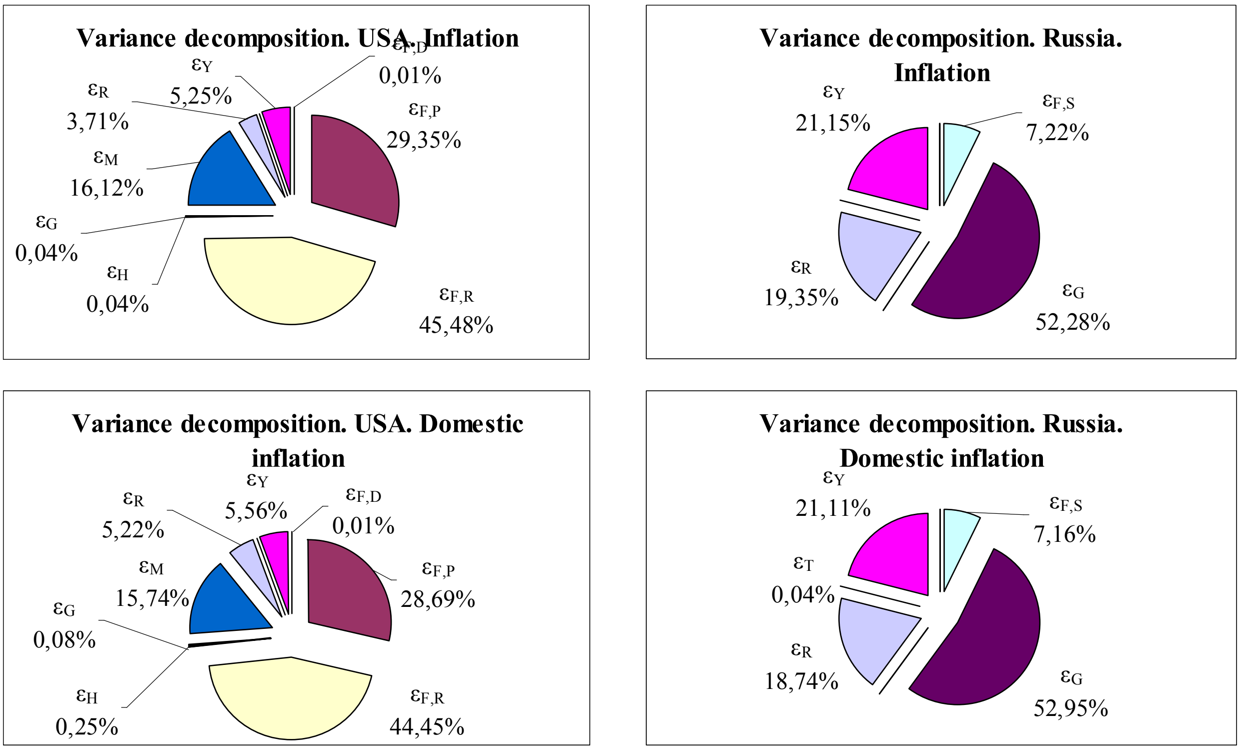
For Russia data was from Q1 1999 till Q4 2008 (39 observation). The following datasets are used for Russia: real and nominal GDP, consumption, investments, government expenditure, export, import growth, nominal compensation for employees, all employees, nominal wage, money measure M0, average of MIBOR and MIBID, MSCI Russia, MSCI AC World, USDRUR. The log-likelihood is equal to 1077,91. The results of estimation are presented in appendix 2.

It should be noted that analytical steady state wasn't found. It makes any calculation of model slow. Few equations were linearized around parameterized point instead of steady state. It leads to huge calculation speed improving because of finding analytical steady state for other variables.

Some comments about parameters values would be done. This model has few features which could be statistically checked easily. First of them is rigidity of householder's foreign asset position. Corresponding parameters are statistically significant for USA. One of rigidity parameters is significant for Russia. It shows that rigidity of householder's foreign asset position exists. It shows indirectly that householder's foreign asset position significant for model.

Another feature is bond position of firms. Significant parameter (for Russia and USA) of corresponding rigidity indirectly shows significance of this feature. Adding of semi finished goods into production function is statistically significant for Russia and USA. Situation with government position in foreign bonds is really interesting. Mean of process $Z_{G,B,t}$ is significant for USA and insignificant for Russia. It's possible to explain such situation for Russia. At the beginning of observation period foreign bond position of government was negative. At the end of observation period foreign bond position of government was positive. Domestic bond position of government was negative during all observation period. So, it's possible that average ratio of domestic and foreign bonds is zero. Another explanation is incorrect form of dependence between foreign and domestic bond position of government. Thus most features of the model are statistically significant. But some features are harder to test. Significance of such features isn't checked.

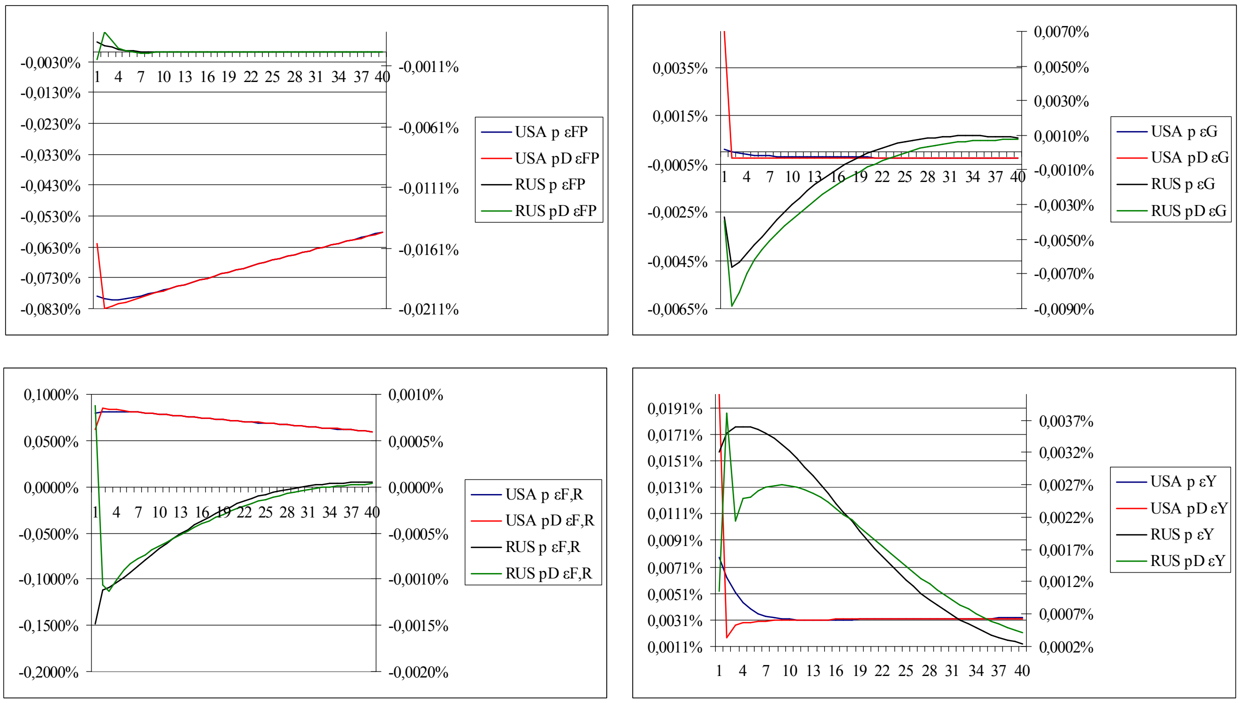
Main interest is behavior of the model. We start from variance decomposition of inflation. The picture is quite different between countries. Only ε_Y and ε_R explain noticeable part of variance in both countries. The difference between domestic inflation and inflation isn't noticeable.



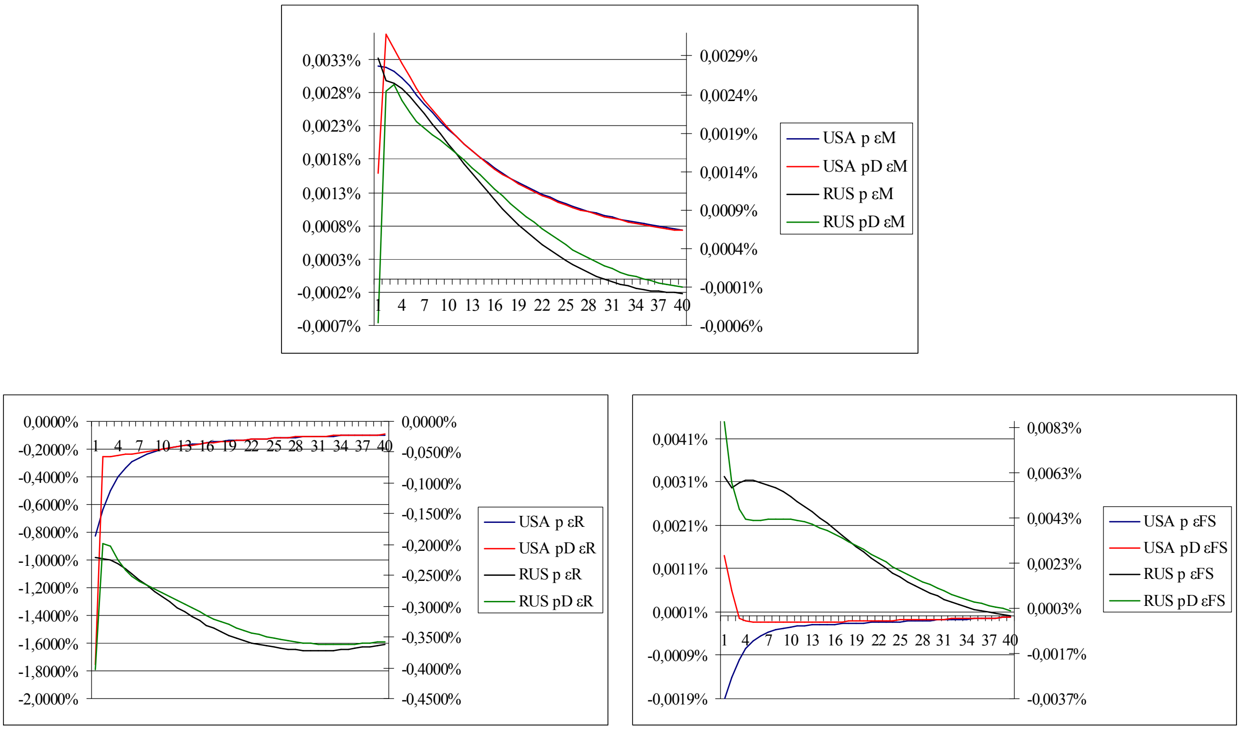
Picture 1 Inflation variance decomposition

IRFs (impulse response function) show difference between USA and Russia. The best example is consequences of government expenditure shock. This shock leads to increase of inflation for a short time in USA. For Russia it leads to decrease of inflation for a long time. It’s unusual situation. Explanation of Russian IRF is following: growth of government expenditure leads to decrease of domestic demand due to taxation and government debts. Decrease of domestic demand leads to decrease of inflation.

Another unusual picture is response for technology shock which leads to higher inflation. The description is following: technology shock leads to growth of domestic production. It leads to growth of demand for inputs of production function. It leads to growth of domestic demand which leads to higher inflation.



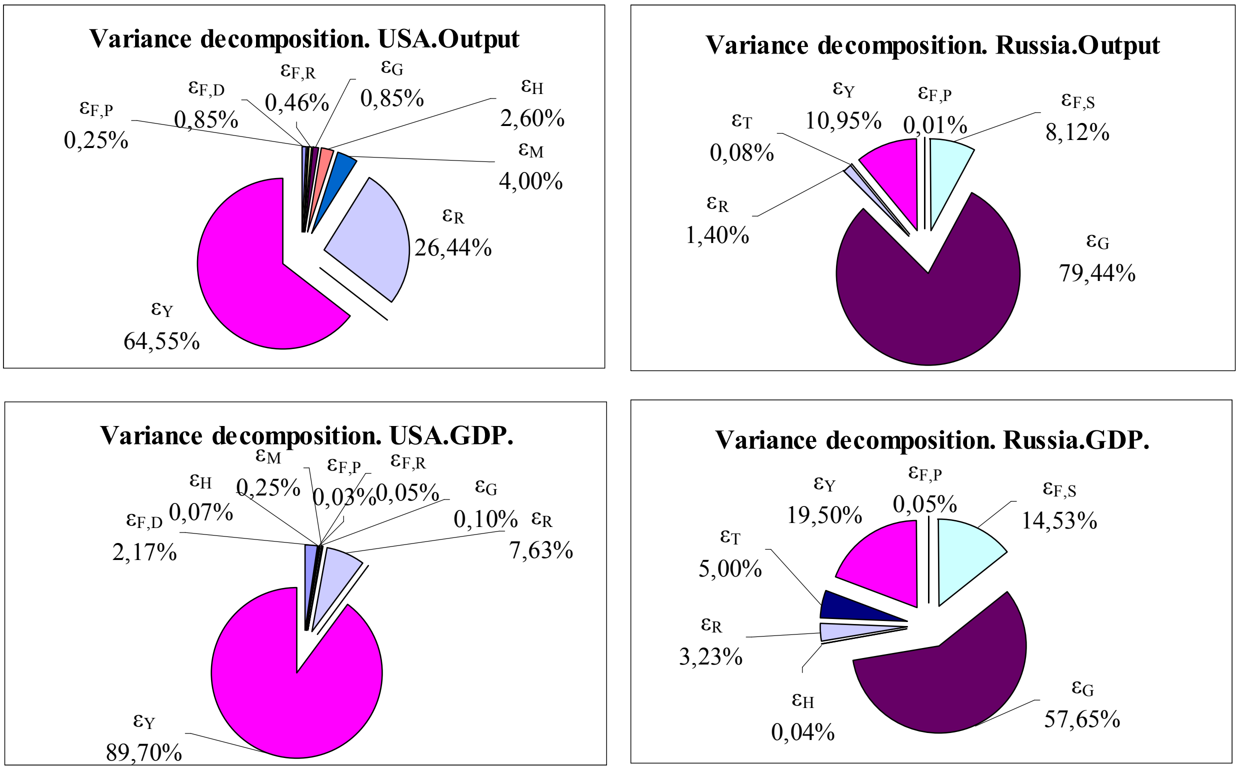
Picture 2 IRFs of inflation and domestic inflation



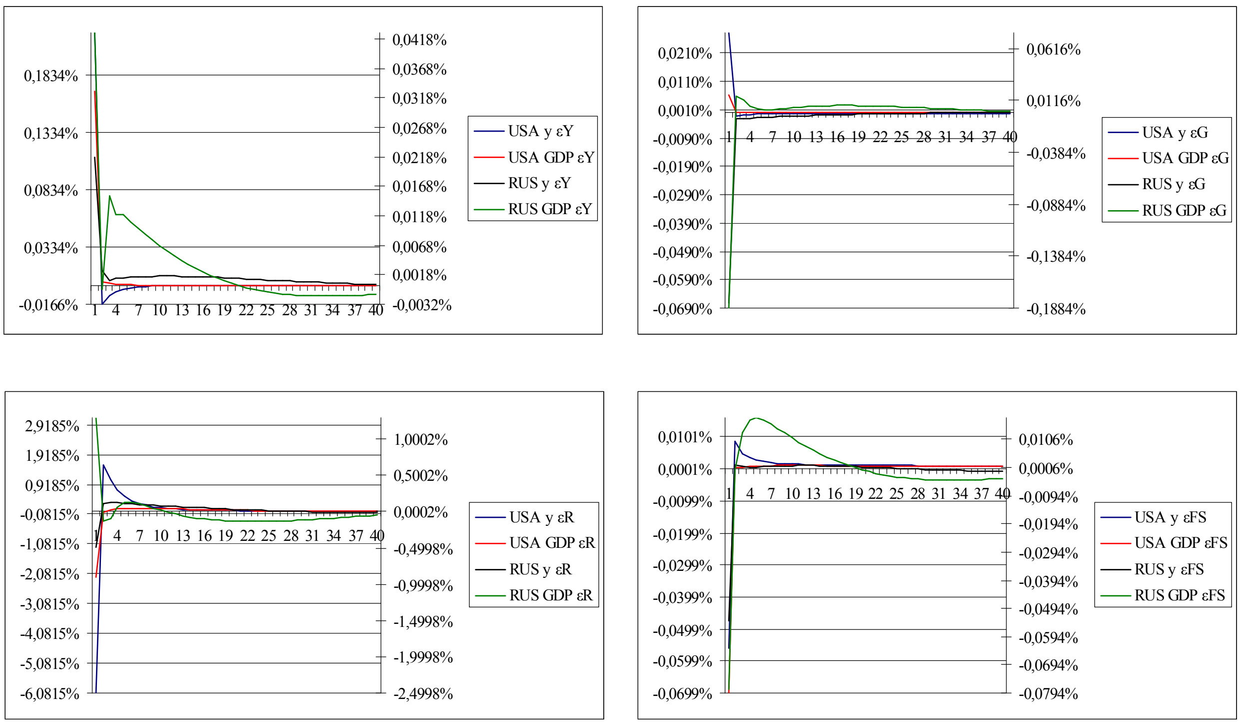
Picture 3 IRFs of inflation and domestic inflation

Variance decomposition of GDP and domestic demand growth shows additional difference between Russia and USA. It also shows difference between GDP and domestic demand.

Consequences of government expenditure shock should be noted. This shock leads to opposite effects in USA and Russia (increase of GDP in USA and Decrease of Russia). This fact could be interpreted as illustration of low efficiency of Russian government expenditure.

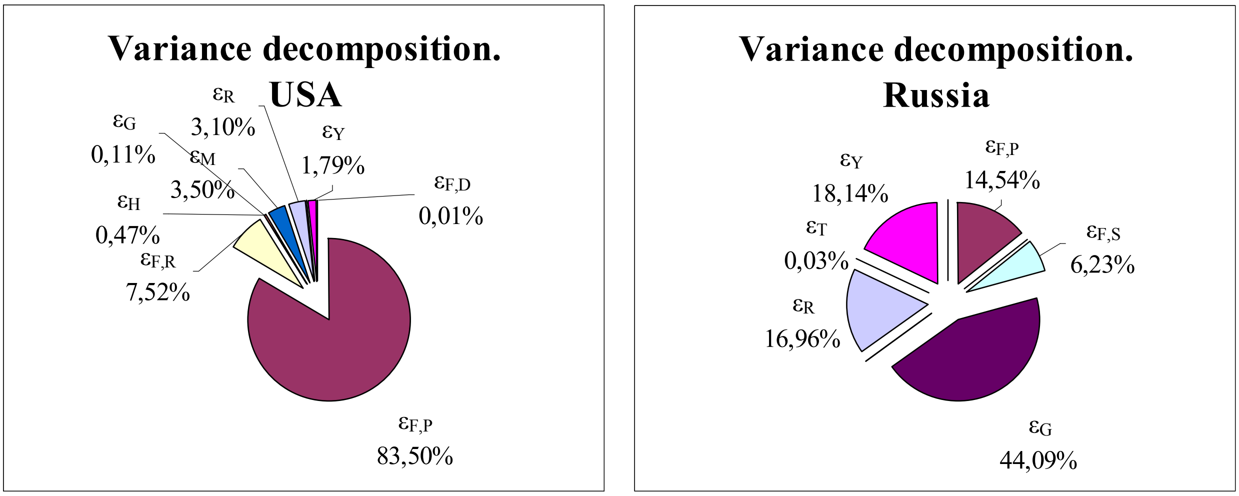


Picture 4 GDP and domestic demand growth variance decomposition

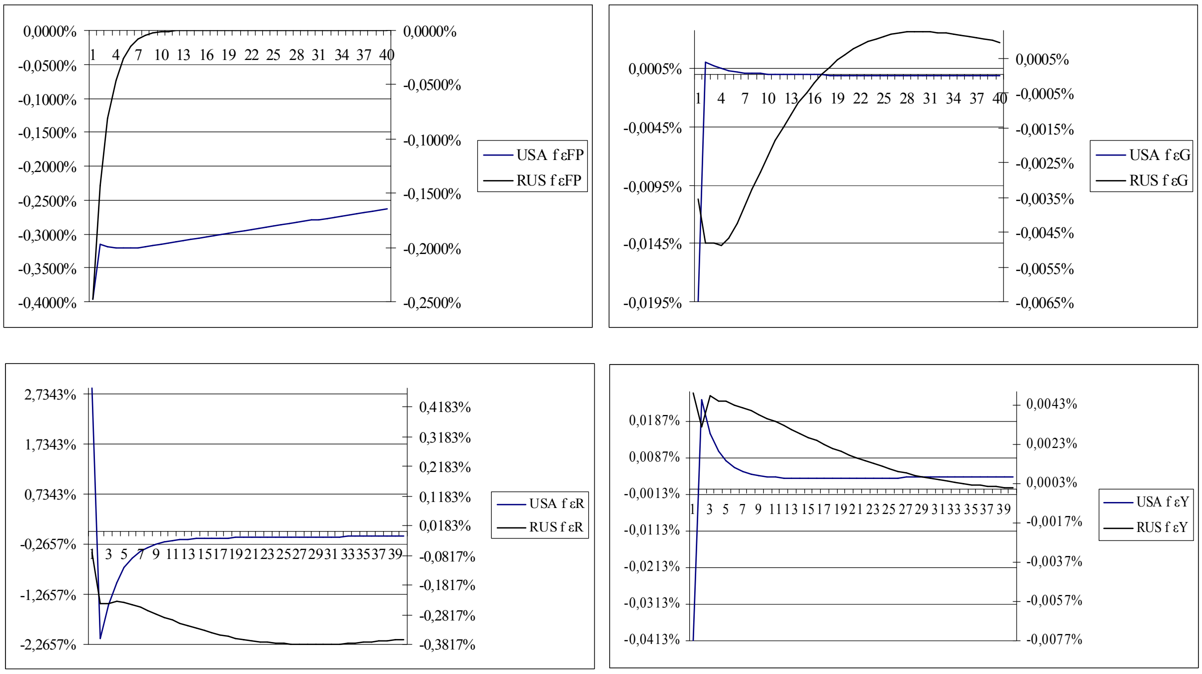


Picture 5 IRFs of GDP and domestic demand growth

Situation with exchange rate is a little bit unusual. It seems that exchange rate variance is result of foreign price shocks in the USA. And domestic factors have low influence. For Russia situation is opposite: domestic factors are main drivers of exchange rate.

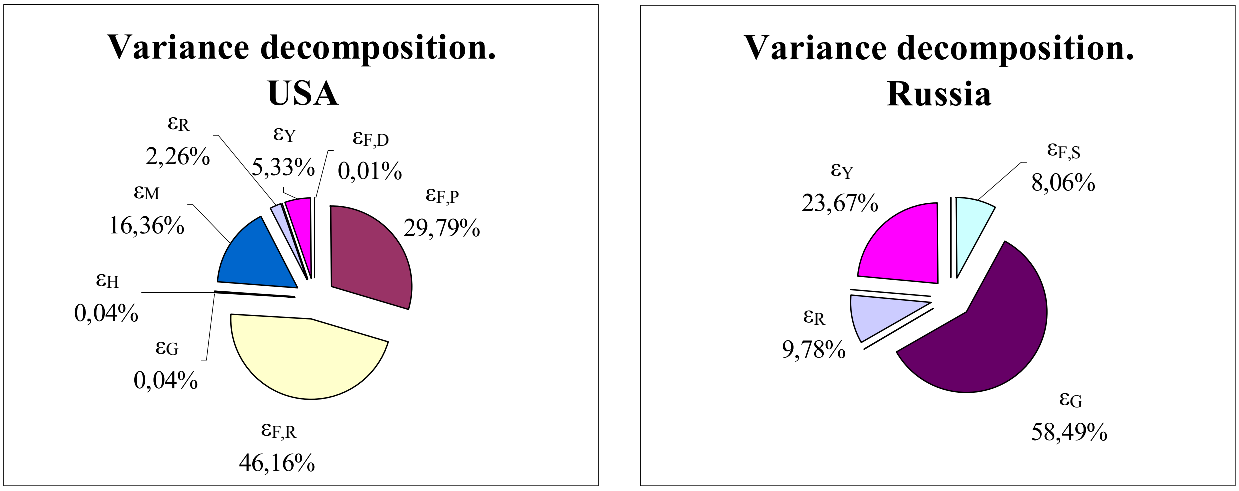


Picture 6 Exchange rate variance decomposition

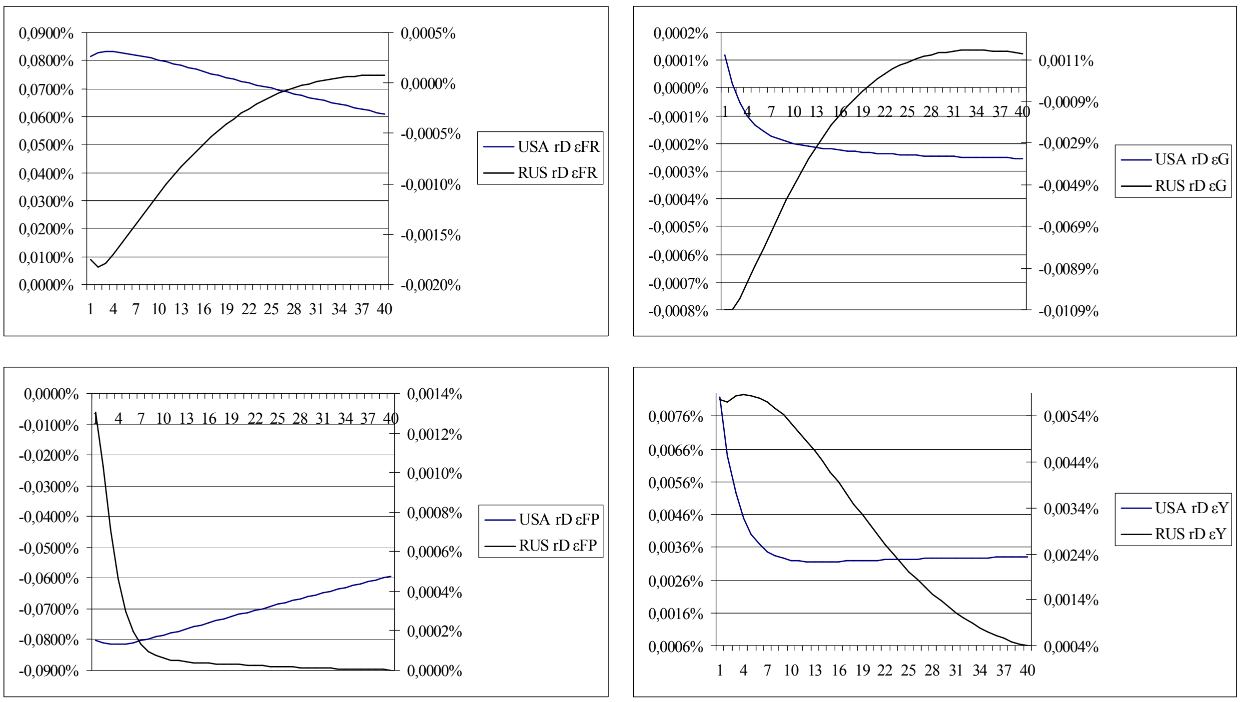


Picture 7 IRFs of exchange rate

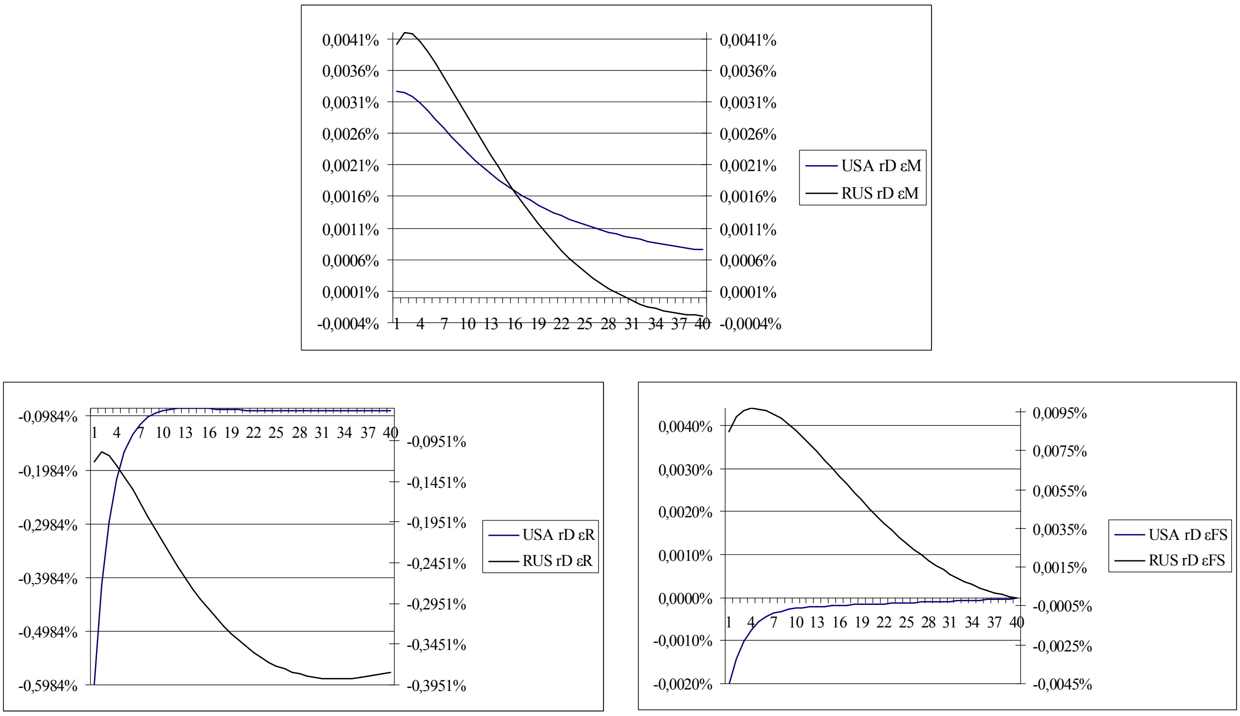
The situation with interest rate (variance decomposition and IRF) is really close to inflation. So, it can be uncommented.



Picture 8 Interest rate variance decomposition

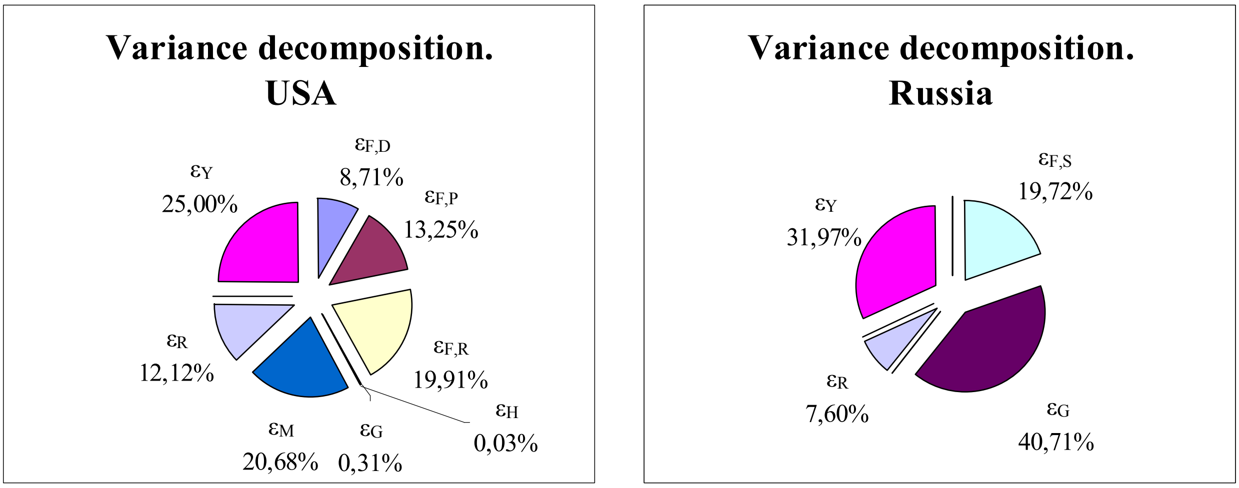


Picture 9 IRFs of interest rate



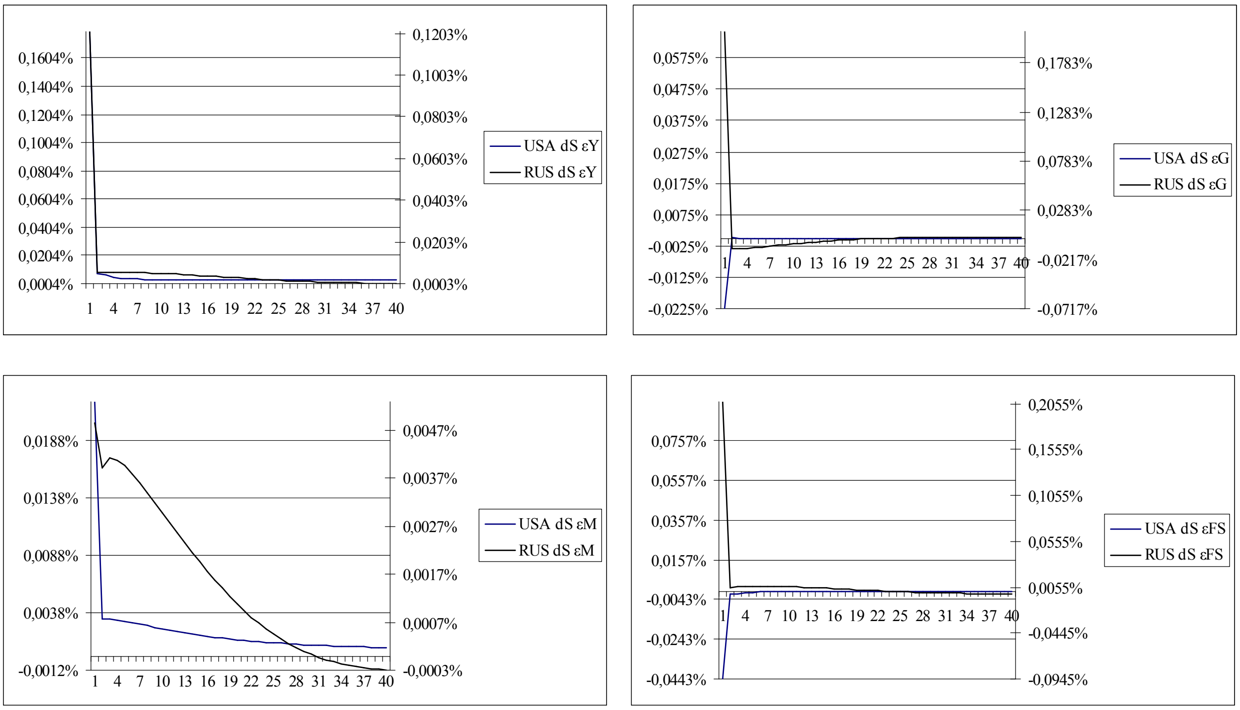
Picture 10 IRFs of interest rate

Equity return is variable that could require comments. First of all we have to understand that expected equity return should be close to interest rate (otherwise householders would greatly change their position in equity which leads to change of equity price). But equity return could differ from interest rate greatly. As result IRFs show that short term effect is high and long term effect is low.

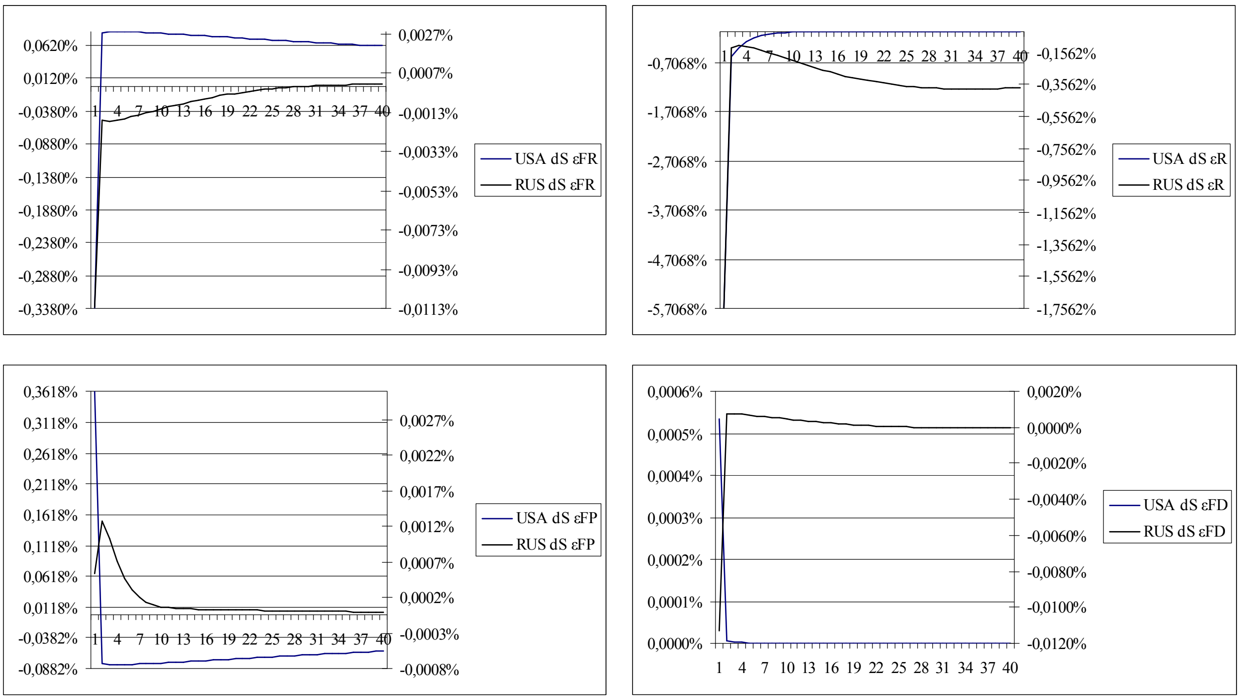


Picture 11 Equity return variance decomposition

The great example here is shock of householder's liquidity preferences. It could appear that long term IRF is differ from IRF of interest rate. At picture 10 responses for USA and Russia are close. At picture 12 they are different. But source of this difference is short term effect which makes scales for Russia and USA different.



Picture 12 IRFs of equity return



Picture 13 IRFs of equity return

Conclusion

At the conclusion main result of the article would be done in the short form:

- The small open economy DSGE model with following unusual features is created:
    1. Capital is owned by firms. Firm makes real investment decision instead of householder.
    2. Householders could own equity of foreign and domestic firms. They are also able to but (or sell) bonds in domestic and foreign currency.
    3. Foreign asset position rigidity of householders.
    4. Firms are able to buy (sell) domestic bonds. There is rigidity of firm's bond position.
    5. Semi-finished goods are input of production function.
    6. Rigidities are added in the production function.
- The model is estimated. Some features are statistically checked:
    - Features number 3, 4, 5 are statistically significant.
    - Feature number 2 is indirectly checked. It is significant.
    - Feature number 6 is indirectly checked. Every rigidity parameter is significant for USA. And 3 of 4 parameters are significant for Russia.
- IRFs and variance decomposition for Russia and USA are calculated. They show:
    - The model is able to generate quite different reaction to the same shock depending on parameters values.
    - Many shocks lead to different or opposite results in the USA and Russia.
    - Government expenditure shock is main source of variables variance in Russia.

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Appendix 1 Optimal conditions in terms of static variables

Table A1.1 Variables

Variable	Meaning	Connected static variable
$B_{D,t}$	value of domestic bonds bought by firms at period t	$b_{D,t} = \left(\frac{B_{D,t}}{P_{D,t}Y_{D,t}}\right)$
$B_{F,D,t}$	value of domestic bonds bought by foreign sector at period t	$b_{F,D,t} = \left(\frac{B_{F,D,t}}{P_tY_t}\right)$
$B_{F,F,t}$	value of foreign bonds bought by foreign sector at period t	$b_{F,F,t} = \left(\frac{F_tB_{F,F,t}}{P_tY_t}\right)$
$B_{H,D,t}$	value of domestic bonds bought by householders at period t	$b_{H,D,t} = \left(\frac{B_{H,D,t}}{P_tY_t}\right)$
$B_{H,F,t}$	value of foreign bonds bought by householders at period t	$b_{H,F,t} = \left(\frac{F_tB_{H,F,t}}{P_tY_t}\right)$
C_t	value of consumption goods basket at period t	$c_t = \ln(C_t/Y_t)$
$D_{D,t}$	dividends of foreign equities at period t	$d_{D,t} = \ln(D_{D,t}/(P_tY_t))$
$D_{F,t}$	dividends of domestic equities at period t	$d_{F,t} = \ln(D_{F,t}/(P_tY_t))$
F_t	exchange rate at period t (number of domestic currency units for one foreign currency unit)	$f_t = \ln(F_t/F_{t-1})$
G_t	government expenditure at period t	$g_t = \ln(G_t/Y_t)$
I_t	demand for investments goods at period t	$i_t = \ln(I_t/Y_t)$
K_t	amount of capital at period t	$k_t = \ln(K_t/Y_t)$
L_t	labor supply at period t	$l_t = \ln(L_tZ_{L,t})$
M_t	money stock at period t	$m_t = \ln(M_t/(P_tY_t))$
$P_{D,t}$	price level for domestic goods at period t	$p_{D,t} = \ln(P_{D,t}/P_t)$
$P_{F,t}$	price level for foreign goods at period t	$p_{F,t} = \ln(P_{F,t}/P_t)$
P_t	price of goods basket at period t	$p_t = \ln(P_t/P_{t-1})$
$R_{D,t}$	interest rate on domestic bonds at period t	$r_{D,t} = \ln(R_{D,t})$
$R_{F,t}$	interest rate on foreign bonds at period t	$r_{F,t} = \ln(R_{F,t})$
$S_{D,t}$	price of domestic equities at period t	$s_{D,t} = \ln(S_{D,t}/(P_tY_t))$
$S_{F,t}$	price of foreign equities at period t	$s_{F,t} = \ln(S_{F,t}/(P_tY_t))$
$T_{L,t}$	payroll tax at period t	$t_{L,t} = T_{L,t}$
W_t	wage at period t	$w_t = \ln\left(\frac{W_t}{Z_{L,t}P_tY_t}\right)$
$X_{F,D,t}$	amount of domestic equities bought by foreign sector at period t	$x_{F,D,t} = X_{F,D,t}$
$X_{F,F,t}$	amount of foreign equities bought by foreign sector at period t	$x_{F,F,t} = X_{F,F,t}$

Table A1.1 Variables (continue)

Variable	Meaning	Connected static variable
$X_{H,D,t}$	amount of domestic equities bought by householders at period t	$x_{H,D,t} = X_{H,D,t}$
$X_{H,F,t}$	amount of foreign equities bought by householders at period t	$x_{H,F,t} = X_{H,F,t}$
$Y_{D,t}$	output of domestic firms at period t	$y_{D,t} = \ln(Y_{D,t}/Y_t)$
$Y_{DD,t}$	demand for semi finished goods at period t	$y_{DD,t} = \ln(Y_{DD,t}/Y_t)$
$Y_{F,t}$	foreign demand for domestic goods at period t	$y_{F,t} = \ln(Y_{F,t}/Y_t)$
Y_t	domestic demand at period t	$y_t = \ln(Y_t/Y_{t-1})$
$\Lambda_{b,t}$	Lagrange Multiplier corresponding to budget restriction of firms at period t	$\lambda_{b,t} = \Lambda_{b,t}$
$\Lambda_{d,t}$	Lagrange Multiplier corresponding to demand restriction of firms at period t	$\lambda_{d,t} = \Lambda_{d,t}/P_t$
$\Lambda_{p,t}$	Lagrange Multiplier corresponding to production function restriction of firms at period t	$\lambda_{p,t} = \Lambda_{p,t}/P_t$
Λ_t	Lagrange Multiplier corresponding to budget restriction of householders at period t	$\lambda_t = \Lambda_t P_t Y_t$
$Z_{D,B,t}$	Exogenous process corresponding to conventional level of debt pressure	$z_{D,B,t} = Z_{D,B,t}$
$Z_{F,B,t}$	Exogenous process corresponding to value of domestic bonds owned by foreign sector	$z_{F,B,t} = Z_{F,B,t}$
$Z_{F,D,t}$	Exogenous process corresponding to dividends of foreign firms	$z_{F,D,t} = \ln(Z_{F,D,t})$
$Z_{F,P,t}$	Exogenous process corresponding to foreign inflation	$z_{F,P,t} = \ln(Z_{F,P,t})$
$Z_{F,R,t}$	Exogenous process corresponding to foreign bond interest rate	$z_{F,R,t} = \ln(Z_{F,R,t})$
$Z_{F,S,t}$	Exogenous process corresponding to price of foreign equities	$z_{F,S,t} = \ln(Z_{F,S,t})$
$Z_{F,X,t}$	Exogenous process corresponding to foreign demand for domestic equities	$z_{F,X,t} = Z_{F,X,t}$
$Z_{F,Y,t}$	Exogenous process corresponding to foreign demand for goods	$z_{F,Y,t} = \ln(Z_{F,Y,t})$
$Z_{G,t}$	Exogenous process corresponding to government expenditure	$z_{G,t} = \ln(Z_{G,t})$
$Z_{G,B,t}$	Exogenous process corresponding to structure of government bond position	$z_{G,B,t} = \ln(Z_{G,B,t})$
$Z_{H,t}$	Exogenous process corresponding to utility of consumption growth	$z_{H,t} = \ln(Z_{H,t})$
$Z_{L,t}$	Exogenous process corresponding to householders amount of labor	$z_{L,t} = \ln(Z_{L,t}/Z_{L,t-1})$
$Z_{M,t}$	Exogenous process corresponding to liquidity preferences of householders	$z_{M,t} = \ln(Z_{M,t})$
$Z_{R,t}$	Exogenous process corresponding to monetary policy	$z_{R,t} = Z_{R,t}$
$Z_{T,t}$	Exogenous process corresponding to taxation policy	$z_{T,t} = Z_{T,t}$
$Z_{Y,t}$	Exogenous process corresponding to technological development	$z_{Y,t} = \ln(Z_{Y,t}/Z_{Y,t-1})$

Householders:

$$e^{-c_t}\left(1+\exp\left(z_{H,t}+\psi\left(c_t-c_{t-1}+y_t\right)\right)-E_t\left(\beta\exp\left(z_{H,t+1}+\psi\left(c_{t+1}-c_t+y_{t+1}\right)\right)\right)\right)=\lambda_t \quad \text{(A1.1)}$$

$$e^{z_{M,t}-m_t}+\phi_{H,B}\left(b_{H,F,t}e^{-m_t}\right)^2e^{-m_t}-\lambda_t+E_t\left(\beta\lambda_{t+1}e^{-p_{t+1}-y_{t+1}}\right)=0 \quad \text{(A1.2)}$$

$$-\lambda_t + E_t\left(\beta\lambda_{t+1}e^{-p_{t+1}-y_{t+1}+r_{D,t}}\right) = 0 \tag{A1.3}$$

$$-\phi_{H,B}\left(b_{H,F,t}e^{-m_t}\right)e^{-m_t} - \lambda_t - E_t\left(\beta\lambda_{t+1}e^{-p_{t+1}-y_{t+1}+r_{F,t}+f_{t+1}}\right) = 0 \tag{A1.4}$$

$$-\lambda_t e^{s_{D,t}} + E_t\left(\beta\lambda_{t+1}\left(e^{s_{D,t+1}} + e^{d_{D,t+1}}\right)\right) = 0 \tag{A1.5}$$

$$-\phi_B x_{H,F,t} - \lambda_t e^{s_{F,t}} + E_t\left(\beta\lambda_{t+1}\left(e^{s_{F,t+1}} + e^{d_{F,t+1}}\right)\right) = 0 \tag{A1.6}$$

$$-e^{(\omega+1)l_t} + \lambda_t\left(1 - T_{L,t}\right)e^{w_t+l_t} = 0 \tag{A1.7}$$

$$e^{c_t} + \begin{pmatrix} b_{H,D,t} + b_{H,F,t} + \\ + e^{s_{D,t}} x_{H,D,t} + \\ e^{s_{F,t}} x_{H,F,t} + e^{m_t} \end{pmatrix} = \left(1 - T_{L,t}\right)e^{w_t+l_t} + \begin{pmatrix} e^{r_{D,t-1}-y_t-p_t} b_{H,D,t-1} + e^{r_{F,t-1}+f_t-y_t-p_t} b_{H,F,t-1} + \\ + \left(e^{s_{D,t}} + e^{d_{D,t}}\right)x_{H,D,t-1} + \\ + \left(e^{s_{F,t}} + e^{d_{F,t}}\right)x_{H,F,t-1} + e^{m_{t-1}-y_t-p_t} \end{pmatrix} \tag{A1.8}$$

Firms:

$$\begin{pmatrix} 1 - \lambda_{b,t} - 2\varphi_D \begin{pmatrix} d_{D,t} + y_t + p_t - \\ - d_{D,t-1} - \overline{p} - \overline{y} \end{pmatrix} e^{-d_{D,t}+y_{D,t}} \lambda_{p,t} + \\ + 2E_t\left(\lambda_{p,t+1}\varphi_D \begin{pmatrix} d_{D,t+1} + y_{t+1} + p_{t+1} - \\ - d_{D,t} - \overline{p} - \overline{y} \end{pmatrix} e^{\begin{pmatrix} -d_{D,t}+y_{D,t+1}+ \\ +y_{t+1}+p_{t+1}-r_{D,t} \end{pmatrix}} \right) \end{pmatrix} = 0 \tag{A1.9}$$

$$-\lambda_{b,t}e^{w_t+l_t-y_{D,t}} + \lambda_{p,t}\alpha_L \begin{pmatrix} \varphi_P\left(p_{D,t} - p_{D,t-1} + p_t - \overline{p}\right)^2 + \varphi_Y\left(y_{D,t} - y_{D,t-1} + y_t - \overline{y}\right)^2 + \\ + \varphi_B\left(b_{D,t} - z_{D,B,t}\right)^2 + \varphi_D \begin{pmatrix} d_{D,t} + y_t + p_t - \\ - d_{D,t-1} - \overline{p} - \overline{y} \end{pmatrix}^2 + 1 \end{pmatrix} = 0 \tag{A1.10}$$

$$-\lambda_{b,t} - \lambda_{p,t}2\varphi_B\left(b_{D,t} - z_{D,B,t}\right)e^{-p_{D,t}} + E_t\left(\lambda_{b,t+1}\right) = 0 \tag{A1.11}$$

$$\begin{pmatrix} -\lambda_{p,t}\left(\begin{pmatrix} \varphi_P\left(p_{D,t} - p_{D,t-1} + p_t - \overline{p}\right)^2 + \\ + \varphi_Y\left(y_{D,t} - y_{D,t-1} + y_t - \overline{y}\right)^2 + \\ + \varphi_B\left(b_{D,t} - z_{D,B,t}\right)^2 + \\ + \varphi_D \begin{pmatrix} d_{D,t} + y_t + p_t - \\ - d_{D,t-1} - \overline{p} - \overline{y} \end{pmatrix}^2 + 1 \end{pmatrix} + \begin{pmatrix} 2\varphi_Y\left(y_{D,t} - y_{D,t-1} + y_t - \overline{y}\right) - \\ - 2\varphi_B\left(b_{D,t} - z_{D,B,t}\right)b_{D,t} \end{pmatrix} \right) + \\ + E_t\left(\lambda_{p,t+1}2\varphi_Y\left(y_{D,t+1} - y_{D,t} + y_{t+1} - \overline{y}\right)e^{\begin{pmatrix} y_{D,t+1}-y_{D,t}+y_{t+1}+ \\ +p_{t+1}-r_{D,t} \end{pmatrix}} \right) + \lambda_{b,t}e^{p_{D,t}} - \lambda_{d,t} \end{pmatrix} = 0 \tag{A1.12}$$

$$-\lambda_{b,t} + \lambda_{p,t} \begin{pmatrix} 1 - \alpha_L - \\ - \alpha_K \end{pmatrix} \begin{pmatrix} \varphi_P\left(p_{D,t} - p_{D,t-1} + p_t - \overline{p}\right)^2 + \\ + \varphi_Y\left(y_{D,t} - y_{D,t-1} + y_t - \overline{y}\right)^2 + \\ + \varphi_B\left(b_{D,t} - z_{D,B,t}\right)^2 + \varphi_D \begin{pmatrix} d_{D,t} + y_t + p_t - \\ - d_{D,t-1} - \overline{p} - \overline{y} \end{pmatrix}^2 + 1 \end{pmatrix} e^{y_{D,t}-y_{DD,t}} = 0 \tag{A1.13}$$

$$E_t\left(\begin{pmatrix}-\lambda_{b,t}+\\+\lambda_{b,t+1}e^{p_{t+1}-r_{D,t}}(1-\delta)\end{pmatrix}+\lambda_{p,t+1}\alpha_K e^{\begin{pmatrix}p_{t+1}-r_{D,t}+y_{t+1}+\\+y_{D,t+1}-k_t\end{pmatrix}}\begin{pmatrix}\varphi_P\left(p_{D,t+1}-p_{D,t}+p_{t+1}-\overline{p}\right)^2+\\+\varphi_Y\left(y_{D,t+1}-y_{D,t}+y_{t+1}-\overline{y}\right)^2+\\+\varphi_B\left(b_{D,t+1}-z_{D,B,t+1}\right)^2+1+\\+\varphi_D\begin{pmatrix}d_{D,t+1}+y_{t+1}+p_{t+1}-\\-d_{D,t}-\overline{p}-\overline{y}\end{pmatrix}^2\end{pmatrix}\right)=0 \quad \text{(A1.14)}$$

$$\begin{pmatrix}\lambda_{b,t}e^{p_{D,t}}-\lambda_{d,t}\theta-\lambda_{p,t}\begin{pmatrix}2\varphi_P\left(p_{D,t}-p_{D,t-1}+p_t-\overline{p}\right)-\\-2\varphi_B\left(b_{D,t}-z_{D,B,t}\right)b_{D,t}\end{pmatrix}-\\-E_t\left(\lambda_{p,t+1}\left(2\varphi_P\left(p_{D,t+1}-p_{D,t}+p_{t+1}-\overline{p}\right)\right)e^{-r_{D,t}+y_{D,t+1}-y_{D,t}+y_{t+1}+p_{t+1}}\right)\end{pmatrix}=0 \quad \text{(A1.15)}$$

$$e^{d_{D,t}}+e^{i_{D,t}}+e^{y_{D,t}}+b_{D,t}e^{y_{D,t}+p_{D,t}}+e^{w_t+l_t}=e^{p_{D,t}+y_{D,t}}+b_{D,t-1}e^{r_{D,t-1}+y_{D,t-1}+p_{D,t-1}-y_t-p_t} \quad \text{(A1.16)}$$

$$e^{k_t}=(1-\delta)e^{k_{t-1}-y_t}+e^{i_t} \quad \text{(A1.17)}$$

$$e^{y_{D,t}}=e^{-\theta p_{D,t}}\left(\omega_D e^{c_t}+\omega_D e^{i_t}+\omega_D e^{y_{DD,t}}\right)+e^{-\theta\left(p_{D,t}-p_{F,t}\right)}e^{y_{F,t}}+e^{g_t} \quad \text{(A1.18)}$$

$$\frac{\begin{pmatrix}\varphi_P\left(p_{D,t}-p_{D,t-1}+p_t-\overline{p}\right)^2+\\+\varphi_Y\left(y_{D,t}-y_{D,t-1}+y_t-\overline{y}\right)^2+\\+\varphi_B\left(b_{D,t}-z_{D,B,t}\right)^2+\\+\varphi_D\begin{pmatrix}d_{D,t}+y_t+p_t-\\-d_{D,t-1}-\overline{p}-\overline{y}\end{pmatrix}^2+1\end{pmatrix}}{\begin{pmatrix}\varphi_P\left(p_{D,t-1}-p_{D,t-2}+p_{t-1}-\overline{p}\right)^2+\\+\varphi_Y\left(y_{D,t-1}-y_{D,t-2}+y_{t-1}-\overline{y}\right)^2+\\+\varphi_B\left(b_{D,t-1}-z_{D,B,t-1}\right)^2+\\+\varphi_D\begin{pmatrix}d_{D,t-1}+y_{t-1}+p_{t-1}-\\-d_{D,t-2}-\overline{p}-\overline{y}\end{pmatrix}^2+1\end{pmatrix}}=\exp\begin{pmatrix}z_{Y,t}+\alpha_L\left(l_t-l_{t-1}-z_{L,t}\right)+\\+\left(1-\alpha_L-\alpha_K\right)\left(y_{DD,t}-y_{DD,t-1}+y_t\right)+\\+\alpha_K\left(k_{t-1}+y_{t-1}-k_{t-2}\right)-\\-y_{D,t}+y_{D,t-1}-y_t\end{pmatrix} \quad \text{(A1.19)}$$

Foreign sector:

$$\exp\left(p_{F,t}-p_{F,t-1}+p_t-f_t\right)=\exp\left(z_{F,P,t}\right) \quad \text{(A1.20)}$$

$$\exp\left(y_{F,t}-y_{F,t-1}+y_t\right)=\exp\left(z_{F,Y,t}\right) \quad \text{(A1.21)}$$

$$b_{F,D,t}\exp(-p_{F,t}-y_{F,t})=z_{F,B,t} \quad \text{(A1.22)}$$

$$x_{F,D,t}=z_{F,X,t} \quad \text{(A1.23)}$$

$$\exp(d_{F,t}-p_{F,t}-y_{F,t})=\exp(z_{F,D,t}) \quad \text{(A1.24)}$$

$$\exp(s_{F,t}-y_{F,t-1}-p_{F,t-1})=\exp(z_{F,S,t}) \quad \text{(A1.25)}$$

$$\exp(r_{F,t})=\exp(z_{F,R,t}) \quad \text{(A1.26)}$$

$$\begin{pmatrix} P_{F,t}\left(\frac{P_{D,t}}{P_{F,t}}\right)^{-\theta} Y_{F,t} + \\ + D_{F,t} \end{pmatrix} + \begin{pmatrix} S_{D,t}X_{F,D,t} + \\ + S_{F,t}X_{F,F,t} + \\ + B_{F,D,t} + \\ + F_t B_{F,F,t} \end{pmatrix} = \begin{pmatrix} P_{F,t} \cdot \\ \cdot \left(\frac{P_{F,t}}{P_t}\right)^{-\theta} \cdot \\ \cdot (1-\omega_D) \cdot \\ (C_t + I_t + Y_{DD,t}) \end{pmatrix} + \begin{pmatrix} (S_{D,t} + D_{D,t})X_{F,D,t-1} + \\ + (S_{F,t} + D_{F,t})X_{F,F,t-1} + \\ + R_{D,t-1}B_{F,D,t-1} + \\ + F_t R_{F,t-1}B_{F,F,t-1} \end{pmatrix} \quad \text{(A1.27)}$$

Balance restrictions:

$$1 = e^{c_t} + e^{i_t} + e^{g_t} \quad \text{(A1.28)}$$

$$1 = \left(\omega_D e^{(1-\theta)p_{D,t}} + (1-\omega_D) e^{(1-\theta)p_{F,t}}\right)^{1/(1-\theta)} \quad \text{(A1.29)}$$

$$x_{H,F,t} + x_{F,F,t} = 1 \quad \text{(A1.30)}$$

$$x_{H,D,t} + x_{F,D,t} = 1 \quad \text{(A1.31)}$$

$$b_{G,D,t} + b_{F,D,t} + b_{H,D,t} + b_{D,t}e^{p_{D,t}+y_{D,t}} = 0 \quad \text{(A1.32)}$$

$$b_{G,F,t} + b_{F,F,t} + b_{H,F,t} = 0 \quad \text{(A1.33)}$$

Goverment:

$$e^{p_{D,t}+g_t} + b_{G,D,t} + b_{G,F,t} = t_{L,t}e^{w_t+l_t} + \begin{pmatrix} e^{r_{d,t-1}-p_t-y_t} b_{G,D,t-1} + \\ + e^{r_{F,t-1}-p_t-y_t+f_t} b_{G,F,t-1} + \\ + e^{m_t} - e^{m_{t-1}-p_t-y_t} \end{pmatrix} \quad \text{(A1.34)}$$

$$r_{D,t} = \gamma_p p_t + \gamma_Y y_t + z_{R,t} \quad \text{(A1.35)}$$

$$t_{L,t}e^{w_t+l_t} = -\gamma_B\left(b_{G,D,t} + b_{G,F,t}\right) + \gamma_G e^{p_{D,t}+g_t} + z_{T,t} \quad \text{(A1.36)}$$

$$z_{G,B,t}b_{G,D,t} = b_{G,F,t} \quad \text{(A1.37)}$$

$$e^{g_t} = e^{z_{G,t}} \quad \text{(A1.38)}$$

Exogenous processes:

$$z_{D,B,t} = \eta_{0,D,B}\left(1-\eta_{1,D,B}\right) + \eta_{1,D,B}z_{D,B,t-1} + \varepsilon_{D,B,t} \quad \text{(A1.39)}$$

$$z_{F,B,t} = \eta_{0,F,B}\left(1-\eta_{1,F,B}\right) + \eta_{1,F,B}z_{F,B,t-1} + \varepsilon_{F,B,t} \quad \text{(A1.40)}$$

$$z_{F,D,t} = \eta_{0,F,D}\left(1-\eta_{1,F,D}\right) + \eta_{1,F,D}z_{F,D,t-1} + \varepsilon_{F,D,t} \quad \text{(A1.41)}$$

$$z_{F,P,t} = \eta_{0,F,P}\left(1-\eta_{1,F,P}\right) + \eta_{1,F,P}z_{F,P,t-1} + \varepsilon_{F,P,t} \quad \text{(A1.42)}$$

$$z_{F,R,t} = \eta_{0,F,R}\left(1-\eta_{1,F,R}\right) + \eta_{1,F,R}z_{F,R,t-1} + \varepsilon_{F,R,t} \quad \text{(A1.43)}$$

$$z_{F,S,t} = \eta_{0,F,S}\left(1-\eta_{1,F,S}\right) + \eta_{1,F,S}z_{F,S,t-1} + \varepsilon_{F,S,t} \quad \text{(A1.44)}$$

$$z_{F,X,t} = \eta_{0,F,X}\left(1-\eta_{1,F,X}\right) + \eta_{1,F,X}z_{F,X,t-1} + \varepsilon_{F,X,t} \quad \text{(A1.45)}$$

$$z_{F,Y,t} = \eta_{0,F,Y}\left(1-\eta_{1,F,Y}\right) + \eta_{1,F,Y} z_{F,Y,t-1} + \varepsilon_{F,Y,t} \tag{A1.46}$$

$$z_{G,t} = \eta_{0,G}\left(1-\eta_{1,G}\right) + \eta_{1,G} z_{G,t-1} + \varepsilon_{G,t} \tag{A1.47}$$

$$z_{G,B,t} = \eta_{0,G,B}\left(1-\eta_{1,G,B}\right) + \eta_{1,G,B} z_{G,B,t-1} + \varepsilon_{G,B,t} \tag{A1.48}$$

$$z_{H,t} = \eta_{0,H}\left(1-\eta_{1,H}\right) + \eta_{1,H} z_{H,t-1} + \varepsilon_{H,t} \tag{A1.49}$$

$$z_{L,t} = \eta_{0,L}\left(1-\eta_{1,L}\right) + \eta_{1,L} z_{L,t-1} + \varepsilon_{L,t} \tag{A1.50}$$

$$z_{M,t} = \eta_{0,M}\left(1-\eta_{1,M}\right) + \eta_{1,M} z_{M,t-1} + \varepsilon_{M,t} \tag{A1.51}$$

$$z_{R,t} = \eta_{0,R}\left(1-\eta_{1,R}\right) + \eta_{1,R} z_{R,t-1} + \varepsilon_{R,t} \tag{A1.52}$$

$$z_{T,t} = \eta_{0,T}\left(1-\eta_{1,T}\right) + \eta_{1,T} z_{T,t-1} + \varepsilon_{T,t} \tag{A1.53}$$

$$z_{Y,t} = \eta_{0,Y}\left(1-\eta_{1,Y}\right) + \eta_{1,Y} z_{Y,t-1} + \varepsilon_{Y,t} \tag{A1.54}$$

Appendix 2 Parameters estimation

Table A2.1 Parameters estimation for USA

Parameter	Value	Standard deviation	t – value	Parameter	Value	Standard deviation	t – value
α_K	$1.90*10^{-1}$	$3.41*10^{-2}$	$5.57*10^{+0}$	$\eta_{1,T}$	$9.72*10^{-1}$	$2.23*10^{-1}$	$4.36*10^{+0}$
α_L	$5.97*10^{-1}$	$4.13*10^{-3}$	$1.45*10^{+2}$	$\eta_{1,Y}$	$-1.53*10^{-1}$	$1.55*10^{-2}$	$-9.88*10^{+0}$
$\bar{b}_{H,D}$	$1.50*10^{+1}$	$6.23*10^{-1}$	$2.41*10^{+1}$	ω	$1.31*10^{+0}$	$1.57*10^{-2}$	$8.33*10^{+1}$
β	$9.94*10^{-1}$	$8.18*10^{-4}$	$1.21*10^{+3}$	ω_D	$5.49*10^{-1}$	$5.66*10^{-3}$	$9.69*10^{+1}$
φ_B	$2.95*10^{-2}$	$2.32*10^{-3}$	$1.27*10^{+1}$	$\bar{p}$	$8.03*10^{-3}$	$4.28*10^{-3}$	$1.88*10^{+0}$
φ_D	$1.00*10^{+1}$	$5.71*10^{+0}$	$1.75*10^{+0}$	ψ	$1.21*10^{+0}$	$3.51*10^{-1}$	$3.44*10^{+0}$
$\varphi_{H,B}$	$4.04*10^{+0}$	$7.87*10^{-3}$	$5.13*10^{+2}$	$\bar{s}_D$	$3.14*10^{+0}$	$2.51*10^{-1}$	$1.25*10^{+1}$
φ_P	$3.60*10^{-1}$	$1.93*10^{-1}$	$1.87*10^{+0}$	δ	$1.00*10^{-4}$	$1.22*10^{+0}$	$8.16*10^{-5}$
φ_S	$4.30*10^{-1}$	$4.78*10^{-3}$	$8.99*10^{+1}$	$\bar{t}_L$	$4.80*10^{-1}$	$1.69*10^{-2}$	$2.84*10^{+1}$
φ_Y	$1.53*10^{-1}$	$1.45*10^{-2}$	$1.05*10^{+1}$	θ	$2.03*10^{+0}$	$1.36*10^{-2}$	$1.49*10^{+2}$
γ_B	$1.41*10^{-2}$	$4.96*10^{-2}$	$2.84*10^{-1}$	$\bar{y}_D$	$1.33*10^{+0}$	$2.96*10^{-3}$	$4.51*10^{+2}$
γ_G	$5.00*10^{-1}$	$1.42*10^{-2}$	$3.52*10^{+1}$	$\varepsilon_{D,B}$	$1.05*10^{-5}$	$9.12*10^{-3}$	$1.15*10^{-3}$
γ_P	$1.02*10^{+0}$	$4.06*10^{-3}$	$2.51*10^{+2}$	$\varepsilon_{F,B}$	$1.75*10^{-5}$	$1.00*10^{+10}$	$1.75*10^{-15}$
γ_Y	$1.00*10^{-3}$	$3.71*10^{-3}$	$2.69*10^{-1}$	$\varepsilon_{F,D}$	$1.00*10^{+0}$	$2.11*10^{-1}$	$4.74*10^{+0}$
$\bar{l}$	$-4.22*10^{-1}$	$1.42*10^{-3}$	$-2.98*10^{+2}$	$\varepsilon_{F,P}$	$2.03*10^{-3}$	$2.72*10^{-2}$	$7.45*10^{-2}$
$\bar{\lambda}$	$1.39*10^{+0}$	$3.95*10^{-3}$	$3.51*10^{+2}$	$\varepsilon_{F,R}$	$2.49*10^{-3}$	$6.06*10^{-3}$	$4.11*10^{-1}$
$\bar{m}$	$2.93*10^{+0}$	$8.90*10^{-3}$	$3.29*10^{+2}$	$\varepsilon_{F,S}$	$1.00*10^{-5}$	$5.77*10^{-2}$	$1.74*10^{-4}$
$\eta_{0,D,B}$	$-1.00*10^{-1}$	$5.72*10^{-2}$	$-1.75*10^{+0}$	$\varepsilon_{F,X}$	$1.02*10^{-5}$	$9.80*10^{-5}$	$1.04*10^{-1}$
$\eta_{0,F,B}$	$2.00*10^{+0}$	$8.80*10^{-1}$	$2.27*10^{+0}$	$\varepsilon_{F,Y}$	$1.00*10^{-5}$	$1.31*10^{-4}$	$7.64*10^{-2}$
$\eta_{0,F,D}$	$1.06*10^{+0}$	$2.47*10^{-3}$	$4.27*10^{+2}$	ε_G	$1.09*10^{-2}$	$6.96*10^{-4}$	$1.57*10^{+1}$
$\eta_{0,F,P}$	$-2.22*10^{-2}$	$1.59*10^{-4}$	$-1.40*10^{+2}$	$\varepsilon_{G,B}$	$1.48*10^{-5}$	$1.00*10^{+10}$	$1.48*10^{-15}$
$\eta_{0,F,R}$	$1.49*10^{-2}$	$1.34*10^{-3}$	$1.11*10^{+1}$	ε_H	$5.83*10^{-1}$	$7.22*10^{-3}$	$8.07*10^{+1}$
$\eta_{0,F,S}$	$6.24*10^{+0}$	$8.23*10^{-3}$	$7.58*10^{+2}$	ε_L	$1.00*10^{-5}$	$4.35*10^{-4}$	$2.30*10^{-2}$
$\eta_{0,F,X}$	$-5.00*10^{-2}$	$1.08*10^{-2}$	$-4.64*10^{+0}$	ε_M	$3.15*10^{-2}$	$4.13*10^{-3}$	$7.62*10^{+0}$
$\eta_{0,F,Y}$	$-2.13*10^{+0}$	$8.53*10^{-3}$	$-2.50*10^{+2}$	ε_R	$2.67*10^{-4}$	$2.05*10^{-2}$	$1.30*10^{-2}$
$\eta_{0,G}$	$-2.01*10^{+0}$	$2.54*10^{-3}$	$-7.92*10^{+2}$	ε_T	$1.00*10^{-5}$	$1.85*10^{-2}$	$5.42*10^{-4}$
$\eta_{0,G,B}$	$5.00*10^{-1}$	$2.21*10^{-3}$	$2.26*10^{+2}$	ε_Y	$4.86*10^{-3}$	$3.25*10^{-2}$	$1.50*10^{-1}$
$\eta_{0,H}$	$-2.52*10^{+0}$	$6.02*10^{-2}$	$-4.19*10^{+1}$	r. consumption	$2.06*10^{-3}$	$1.08*10^{-1}$	$1.90*10^{-2}$
$\eta_{0,L}$	$-4.32*10^{-3}$	$5.21*10^{-4}$	$-8.29*10^{+0}$	r. export	$2.11*10^{-2}$	$1.30*10^{-3}$	$1.62*10^{+1}$
$\eta_{0,M}$	$-9.54*10^{-5}$	$1.62*10^{-3}$	$-5.88*10^{-2}$	r. gov. expend.	$3.46*10^{-3}$	$6.38*10^{-1}$	$5.43*10^{-3}$
$\eta_{0,R}$	$8.22*10^{-3}$	$4.99*10^{-3}$	$1.65*10^{+0}$	r. GDP	$1.11*10^{-3}$	$1.97*10^{-2}$	$5.63*10^{-2}$
$\eta_{0,T}$	$5.10*10^{-1}$	$1.00*10^{+10}$	$5.10*10^{-11}$	r. investment	$3.51*10^{-3}$	$4.98*10^{-4}$	$7.04*10^{+0}$
$\eta_{0,Y}$	$6.69*10^{-4}$	$5.38*10^{-4}$	$1.24*10^{+0}$	r. import	$2.05*10^{-2}$	$2.32*10^{-2}$	$8.83*10^{-1}$
$\eta_{1,D,B}$	$-2.62*10^{-1}$	$1.00*10^{+10}$	$-2.62*10^{-11}$	employment	$1.91*10^{-3}$	$1.83*10^{-4}$	$1.05*10^{+1}$
$\eta_{1,F,B}$	$1.54*10^{-2}$	$1.00*10^{+10}$	$1.54*10^{-12}$	M1	$1.54*10^{-2}$	$9.12*10^{-3}$	$1.69*10^{+0}$
$\eta_{1,F,D}$	$-1.26*10^{-1}$	$2.00*10^{-2}$	$-6.31*10^{+0}$	n. consumpt.	$1.78*10^{-3}$	$2.36*10^{-2}$	$7.57*10^{-2}$
$\eta_{1,F,P}$	$9.95*10^{-1}$	$2.03*10^{-2}$	$4.90*10^{+1}$	n. export	$2.57*10^{-2}$	$1.57*10^{-3}$	$1.63*10^{+1}$
$\eta_{1,F,R}$	$9.95*10^{-1}$	$7.58*10^{-3}$	$1.31*10^{+2}$	n. gov. expend.	$2.96*10^{-3}$	$1.66*10^{-2}$	$1.78*10^{-1}$
$\eta_{1,F,S}$	$9.95*10^{-1}$	$9.78*10^{-1}$	$1.02*10^{+0}$	n. GDP	$1.29*10^{-3}$	$2.60*10^{-2}$	$4.96*10^{-2}$
$\eta_{1,F,X}$	$-8.98*10^{-2}$	$1.00*10^{+10}$	$-8.98*10^{-12}$	n. investment	$5.13*10^{-3}$	$1.41*10^{-2}$	$3.64*10^{-1}$
$\eta_{1,F,Y}$	$9.95*10^{-1}$	$1.06*10^{-2}$	$9.39*10^{+1}$	n. import	$2.88*10^{-2}$	$1.73*10^{-3}$	$1.66*10^{+1}$
$\eta_{1,G}$	$9.72*10^{-1}$	$1.21*10^{+1}$	$8.01*10^{-2}$	MSCI USA	$7.97*10^{-2}$	$3.69*10^{-1}$	$2.16*10^{-1}$
$\eta_{1,G,B}$	$3.27*10^{-1}$	$1.00*10^{+10}$	$3.27*10^{-11}$	MSCI world	$8.92*10^{-2}$	$2.28*10^{-1}$	$3.90*10^{-1}$
$\eta_{1,H}$	$9.09*10^{-1}$	$2.74*10^{-1}$	$3.31*10^{+0}$	average wage	$4.95*10^{-3}$	$7.87*10^{-4}$	$6.29*10^{+0}$
$\eta_{1,L}$	$-6.99*10^{-1}$	$3.43*10^{-2}$	$-2.04*10^{+1}$	comp.for empl.	$4.70*10^{-3}$	$3.95*10^{-3}$	$1.19*10^{+0}$
$\eta_{1,M}$	$9.27*10^{-1}$	$2.58*10^{-2}$	$3.59*10^{+1}$	n.board doll.in.	$2.66*10^{-2}$	$1.09*10^{-2}$	$2.43*10^{+0}$
$\eta_{1,R}$	$9.21*10^{-1}$	$6.25*10^{-3}$	$1.47*10^{+2}$	LIBOR 3M	$6.33*10^{-3}$	$1.77*10^{-2}$	$3.57*10^{-1}$

Table A2.2 Parameters estimation for Russia

Parameter	Value	Standard deviation	t – value	Parameter	Value	Standard deviation	t – value
α_K	$1.90*10^{-1}$	$3.70*10^{-3}$	$5.14*10^{+1}$	$\eta_{1,T}$	$-9.95*10^{-1}$	$3.29*10^{-3}$	$-3.03*10^{+2}$
α_L	$5.68*10^{-1}$	$1.15*10^{-2}$	$4.93*10^{+1}$	$\eta_{1,Y}$	$-2.52*10^{-1}$	$9.25*10^{-2}$	$-2.73*10^{+0}$
$\bar{b}_{H,D}$	$5.00*10^{+0}$	$7.00*10^{+0}$	$7.14*10^{-1}$	ω	$6.44*10^{+0}$	$4.92*10^{-2}$	$1.31*10^{+2}$
β	$9.82*10^{-1}$	$4.33*10^{-3}$	$2.27*10^{+2}$	ω_D	$2.01*10^{-1}$	$8.94*10^{-4}$	$2.25*10^{+2}$
φ_B	$5.35*10^{-2}$	$8.05*10^{-3}$	$6.65*10^{+0}$	$\bar{p}$	$5.00*10^{-2}$	$1.37*10^{-2}$	$3.66*10^{+0}$
φ_D	$3.78*10^{+0}$	$7.57*10^{-1}$	$5.00*10^{+0}$	ψ	$1.00*10^{-3}$	$2.89*10^{-1}$	$3.46*10^{-3}$
$\varphi_{H,B}$	$1.02*10^{+2}$	$1.55*10^{+2}$	$6.58*10^{-1}$	$\bar{s}_D$	$3.00*10^{+0}$	$1.31*10^{+0}$	$2.28*10^{+0}$
φ_P	$6.21*10^{+0}$	$7.05*10^{-1}$	$8.81*10^{+0}$	δ	$1.96*10^{-4}$	$1.14*10^{-5}$	$1.72*10^{+1}$
φ_S	$5.61*10^{-1}$	$1.31*10^{-2}$	$4.27*10^{+1}$	$\bar{t}_L$	$1.04*10^{-1}$	$4.74*10^{-3}$	$2.20*10^{+1}$
φ_Y	$9.06*10^{-8}$	$1.00*10^{+10}$	$9.06*10^{-18}$	θ	$1.69*10^{+0}$	$1.23*10^{-2}$	$1.37*10^{+2}$
γ_B	$3.00*10^{-1}$	$2.29*10^{-1}$	$1.31*10^{+0}$	$\bar{y}_D$	$1.00*10^{+0}$	$3.80*10^{-3}$	$2.64*10^{+2}$
γ_G	$5.00*10^{-1}$	$4.55*10^{+1}$	$1.10*10^{-2}$	$\varepsilon_{D,B}$	$1.06*10^{-4}$	$2.37*10^{-2}$	$4.49*10^{-3}$
γ_P	$1.62*10^{+0}$	$1.78*10^{-2}$	$9.07*10^{+1}$	$\varepsilon_{F,B}$	$9.56*10^{-4}$	$1.00*10^{+10}$	$9.56*10^{-14}$
γ_Y	$2.68*10^{-2}$	$1.37*10^{-2}$	$1.97*10^{+0}$	$\varepsilon_{F,D}$	$1.01*10^{-4}$	$5.00*10^{-3}$	$2.02*10^{-2}$
$\bar{l}$	$-2.23*10^{-1}$	$1.75*10^{-3}$	$-1.27*10^{+2}$	$\varepsilon_{F,P}$	$3.15*10^{-2}$	$6.51*10^{-3}$	$4.83*10^{+0}$
$\bar{\lambda}$	$1.34*10^{+0}$	$1.18*10^{-2}$	$1.14*10^{+2}$	$\varepsilon_{F,R}$	$1.00*10^{-4}$	$1.38*10^{-2}$	$7.26*10^{-3}$
$\bar{m}$	$2.54*10^{+0}$	$2.46*10^{-1}$	$1.03*10^{+1}$	$\varepsilon_{F,S}$	$3.20*10^{-2}$	$4.68*10^{-1}$	$6.82*10^{-2}$
$\eta_{0,D,B}$	$-1.00*10^{-1}$	$3.92*10^{-1}$	$-2.55*10^{-1}$	$\varepsilon_{F,X}$	$2.65*10^{-4}$	$1.03*10^{-5}$	$2.59*10^{+1}$
$\eta_{0,F,B}$	$1.12*10^{-8}$	$2.98*10^{-3}$	$3.77*10^{-6}$	$\varepsilon_{F,Y}$	$1.00*10^{-4}$	$3.64*10^{-3}$	$2.75*10^{-2}$
$\eta_{0,F,D}$	$-1.73*10^{-1}$	$5.25*10^{-3}$	$-3.29*10^{+1}$	ε_G	$7.62*10^{-2}$	$1.00*10^{-2}$	$7.62*10^{+0}$
$\eta_{0,F,P}$	$2.65*10^{-2}$	$2.08*10^{-2}$	$1.27*10^{+0}$	$\varepsilon_{G,B}$	$1.02*10^{-4}$	$1.00*10^{+10}$	$1.02*10^{-14}$
$\eta_{0,F,R}$	$8.11*10^{-7}$	$8.52*10^{-3}$	$9.52*10^{-5}$	ε_H	$4.96*10^{-1}$	$3.07*10^{-5}$	$1.62*10^{+4}$
$\eta_{0,F,S}$	$6.25*10^{+0}$	$4.09*10^{-2}$	$1.53*10^{+2}$	ε_L	$1.00*10^{-4}$	$1.95*10^{-8}$	$5.12*10^{+3}$
$\eta_{0,F,X}$	$-5.00*10^{-2}$	$6.16*10^{-3}$	$-8.12*10^{+0}$	ε_M	$1.00*10^{-4}$	$1.95*10^{-8}$	$5.12*10^{+3}$
$\eta_{0,F,Y}$	$-8.32*10^{-1}$	$1.00*10^{-2}$	$-8.31*10^{+1}$	ε_R	$2.40*10^{-3}$	$4.52*10^{-4}$	$5.30*10^{+0}$
$\eta_{0,G}$	$-1.77*10^{+0}$	$9.99*10^{-3}$	$-1.77*10^{+2}$	ε_T	$4.21*10^{-3}$	$1.97*10^{-1}$	$2.14*10^{-2}$
$\eta_{0,G,B}$	$4.68*10^{-8}$	$7.20*10^{-3}$	$6.49*10^{-6}$	ε_Y	$6.28*10^{-2}$	$7.84*10^{-3}$	$8.01*10^{+0}$
$\eta_{0,H}$	$-6.34*10^{+0}$	$4.43*10^{-1}$	$-1.43*10^{+1}$	r. consumption	$1.37*10^{-2}$	$6.02*10^{-3}$	$2.28*10^{+0}$
$\eta_{0,L}$	$8.96*10^{-4}$	$2.93*10^{-2}$	$3.06*10^{-2}$	r. export	$8.63*10^{-2}$	$1.02*10^{-2}$	$8.45*10^{+0}$
$\eta_{0,M}$	$-7.42*10^{-5}$	$7.41*10^{-3}$	$-1.00*10^{-2}$	r. gov. expend.	$1.91*10^{-2}$	$3.27*10^{-3}$	$5.83*10^{+0}$
$\eta_{0,R}$	$1.85*10^{-2}$	$3.05*10^{-2}$	$6.05*10^{-1}$	r. GDP	$1.64*10^{-2}$	$4.02*10^{-3}$	$4.08*10^{+0}$
$\eta_{0,T}$	$6.39*10^{-1}$	$1.00*10^{+10}$	$6.39*10^{-11}$	r. investment	$1.37*10^{-1}$	$2.05*10^{-2}$	$6.69*10^{+0}$
$\eta_{0,Y}$	$1.78*10^{-3}$	$3.57*10^{-5}$	$4.99*10^{+1}$	r. import	$7.14*10^{-2}$	$4.21*10^{-2}$	$1.69*10^{+0}$
$\eta_{1,D,B}$	$9.94*10^{-1}$	$1.00*10^{+10}$	$9.94*10^{-11}$	employment	$6.49*10^{-2}$	$9.10*10^{-3}$	$7.13*10^{+0}$
$\eta_{1,F,B}$	$1.84*10^{-2}$	$1.00*10^{+10}$	$1.84*10^{-12}$	M0	$5.02*10^{-2}$	$5.96*10^{-3}$	$8.42*10^{+0}$
$\eta_{1,F,D}$	$-9.90*10^{-1}$	$1.23*10^{-3}$	$-8.07*10^{+2}$	n. consumpt.	$9.18*10^{-3}$	$5.15*10^{-3}$	$1.78*10^{+0}$
$\eta_{1,F,P}$	$5.70*10^{-1}$	$1.89*10^{-1}$	$3.01*10^{+0}$	n. export	$7.39*10^{-2}$	$9.78*10^{-3}$	$7.56*10^{+0}$
$\eta_{1,F,R}$	$9.21*10^{-1}$	$1.13*10^{-2}$	$8.16*10^{+1}$	n. gov. expend.	$5.87*10^{-2}$	$9.01*10^{-2}$	$6.52*10^{-1}$
$\eta_{1,F,S}$	$9.85*10^{-1}$	$2.13*10^{+1}$	$4.62*10^{-2}$	n. GDP	$2.64*10^{-2}$	$1.32*10^{-2}$	$2.00*10^{+0}$
$\eta_{1,F,X}$	$-6.46*10^{-1}$	$1.00*10^{+10}$	$-6.46*10^{-11}$	n. investment	$7.62*10^{-2}$	$2.39*10^{-2}$	$3.19*10^{+0}$
$\eta_{1,F,Y}$	$9.12*10^{-1}$	$1.09*10^{-2}$	$8.34*10^{+1}$	n. import	$6.05*10^{-2}$	$7.21*10^{-3}$	$8.38*10^{+0}$
$\eta_{1,G}$	$9.95*10^{-1}$	$6.90*10^{-1}$	$1.44*10^{+0}$	MSCI RUS	$2.58*10^{-1}$	$3.02*10^{-2}$	$8.54*10^{+0}$
$\eta_{1,G,B}$	$2.62*10^{-1}$	$1.00*10^{+10}$	$2.62*10^{-11}$	MSCI world	$1.13*10^{-1}$	$6.75*10^{-1}$	$1.67*10^{-1}$
$\eta_{1,H}$	$-9.63*10^{-1}$	$7.63*10^{-1}$	$-1.26*10^{+0}$	wage	$1.03*10^{-4}$	$1.12*10^{-5}$	$9.19*10^{+0}$
$\eta_{1,L}$	$-1.16*10^{-1}$	$5.78*10^{-3}$	$-2.01*10^{+1}$	comp.for empl.	$6.05*10^{-2}$	$8.29*10^{-3}$	$7.30*10^{+0}$
$\eta_{1,M}$	$9.49*10^{-1}$	$3.78*10^{+1}$	$2.51*10^{-2}$	USDRUR	$1.00*10^{-4}$	$1.76*10^{-3}$	$5.69*10^{-2}$
$\eta_{1,R}$	$9.95*10^{-1}$	$3.03*10^{-1}$	$3.28*10^{+0}$	interest rate	$9.71*10^{-3}$	$1.41*10^{-2}$	$6.89*10^{-1}$