Econometric model of macroeconomic dynamics in Russian Federation

A final version

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Abstract

The paper describes an econometric model of the Russian economy which is tailored to analyze and explain current trends in Russian economy and to forecast its dynamics for the next 2 - 4 years. Its additional function is to show how different factors affect the key macroeconomic variables under the different variants of macroeconomic policy and scenarios of the external economic situation.

The model showed that if all exogenous variables (export and import prices, the money mass and economically active population) will change with the average rates they had during last three years the average annual growth rate of Russian economy for the next four years is -0.7 % while inflation remains as strong as about 7 % annually. The dynamics of gross capital formation will be negative in real terms.

Under the assumptions of rapid import prices increase the dynamics of the GDP becomes worse. Active monetary policy improves the GDP growth but at the expense of higher inflation. Aggressive fiscal policy has a negative impact on gross capital formation.

1. Introduction

Over the past three years Russian economy has demonstrated declining growth rates.[1] Its well-known weaknesses make further slowdown very likely. Among them there are the relatively weak financial system, low total factor productivity, strong dependence on the world commodity markets, and a lack of adequate corporate governance.

Our goal is to analyze and explain current trends in Russian economy and to forecast its dynamics for the next 2 - 4 years using an econometric model. An additional important function of this model is to show how different factors affect the key macroeconomic variables under the different variants of macroeconomic policy and scenarios of the external economic situation.

Among the econometric models of Russian economy we mention first of all those made by Basdevant (2000), Aivazian et al. (2006, 2013a, 2013b) and Benedictow et al. (2013). Other works use models in order to analyze the impact of different policy aspects on Russian economy besides (see e.g. Alexeev et al. 2003; Jensen et al., 2004; Rutherford et al., 2005). BOFIT's scientists (Kerkela, 2004) used computable general equilibrium (CGE) model to study the effects of price liberalization in Russian energy markets and vector autoregressive (VAR) model for the analysis of the role of oil prices in Russian economy (Rautava, 2002). Merlevede et al. (2009) estimated a macroeconomic model in order to analyze of the impact of oil price on Russian economic performance.

We have developed a macro econometric model in order to answer the following questions.

1. What are the main driving forces of Russian economy?
2. What are its perspectives in the coming years?

3. What are the role of fiscal and monetary policy and the impact of the external economic' and the demographic factors on the dynamics of Russian economy?

4. What are the consequences of different scenarios of fiscal and monetary policy and of external shocks for it?

The actual data for our research were obtained from official Russian statistical sources, and this approach distinguishes from the work of e.g. Basdevant (2000) where the Kalman filter for unobserved data was used and from the work of Benedictow et al. who used mostly non-Russian sources of data.

Our model is a system of equations and identities that describe the relationships between different variables rather than unrelated equations that makes it different from the works of e.g. Aivazian et al. (2006, 2013a, 2013b). For given values of exogenous variables (which represent fiscal and monetary policy and external and demographic factors) it is solved to determine the values of endogenous ones.

We consider it is important to describe a supply side of the economy in the model. That's why production function and the equations that demonstrate the supply of labor and of fixed capital are included in our model that makes it different from e.g. Benedictow et al. model whose approach is based on an analysis of the demand side of economy. As market clearing conditions are not fulfilled in Russian economy completely it is necessary to include both supply and demand factors in the equations of the model.[2] That means that in the model the aggregate supply represented by the variable of nominal GDP (symbol NQ) is not equal to the generally accepted definition of aggregate demand as sum of households' consumption C), gross fixed capital formation (I), government purchases (G) and net export (NX). But the difference between aggregate supply and aggregate demand is equal to inventory change (symbol S) as it is accepted (with certain assumptions) in national accounts system. The

variable of inventory change has a negative sign in the equation 4 that determines the GDP deflator price index. That is when the aggregate demand exceeds the aggregate supply the volume of inventory reduces and the prices increase and vice versa. Accordingly the model is moving towards equilibrium (in a conventional sense) although it doesn't reach it entirely (as it happens in practice).

The estimated equations are interpretable in accordance with economic theory and satisfy standard statistical tests of time series and of residual properties and of parameter stability. The model gives a satisfactory explanation of past dynamics of the endogenous variables.

In section 2 we present a brief description of methods we used to estimate the parameters of the model. Section 3 gives a detailed description of model's equations and identities. In sections 4 and 5 we discuss the values of multipliers of exogenous variables and different scenarios for Russian economy for coming years. In section 6 we try to explain the results we got. Section 7 concludes. Appendixes contain the total list of variables and equations and identities, and the main results of the model calculations.

In our approach we follow the traditions of econometric modeling established by Klein (1950), Klein and Goldberger (1955), Fair (1984, 1994, 2005), and by the creators of the Wharton, MPS, DRI Brookings, and authors of other well-known models.[3]

2. Estimation Methods

The model is fully recursive.[4] Its parameters were estimated by Ordinary Least Squares (OLS),[5] by General Least Squares (GLS), by Two-Stage Least Squares (TSLS) and by Maximum Likelihood – Autoregressive Conditional Heteroskedasticity (ML – ARCH)

methods. Unrestricted VAR models were used as the first step to select significant regressors besides.

Standard deviations were used as weights for disturbances in the GLS; exogenous variables and their lags, and lags of endogenous variables were used as instruments in TSLS estimates. In ML – ARCH method only the simplest GARCH (1, 1) specification was used.

The cointegration relations between time series were estimated by Fully Modified Least-Squares (FMOLS) besides using h Park added variables,[6] Engle – Granger,[7] and Philips – Ouliaris tests[8] for testing cointegration.

Such procedures as the Breush-Godfrey test for serial correlation,[9] ARCH and Breusch – Godfrey – Pagan tests to test for heteroscedasticity;[10] the Quandt – Andrews and Chow breakpoint tests for parameter stability,[11] the Augmented Dickey-Fuller (ADF) test for unit root as for series and for residuals in each specification to test cointegration,[12] and other tests were performed for each equation to verify the quality of estimates.[13] Standard errors and covariance are White heteroskedasticity-consistent in OLS, GLS and TSLS estimates.[1] Bollerslev-Wooldridge robust standard errors and covariance specification was used in ML – ARCH estimation.[15] The results of the most important statistical coefficient and tests are shown in Appendix 2 in the bottom of each equation's description.

The insignificant variables were removed from equations.

The final selection of estimated equations was carried out in accordance with the following criteria:

1. equation has appropriate statistical properties;
2. the signs of parameters are consistent with economic theory;

3. the inclusion of the equation in the model [as a system of equations] demonstrates the best values of Theil coefficients in a post forecast imitations carried out by means of the entire model.

In the majority of equations the ML – ARCH were selected as they showed the best properties in accordance with these criteria. TSLS estimates were used to test the exogeneity of variables (all of them passed the test).

3. Model

3.1.General description of the model

The model consists of 24 equations and 24 identities that describe the relationships between 54 variables. They consist of 6 exogenous and 48 endogenous variables.

All the variables can be grouped in seven units:

1. Social unit;
2. The Investment unit;
3. The Production unit
4. Price unit
5. Bank unit
6. Fiscal unit
7. Foreign economy unit

A complete list of variables is presented in Appendix 1 and a complete list of the estimated equations and of identities in Appendix 2.

The supply side of the model consists first of all of two-factor production function and the equations of labor and fixed capital supply. The gross fixed capital formation that determines the supply of fixed is determined capital, in turn, by three equations and one identity:

a) Equation of investments financed by the gross profit;

b) Equation of government investments;

c) Equation of investments financed by the bank loans;

d) Identity that sums up all these three types.

The investments financed by the gross profit depend on its amount and on their profitability. The net marginal revenue on fixed capital is used as a proxy for the latter.[16]

The government investments in the model depend on the amount of taxes collected.

Investments financed by the bank loans to companies depend on the amount of the latter and on investment profitability. Bank credits, in turn, depend on the volume of deposits. Ruble and currency credits and deposits are determined by separate equations as that they depend on different factors in Russia.

The number of employees' variable depends on demographic factors (represented by the number of economically active population) and on average wages per employee. The latter depends on marginal revenue on labor.

The demand side of the model is represented by the variables of internal and of external demands that together with money mass help to determine the price level.

The price level in turn affects the amount of nominal incomes, that is, gross profit and gross wages first of all. The incomes, on the other hand, affect the elements of aggregate demand and supply of factors of production.

As the price level is affected not only by demand but by supply factors also its change promotes the movement of the model toward equilibrium.

There are some other variables in the model too. First it is the ruble to dollar exchange rate index which affects the price level and some other variables. It depends on export and import prices first of all. Second it is capital account balance as an exogenous variable and it affects the dollar rate. Third there are indirect taxes and corporate income tax' variables which serve as a proxy for government revenues in the model and affect the amount of net corporate income and on the amount of government investment in fixed capital. Fourth bank loans to households are included as a separate variable as they affect the consumer demand. Fifth there are different price indexes (CPI, transportation services' tariffs, etc.) included in the model besides the GDP deflator as they affect different other variables.

3.2.Data

The model was estimated mostly on quarterly time series for the period Q1 1999 to Q4 2014 (as the data accuracy for the previous periods is questionable), but the sample size varies across the equations due to data availability and to stability of estimates. The largest part of data is from Rosstat (2015a). Data for money mass and for banks' credits and deposits are from the Bank of Russia (2015); data for corporate income tax and ruble to dollar exchange rate are from Institute of Economic Forecasting (IEF, 2015). Based on Rosstat (2015a) and IEF raw data we calculated cumulative indexes for deflators of the GDP, gross capital formation, export and import prices, and CPI index which are absent in official Russian statistics. In Section 5 devoted to forecasts we used the results of Russian Demographic Forecast performed up to the year 2030 (see Rosstat 2015b).

3.3.Equations and identities of the model[17]

Let's describe the equations and identities of the model in detail.

Equation 1 shows that fixed capital stock depends on gross capital formation. The 8th lag in this equation reflects a long construction lag in Russian economy and the specifics of Russian accounting practice.[18]

Equation 2 shows that number of employees depends on the economically active population and on difference between net marginal revenue on labor and average wages but negatively on the share of gross wages in the GDP. The number of economically active population represents the supply factors of labor in this equation; two other variables represent the factors that affect the demand on labor.

In accordance with classical economic theory at the point of equilibrium of the company the marginal revenue on production factor should be equal to its price. But Russian economy is not in equilibrium; the labor market is not an exception as is it is subjected to strong government regulation.[19] That's why the difference between the net marginal revenue on labor and average wages may create an additional demand for labor.[20]

Equation 3 is the Cobb-Douglas, constant returns to scale production function.[2] Production per employee here depends not only on capital per employee but also on lagged GDP values per employee (that reflects seasonal fluctuations in Russian economy), and on some other variables that reflect on output. Among the latter we see import prices (PIM), the share of import in the GDP (IMP/NQ), the tax burden (PTAX + INTAX)/NQ and the elements of aggregate demand.

The crux of the matter lies in the fact that traditional economic theory defines the production function as *maximum* output for a given amount of production factors' input.[22] But

in reality we estimate production function using *actual* but not maximum output.[23] Taking into account this fact we need to explain what factors will affect the gap between maximum and actual output. An illustration of the fact that this gap was significant in Russian economy is the statistics of low-capacity utilization in it since 1995.[24]

We can suppose that the elements of demand will affect on this gap first of all.[25] The role of import prices is significant (with negative sign) as about 1/3 of Russian import (prior to 2014) consisted of intermediate goods and another 1/3 of investment goods. Their appreciation will diminish output for a given amount of fixed capital and labor used.

The share of import the share of import can also explain the part of the gap as the remaining 1/3 of import consists of consumer goods which can be partly substituted by domestic production. The corresponding variable has negative sign that means that Russian producers have a chance to increase production (and capacity utilization, consequently) in the conditions of decline in competition from imports.

The value of tax burden also affects the gap as it affects the optimism or pessimism of producers (and their desire not to expand but to send earnings abroad as a consequence).

Equation 4 shows that the GDP deflator depends on money supply, on external economic factors (export and import prices and on dollar exchange rate), and on indirect taxes. It depends negatively on volume of real GDP and on inventory change.

This equation illustrates a significant role that world economy plays in determination of the level of inflation in Russia though the elasticity analysis shows that their influence has decreased dramatically over the last fifteen years. The dependence of the price level on indirect taxes is also not surprising as the latter account for 16 % of the GDP and for 62 % of total government revenue.

At the same time the increase of aggregate supply has negative impact on prices that is illustrated by the presence of such variables as real GDP and inventory change in the equation. The latter plays the role of a partial (but not complete) of supply and demand in the model as it was mentioned above.

Identity 5 determines the volume of nominal GDP; identities 6 and 7 define elasticity of output on capital and labor, respectively.[26] Identities 8 and 9 define the net marginal revenue on fixed capital and on labor, respectively.

Equation 10 shows that average gross wage per worker depends on the net marginal revenue on labor, on gross capital formation, on government purchases and on energy inputs' prices.[27] The role of the first one can be explained by microeconomic theory of a firm. Average real wages improved on 4 times in Russia since 1999 mostly due to the improvement of the marginal revenue of labor. Investment in fixed capital creates additional demand for labor that pushes the average wages up. The influence of government purchases is obvious as large share of employed operate under state order (if not to take into account an indirect influence of the level of salaries paid in government institutions).[28] The influence of prices on energy inputs can be explained by the fact of significant weight by energy activities in Russian economy and by high average wages there (more than twice higher than Russian average).

Identity 11 defines the total wages in the economy.

Equation 12 shows that the households' consumption depends on the GDP, net of indirect taxes, on the level of consumer prices, on bank loans to households, on gross wages per employee, on government transfers paid.[29] Households' consumption in Russia increased 2.8 times since 1995 mostly due to remarkable growth of the GDP (on about 1.8 times) and of real average wages and of real social transfers (both on about 4 times).[30]

The GDP and average wages and social transfers are presented as separate variables in this equation due to the following reasons: a) not all incomes take shape as wages; b) there is hidden wages (but detected in the GDP); c) the increase of the share of wages in the GDP and the ratio of social transfers to wages may change the consumer demand as these sources of income may have marginal propensity to consume that differs from other ones.

Identity 13 defines gross corporate income and identity 14 the same net of corporate income tax.

Equation 15 shows that investment in fixed assets at companies' own expense (that is, financed by retained earnings and accrued depreciation) depends on marginal revenue on fixed capital (as a proxy for investment profitability) and on net corporate income first of all. It depends on government investment, on total national savings, on government purchases, on transportation tariffs and on import.[31]

Government investment has a strong positive impact on private investment as the latter usually seeks for support from the former in Russia. At the same time the government purchases (its expenditures on current needs) have a strong negative impact due to "crowding out" effect.[32]

Presence of national savings as a separate variable in this equation may serve as an evidence of presence of other than retained profit (probably hidden) sources of savings that serve to finance private investment. The recorded statistics of profits may be incredible besides.

The negative impact of transportation tariffs shows their significant influence on economic activity in Russia (railway tariffs first of all). The volume import has mixed effect on private investment: negative in regard to import substitution and positive when we take in account a strong dependence of Russian economy on imported modern equipment.

Equation 16 shows that investment in fixed assets at the expense of a consolidated state budget depends on the tax payment first of all. The sum of indirect taxes and corporate income tax serves as a proxy for government revenues in this equation (they constitute together 70 % of total revenue of consolidated budget of Russian Federation). Similar to private one the government investment depends on transportation tariffs and on import.

Equations and identities 17-24 and 45 represent a bank block of the model.[33]

Equation 17 determines that households' denominated bank deposits depend on money mass and on the level of GDP, and negatively on the share of households' consumption in the latter.[34]

Equation 18 explains that corporate denominated bank deposits depend also on money mass and on the level of GDP, and negatively on the price level (as inflation depreciates the cash balances).

Equation 19 shows that of households' currency deposits depend positively on average gross wages and on dollar exchange rate as they try to protect their savings when ruble weakens. But due to overall strengthening of economic and banking system and to growing demand for national currency which follows the economic recovery the share of this type of deposits reduced. That's why the money mass variable enters this equation with negative sign.

Equation 20 shows that corporate currency deposits grow together with their denominated deposits and with the volume of the GDP and that their value increases when ruble weakens.

Identities 21 - 23 calculate the total volume of denominated and currency deposits, and overall bank deposits, respectively.

Equation 24 shows that the amount of denominated bank loans to companies depends positively on the amount of deposits and on the GDP. They depend negatively on dollar rate

as when ruble weakens companies need more loans nominated in foreign currency. Negative role of transportation tariffs can be explained by deteriorative impact of their increase on economic environment. At the same time bank loans to business are supported by the credits of the Bank of Russia to themselves.

Bank loans to companies nominated in foreign currency (equation 25) also depend on the volume of deposits and on the GDP, and on dollar rate. Ruble weakening strengthens the demand for such credits (in deteriorated circumstances of 2008 and 2014 it increased more than usual that two dummy variables reflect).

Identity 26 summarizes the value of denominated and currency bank loans to companies.

Equation 27 shows that the volume of bank loans to households depends positively on the volume of deposits and on the real wages, and on real interest rates. The growth of real wages increases the probability of consumer loans repayment. But the influence of dollar rate on them is negative as credit balances depreciate in the situation of ruble weakening.

Equation 28 shows the dependence of investment in fixed capital by means of bank loans on total bank loans to companies and on net marginal revenue on fixed capital, and on investment from internal sources. They depend positively on government purchases may be due to the fact the majority of large Russian banks are state-owned and they tend to finance the fulfillment of government orders.[35] They depend negatively on import prices maybe because the investment by means of bank loans is largely used to finance import contracts.

Identity 29 determines the amount of gross capital formation as a sum of investment from all sources of funding.

Identity 30 determines the volume of the corporate income tax collected. Though the official corporate income tax rate in Russia is equal to 20 % the internal revenue service

collects only 10 % of corporate' income (the reason is tax evasion and privileges). This figure is remarkably stable in recent years. That's why we use this value (0.1) of proportionality factor in this identity. In identity 31 the value of 0.16 (as a share of the GDP) was selected for the same reasons for indirect taxes.

Equations and identities 32 – 38 represent the foreign economic unit of the model. Equation 32 shows that dollar exchange rate decreases (ruble strengthens) when export prices increase and that ruble weakens when import prices rise. The capital account and interest rates also have some impact on the dollar rate but very small (the absolute values of corresponding elasticity of dollar rate on both variables in near zero). At the same time the impact of the money mass on dollar rate is rather strong (the positive sign in front of this variable means that ruble weakens when the money mass volume increases).

It is worth mentioning the significant and positive parameters in front of dummy variable for 2013 year and especially for Q4 2014 that reflects significant ruble weakening in these periods due to macroeconomic instability.

Identities 33 and 34 determine the ruble indexes of export and import prices, respectively.

Equation 35 shows that the volume of Russian exports depends on export prices and on the volume of the GDP, but negatively depends on internal private demand. The increase of the value of transportation tariffs reduces the volume of export as the large part of it is oil and gas pumped abroad through pipelines and gas pipelines.

Identity 36 determines the internal private demand as a sum of households' consumption and of gross fixed capital formation.

Equation 34 shows that the amount of import depends on GDP and on internal private demand but negatively on import prices. The presence of these two variables in the equation

shows that the volume of import is determined by government demand also. The increase of the value of transportation tariffs reduces the volume of import too.

Identity 38 determines the value of the net export.

Identity 39 determines the volume of government purchases. The proportionality factor was taken equal to 0.18 in this identity. This corresponds to an average share of public procurement in GDP established in recent years.

Identity 40 determines the volume of inventory change.

Equation 41 determines the level of Moscow interbank loan rate. It depends on the Bank of Russia key loan rate (KEY variable) first of all. The volume of money mass and of the GDP and foreign economic variables also have some impact on this rate but not very strong (as elasticity analysis show).

Identity 42 determines the volume of national savings.

Identity 43 determines the index of transportation tariffs as a ratio to the GDP deflator. The proportionality factor was taken equal to 0.87 as corresponds to its average value established in recent years.

Identity 44 determines the volume of government social transfers. The proportionality factor was taken equal to 0.13 in this identity. This corresponds to their average share in the GDP established in recent years.

Identity 45 determines the volume of banks' obligations to the Bank of Russia. The proportionality factor was taken equal to 0.13 in this identity. This corresponds to their average ratio to the total volume of banks' loans to business and to households established in recent years.

Equation 46 shows that the consumer price index value depends on the total volume of households' consumption and on import prices. The latter is also an evidence of strong

dependence of Russian economy on import. The increase of national savings has a moderate negative impact on consumer prices.

The money mass is insignificant in this equation that can be explained by the fact that prices of many consumer goods in Russia are regulated by the government (and by local governments too). Often it is done not only in accordance with law but by means of unofficial "recommendations" to keep consumer prices down. Such conclusion is supported by the fact that in the period 1999 – 2014 the ratio of CPI to the GDP deflator reduced from 0.9 to 0.57. But money mass has an *indirect* influence on consumer prices in the model via equation of the GDP deflator (equation 4).

Equation 47 calculates the gross fixed capital formation deflator that depends both on the GDP deflator and the volume of gross fixed capital formation (but foreign economic variables have some impact on it also).

Final equation 48 shows that energy inputs' price index depends on export prices and on transportation tariffs and on indirect taxes. That's obvious as oil, gas and oil products account for 70 % of Russian export; that's why export prices and transportation tariffs have impact on internal prices of these products. And indirect taxes on oil and gas extraction and export account for more than half of total indirect taxes collection.

4. The Ex-post Forecast Results and the Multipliers

We carried out the ex-post "historical" simulation for the period Q1 2008 – Q4 2014 first of all and then ex-post-forecast for the period Q1 2012 – Q4 2014 on the equations re-estimated on the diminished sample Q1 1995 – Q4 2011. Theil coefficients for all of the endogenous

variables in both procedures do not exceed 0.3.[36] The model predicts correctly all the turning points of endogenous variables. Therefore, we can assume that the model shows good properties and can be used for the analysis and forecasting.

On the basis of the estimated model, we calculated the multipliers, that is, the percent reaction of endogenous variables at 1% of the variation of the exogenous variable. These calculations were fulfilled not in traditional manner.[37] First we made a forecast of Russian economy by means of the model for the years 2015-2019 given all the exogenous variables fixed on the average 2011 – 2014 level (we call it "zero forecast variant"). Then we changed one of the exogenous by 1 % other exogenous variables left unchanged and compared the result with the zero variant. The multipliers got with such procedure for main three endogenous variables are shown in Appendix 3, table A3.1.

The values of multipliers allow the following conclusions. The economically active population still has a strong influence on economic growth in Russia.[38] Dollar import prices have a noticeable negative effect on real economic variables; the impact of export prices is sufficiently weaker. The money supply has a strong positive effect on inflation (that is obvious) but its impact on real variables is much weaker. Multipliers of the Bank of Russia's key rate and of capital account balance are small.

5. The Forecasts

The estimated model allows us to make forecasts for the Russian economy. Their results are presented in Appendix 4.[39]

In the 1st variant (see table A4.1) we allowed all exogenous variables to change with the average rates they had during last three years. In this variant the average annual growth rate of Russian GDP for short-term period (2015-2016 years) is -1.4 % and for long-term (2015-2019) it is -0.7 % while inflation remains as strong as about 7 % annually. The dynamics of gross capital formation is negative in real terms.

Other versions of forecast are presented in the table A4.2 only for long-term period. The main differences between other versions of the forecast consist of different assumptions about the dynamics of export and import prices and about fiscal and monetary policy. Under the assumption of rapid export prices growth the average annual GDP growth increases by 1.8 percentage points but remains weak. Under the assumption of rapid import prices increase the recessions strengthens sufficiently. Active monetary policy increases the GDP annual rate but it remains almost zero and it is achieved at the expense of much higher inflation. Aggressive fiscal policy has a strong negative impact on gross capital formation.

6. What are the reasons of recent situation in Russian economy?

Data analysis, elasticity of dependent variables on independent ones and impulse multipliers calculated by means of the model shed light on the reasons of such forecast results. Here we try to sum them. They are illustrated by graphs presented in Appendix 5.

1. A labor force stagnation (pictures A5.1 and A5.2);
2. A rapid increase of average wages (picture A5.3);
3. A decrease of a profitability as a result (picture A5.4);
4. A rapid increase of consumer expenditures (picture A5.5) and of government procurement (picture A5.6) lead to a decrease of national savings (picture A5.7);

5. These factors are strengthened by weak government investment policy (picture A5.8) and high credit risk (picture A5.9);

6. As a result fixed capital formation stagnates (pictures A5.10 and A5.11);

7. A very important reason of Russian economic slowdown is a stagnation of total factor productivity (picture A5.12);

8. Russian economy preserves high rates of inflation mostly due to high rates of money mass (picture A5.13);

9. Foreign economic factors which were favorable for Russia since 1999 but worsened since 2013. This related primarily to export prices (picture A5.14);

10. Favorable terms of trade (picture A5.15) and dollar real depreciation (up to Q4 2014, picture A5.16) lead to high growth of import (picture A5.17), to decrease of net export (picture A5.18) and of openness of Russian economy (pictures A5.19 and A5.20) and to more and more one-sided structure of Russian export (picture A5.21).

7. Conclusions

The model and forecasts show that the next four years will be difficult for Russian economy. Its growth rates will be negative or very slow even in favorable external economic circumstances. Inflation will be likely as high as 7 % per year. The main reasons for it are low total factor productivity and low investment rate. The ability of Russian banking system to support the economic growth is limited due to its low share in the economy and mostly short-term structure.

Russian economy is sufficiently dependent on the world economy, especially on prices of import goods.

The diversification of the Russian economy is all the more necessary because it largely depends on demographic factors. Workforce reduction which began a few years ago puts the new challenges in the fields of improvement of education, healthcare, scientific and technological advances the main purpose of which is overall increase of economic efficiency. Failure to meet these challenges will leave Russia dependent on world commodity markets; will retain an inherent weakness of her economy which will always need external shocks in order to have positive rates of growth.

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Appendix 1

Table A1.1 Model variables grouped in alphabetical order

Exogenous variables

1. CAP: Capital account balance
2. KEY: The Bank of Russia' key loan rate
3. M: Money mass
4. N: Economically active population, age 15-72
5. PEXP_D: Dollar index of export prices
6. PIM_D: Dollar index of import prices

Endogenous variables

7. C: Households' consumption
8. CH: Bank loans to households
9. CPI: Consumer price index
10. CR: Ruble bank loans to companies
11. CT: Total bank loans to companies
12. CV: Foreign currency bank loans to companies
13. DEP: Total bank deposits
14. DEPCB: Banks' obligations to the Bank of Russia
15. DEPR: Total bank ruble deposits
16. DEPRF: Companies' bank ruble deposits
17. DEPRP: Households' bank ruble deposits
18. DEPV: Total bank foreign currency deposits
19. DEPVF: Companies' bank foreign currency deposits
20. DEPVP: Households' bank foreign currency deposits
21. DI: Fixed capital price index
22. DOLLAR: Ruble to dollar exchange rate index
23. EXP: Export
24. G: Government purchases
25. I: Gross fixed capital formation
26. IB: Investment in fixed capital through bank loans
27. IG: Investment in fixed capital from state budget
28. IMP: Import
29. INTAX: Indirect taxes paid
30. IO: Investment in fixed capital on companies' own expense
31. IPD: Internal private demand
32. K: Fixed capital
33. L: Total employment
34. MIACR: Moscow interbank loan rate
35. NMRK: Net marginal revenue on fixed capital
36. NMRL: Net marginal revenue on labor
37. NQ: Nominal GDP
38. NROK: Net profit
39. NX: Net export
40. P: GDP deflator price index
41. PEN: Energy inputs' price index
42. PEXP: Ruble index of export prices
43. PIM: Ruble index of import
44. PTAX: Corporate income tax paid
45. Q: GDP in constant prices
46. ROK: Gross profit
47. S: Inventory change
48. SAVE: Total national savings

49. TARIF: Transportation services' tariffs' index
50. TRANSF : Government transfers
51. TW: Total wages paid in the economy
52. W: Gross wages per 1 employee
53. ε_K: Elasticity of GDP on fixed capital
54. ε_L: Elasticity of GDP on labor

Auxiliary variables and symbols

T: Time trend
k_H: proportionality factor for variable H
DX: Dummy for year X: 0 before and 1 after
DXQY: Dummy for year X, quarter Y
(-v): Lag of v degree

Table A1.2. Model variables grouped in units

Name	Symbol	Type	N of equation or identity	N in alphabetical order
I. Social unit				
Economically active population	N	X		4
Total employment	L	D	2	33
Gross wages per 1 employee	W	D	10	52
Total wages paid in the economy	TW	D	11	51
Government transfers	TRANSF	D	44	50
Households' consumption	C	D	12	7
II. The investment unit				
Fixed capital	K	D	1	32
Gross profit	ROK	D	13	46
Net profit	NROK	D	14	38
Total national savings	SAVE	D	42	48
Gross fixed capital formation	I	D	29	25
Investment in fixed capital on companies' own expense	IO	D	15	30
Investment in fixed capital through bank loans	IB	D	28	26
Investment in fixed capital at the expense of state budget	IG	D	16	27
III. The production unit				
GDP in constant prices	Q	D	3	45
Nominal GDP	NQ	D	5	37
Inventory change	S	D	40	47
Elasticity of GDP on labor	ε_L	D	7	54
Elasticity of GDP on fixed capital	ε_K	D	6	53
Net marginal revenue on labor	NMRL	D	9	36
Net marginal revenue on fixed capital	NMRK	D	8	35
IY. Price unit				
GDP deflator price index	P	D	4	40
Consumer price index	CPI	D	46	9
Fixed capital price index	DI	D	47	21
Transportation services' tariffs' index	TARIF	D	43	49
Energy inputs' price index	PEN	D	48	41

Table A1.2, continued

Y. Bank unit				
Money mass	M	X		3
The Bank of Russia' key loan rate	KEY	X		2
Moscow interbank loan rate	MIACR	D	41	34
Banks' obligations to the Bank of Russia	DEPCB	D	45	14
Households' bank ruble deposits	DEPRP	D	17	17
Companies' bank ruble deposits	DEPRF	D	18	16
Households' bank foreign currency deposits	DEPVP	D	19	20
Companies' bank foreign currency deposits	DEPVF	D	20	19
Total bank ruble deposits	DEPR	D	21	15
Total bank foreign currency deposits	DEPV	D	22	18
Total bank deposits	DEP	D	23	13
Ruble bank loans to companies	CR	D	24	10
Foreign currency bank loans to companies	CV	D	25	12
Total bank loans to companies	CT	D	26	11
Bank loans to households	CH	D	27	8
YI. Fiscal unit				
Corporate income tax paid	PTAX	D	30	44
Indirect taxes paid	INTAX	D	31	29
Government purchases	G	D	39	24

Table A1.2, continued

YII. Foreign economy unit				
Dollar index of export prices	PEXP_D	X		5
Dollar index of import prices	PIM_D	X		6
Ruble index of export prices	PEXP	D	33	42
Ruble index of import prices	PIM	D	34	43
Ruble to dollar exchange rate index	DOLLAR	D	32	22
Export	EXP	D	35	23
Import	IMP	D	37	28
Net export	NX	D	38	39
Capital account balance	CAP	X		1
Internal private demand	IPD	D	36	31

Note: X means “exogenous variable”, D means “endogenous variable”

Appendix 2

Table A2.1

A total list of equations and identities of the model: a compact mathematical presentation

$$K = f_K(I) \tag{1}$$

$$L = f_L(N, NMRL, W, TW, NQ) \tag{2}$$

$$Q = f_Q(K, L, IMP, PIM, DI, PTAX, INTAX, C, I, G, NX) \tag{3}$$

$$P = f_P(M, Q, PIM, INTAX, DOLLAR, S) \tag{4}$$

$$NQ = PQ \tag{5}$$

$$\varepsilon_K = \frac{\partial Q}{\partial K}\frac{K}{Q} \tag{6}$$

$$\varepsilon_L = \frac{\partial Q}{\partial L}\frac{L}{Q} \tag{7}$$

$$NMRK = \varepsilon_K \frac{PQ - INTAX - PTAX}{K} \tag{8}$$

$$NMRL = \varepsilon_L \frac{PQ - INTAX}{L} \tag{9}$$

$$W = f_W(NMRL, I, G, PEN) \tag{10}$$

$$TW = WL \tag{11}$$

$$C = F_C(NQ, W, TRANSFER, INTAX, CPI, CH, SAVE) \tag{12}$$

$$ROK = NQ - TW - INTAX \tag{13}$$

$$NROK = ROK - PTAX \tag{14}$$

$$IO = f_{IO}(NMRK, NROK, SAVE, G, IG, TARIF, IMP, NQ, DI) \tag{15}$$

$$IG = f_{IG}(PTAX, INTAX, TARIF, IMP, DI) \tag{16}$$

$$DEPRP = f_{DEPRP}(M, NQ, C) \tag{17}$$

$$DEPRF = f_{DEPRF}(M, P, Q, DEPCB) \tag{18}$$

$$DEPVP = f_{DEPVP}(M, DOLLAR, W, CPI, DEPCB) \tag{19}$$

$$DEPVF = f_{DEPVF}(DEPRF, NQ, DOLLAR) \tag{20}$$

Table A2.1, continued

$$DEPR = DEPRP + DEPRF \tag{21}$$

$$DEPV = DEPVP + DEPVF \tag{22}$$

$$DEP = DEPR + DEPV \tag{23}$$

$$CR = f_{CR}(DEPR, NQ, DOLLAR, DEPCB, TARIF) \tag{24}$$

$$CV = f_{CV}(DEPV, DOLLAR, NQ) \tag{25}$$

$$CT = CR + CV \tag{26}$$

$$CH = f_{CH}(DEP, W, DOLLAR, MIACR) \tag{27}$$

$$IB = f_{IB}(NMRK, CT, IO, G, DI, DOLLAR, PIM, IMP) \tag{28}$$

$$I = IO + IG + IB \tag{29}$$

$$PTAX = k_{PTAX} ROK \tag{30}$$

$$INTAX = k_{INTAX} NQ \tag{31}$$

$$DOLLAR = f_{DOLLAR}(PEXP\_D, PIM\_D, CAP, MIACR, M) \tag{32}$$

$$PEXP = (PEXP\_D)(DOLLAR) \tag{33}$$

$$PIM = (PIM\_D)(DOLLAR) \tag{34}$$

$$EXP = f_{EXP}(PEXP\_D, DOLLAR, Q, IPD, TARIF, P) \tag{35}$$

$$IPD = C + I \tag{36}$$

$$IMP = f_{IMP}(PIM\_D, DOLLAR, NQ, IPD, TARIF, P) \tag{37}$$

$$NX = EXP - IMP \tag{38}$$

$$G = k_G NQ \tag{39}$$

$$S = NQ - C - I - G - NX \tag{40}$$

$$MIACR = f_{MIACR}(KEY, M, Q, DOLLAR, PEXP, PIM) \quad (41)$$

$$SAVE = NQ - C - G \quad (42)$$

$$TARIF = k_{TARIF} P \quad (43)$$

$$TRANSFER = k_{TRANSFER} NQ \quad (44)$$

$$DEPCB = k_{DEPCB}(CT + CH) \quad (45)$$

Table A2.1, continued

$$CPI = f_{CPI}(C, PIM, SAVE) \quad (46)$$

$$DI = f_{DI}(P, I, IMP, PIM\_D, NQ) \quad (47)$$

$$PEN = f_{PEN}(P, PEXP, TARIF, INTAX) \quad (48)$$

Table A2.2

List of equations and identities of the model: a detailed econometric presentation (estimated equations only)

№	*Equation / Identity*
1	K/P(-1) = 0.509K(-1)/P(-2) +0.32K(-4)/P(-5) – 0.32K(-5)/P(-6) + (0.044)** (0.082)** (0.079)** 3.542I(-8)/P(-8) – 6.5T + 1457.8 + 202.2D08 + 97.6D12 + 212.7D13Q1 (0.643)** (1.81)**(196.6)**(58.8)** (31.2)** (37.8)** + 339.1D14Q1 (43.3)** $R^2 = 0.909$ DW = 2.120
2	L = 0.386L(-1)+ 0.417L(-4) – 0.358L(-5) – 0.157L(-8) + 0.818N - (0.025)** (0.040)** (0.043)** (0.032)** (0.038)** - 0.511N(-4) + 0.374N(-5) + 0.028(NMRL(-1) – W(-1)) + (0.043)** (0.045)** (0.006)** 0.055(NMRL(-6)–W(-6))+0.094(NMRL(-8)–W(-8))–6.1TW(-1)/NQ(-1) (0.004)** (0.006)** (2.01)** + 14.25(TW(-5)/NQ(-5)) – 13.63(TW(-7)/NQ(-7)) + 1.078D10 (1.88)** (0.99)** (0.057)** $R^2 = 0.974$ DW = 1.711 JARQUE – BERA = 1.923 (Prob. = 0.382) ARCH LM Test: F = 0.043 (Prob. = 0.88)

Table A2.2, continued

№	*Equation / Identity*
3	ln(Q/L) = 0.121ln(K/L) - 0.0947PIM + (0.026)** (0.0018)** + 0.55ln(Q(-1)/L(-1)) – 0.19ln(Q(-2)/L(-2)) + (0.055)** (0.049)** + 0.82ln(Q(-4)/L(-4)) – 0.54ln(Q(-5)/L(-5)) + (0.038)** (0.061)** – 0.0034(DI(-1)) + 0.035D09 - (0.0002)** (0.011)** - 0.366(IMP(-2)/NQ(-2)) + 0.497(IMP(-4)/NQ(-4)) - (0.101)** (0.132)** -0.299(IMP(-8)/NQ(-8)) – 0.096(PTAX(-2) + INTAX(-2))/NQ(-2) (0.083)** (0.047)* + 0.000268(C(-6) + I(-6) + G(-6) + NX(-6))/NQ(-6) (0.0000842)** R^2 = 0.996 DW = 2.199 JARQUE – BERA = 1.537 (Prob. = 0.463) ARCH LM Test: F = 0.004 (Prob. = 0.94)
4	P - P(-1) = 0.0005(M(-2) – M(-3)) + 0.269(M/Q – M(-1)/Q(-1)) - (0.0000648)** (0.018)** - 0.145(M(-1)/Q(-1) – M(-2)/Q(-2)) + 0.001539(INTAX – INTAX(-1)) + (0.038)** (0.000146)** + 0.079(PEXP – PEXP(-1)) + 0.262(PIM(-4) – PIM(-5)) + (0.041)* (0.047)** + 0.299(DOLLAR(-2) – DOLLAR(-3)) - (0.012)** - 0.000234(S(-3) – S(-4)) – 0.000882(S(-8) – S(-9)) (0.000115)* (0.000208)** R^2 = 0.933 DW = 2.186 JARQUE – BERA = 0.246 (Prob. = 0.88) ARCH LM Test: F = 1.77 (Prob. = 0.18)

Table A2.2, continued

№	*Equation / Identity*
10	W – W(-1) = -0.287(W(-1) – W(-2)) – 0.286(W(-5) – W(-6)) - (0.079)** (0.053)** - 0.396(W(-6) – W(-7)) – 0.321(W(-7) – W(-8)) + (0.094)** (0.094)** + 0.300(NMRL – NMRL(-1)) + 0.195(NMRL(-7) – NMRL(-8)) + (0.026)** (0.049)** + 0.0025(I(-1) – I(-2)) + 0.0056(I(-4) – I(-5)) + 0.0028(I(-6) – I(-7)) - (0.0002)** (0.0005)** (0.0002)** - 0.0047(I(-8) – I(-9)) + 0.0074(G – G(-1)) + 0.0089(G(-1) – G(-2)) + (0.0006)** (0.001)** + 0.0098(G(-7) – G(-8)) + 0.0091(G(-8) – G(-9)) + 0.026T - (0.002)** (0.002)** (0.006)** + 0.88(PEN – PEN(-1)) (0.26)** $R^2 = 0.965$ DW = 2.459 JARQUE – BERA = 2.49 (Prob. = 0.28) ARCH LM Test: F = 0.01 (Prob. = 0.91)

Table A2.2, continued

№	*Equation / Identity*
12	C – C(-1) = 0.000182(CH(-4) – CH(-5)) - (0.0000173)** - 91.2(CPI(-1) – CPI(-2)) – 86.8(CPI(-3) – CPI(-4)) + (9.37)** (10.36)** + 0.389((NQ – INTAX) – (NQ(-1) – INTAX(-1))) + (0.018)** + 23.74*(W(-2) – W(-3)) + 0.47(TRANSF(-1) – TRANSF(-2)) + (3.30)** (0.06)** + 0.05(SAVE(-1) – SAVE(-2)) + 347.6D08Q4 + 89.4D14Q4 (0.02)* (35.8)** (36.8)* R^2 = 0.978 DW = 1.890 JARQUE – BERA = 2.01 (Prob. = 0.36) ARCH LM Test: F = 0.56 (Prob. = 0.45)

Table A2.2, continued

№	*Equation / Identity*
15	IO/DI(-1) – IO(-1)/DI(-2) = 0.286(IO(-4) – IO(-5)) + (0.021)** + 0.544(NMRK*NROK/DI(-1) – NMRK(-1)NROK(-1)/DI(-2)) + (0.038)** + 1.126(IG(-4)/DI(-5) – IG(-5)/DI(-6)) + 0.060** + 0.214(SAVE/DI(-1) – SAVE(-1)/DI(-2)) – (0.008)** - 0.330(G/DI(-1) – G(-1)/DI(-2)) – (0.050)** - 16.64(TARIF(-3)/DI(-4) – TARIF(-4)/DI(-5)) - (3.51)** - 72.6(IMP(-1)/NQ(-1) - IMP(-2)/NQ(-2)) - (15.2)** -36.6(IMP(-2)/NQ(-2) - IMP(-3)/NQ(-3)) + (18.4)* + 0.228(IMP(-2)/DI(-3) – IMP(-3)/DI(-4)) - (0.019)** - 0.162(IMP(-3)/DI(-4) – IMP(-4)/DI(-5)) (0.019)** $R^2 = 0.995$ DW = 1.673 JARQUE – BERA = 4.47 (Prob. = 0.11) ARCH LM Test: F = 0.77 (Prob. = 0.38)

Table A2.2, continued

№	*Equation / Identity*
16	IG/DI(-1) = 0.152IG(-1)/DI(-2) + 0.395IG(-8)/DI(-9) + (0.017)** (0.029)** + 0.063(PTAX + INTAX)/DI(-1) + (0.004)** + 0.054(PTAX(-8) + INTAX(-8))/DI(-9) + (0.008)** + 0.17IMP(-4)/DI(-5) – 0.16IMP(-7)/DI(-8) (0.007)** (0.008)** - 9.48TARIF(-2)/DI(-3) + 4.8 + 2.88D07Q4 – 2.12D14 (1.59)** (1.3)** (0.31)** (0.39)** $R^2 = 0.987$ DW = 1.871 JARQUE – BERA = 0.02 (Prob. = 0.99) ARCH LM Test: F = 0.08 (Prob. = 0.77)
17	DEPRP – DEPRP(-1) = 364.6(M(-1) – M(-2)) + 66.8(NQ – NQ(-1)) – (34.0)** (23.1)** - 1334554(C(-7)/NQ(-7) – C(-8)/NQ(-8)) + 122915D10 (368339)** (58651)* $R^2 = 0.875$ DW = 1.989 JARQUE – BERA = 28.3 (Prob. = 0.01) BREUSCH – GODFREY SERIAL CORRELATION LM TEST: F = 0.12 (Prob. = 0.88) HETEROSCEDASTICITY TEST BREUSCH – PAGAN - GODFREY: F = 3.49 (Prob. = 0.01) (34.0)** (23.1)** - 1334554(C(-7)/NQ(-7) – C(-8)/NQ(-8)) + 122915D10 (368339)** (58651)*

Table A2.2, continued

№	*Equation / Identity*
18	DEPRF – DEPRF(-1) = - 0.517(DEPRF(-2) – DEPRF(-3)) + (0.073)** + 0.208(DEPRF(-3) – DEPRF(-4)) – 0.535(DEPRF(-4) – DEPRF(-5)) - (0.059)** (0.113)** - 0.364(DEPRF(-6) – DEPRF(-7)) + 0.477(DEPRF(-7) – DEPRF(-8)) - (0.087)** (0.096)** - 0.786(DEPRF(-8) – DEPRF(-9)) + 290(M(-5) – M(-6)) + (0.136)** (59.5)** + 433.4(M(-8) – M(-9)) – 194011(P – P(-1) – 237584(P(-6) – P(-7)) + (67.1)** (27255)** (42108)** + 3085(Q(-5) – Q(-6)) + 2818(Q(-7) – Q(-8)) – (1157)* (1272)* - 0.368(DEPCB – (DEPCB(-1)) – 0.297(DEPCB(-2) – DEPCB(-3)) – (0.041)** (0.036)** - 0.336(DEPCB(-6) – DEPCB(-7)) + 0.414(DEPCB(-7) – DEPCB(-8)) - (0.035)** (0.059)** - 0.177(DEPCB(-8) – DEPCB(-9)) + 7116T (0.037)** (2066)** $R^2 = 0.923$ DW = 2.113 JARQUE – BERA = 1.60 (Prob. = 0.44) BREUSCH – GODFREY SERIAL CORRELATION LM TEST: F = 0.092 (Prob. = 0.91) HETEROSCEDASTICITY TEST BREUSCH – PAGAN - GODFREY: F = 0.61 (Prob. = 0.85)

Table A2.2, continued

№	*Equation / Identity*	
19	DEPVP/CPI = 0.303DEPVP(-1)/CPI(-1) – 0.225DEPVP(-2)/CPI(-2) + (0.062)** (0.072)** + 0.382DEPVP(-4)/CPI(-4) – 0.453DEPVP(-5)/CPI(-5) + (0.052)** (0.078)** + 0.292DEPVP(-6)/CPI(-6) – 0.090DEPVP(-7)/CPI(-7) – (0.074)** (0.037)* - 54M(-2)/CPI(-2) + 15.2M(-4)/CPI(-4) + 2867W(-2)/CPI(-2) + (2.0)** (5.2)** (378)** + 22223DOLLAR/CPI + 0.104DEPCB/CPI + 1869T + 25754D09 (1926)** ((0.0003)** (2692)** $R^2 = 0.989$ DW = 1.879 JARQUE – BERA = 0.76 (Prob. = 0.68) ARCH LM Test: F = 0.81 (Prob. = 0.37)	(2 2 1)
20	DEPVF/DOLLAR = 0.488DEPVF(-1)/DOLLAR(-1) + (0.150)** + 0.578DEPRF/DOLLAR – 0.416DEPRF(-1)/DOLLAR(-1) + (0.062)** (0.070)** + 0.175DEPRF(-4)/DOLLAR(-4) – 96NQ(-1)/DOLLAR(-1) + (0.081)* (26)** + 118NQ(-2)/DOLLAR(-2) – 50842D11 (29)** (21570)* $R^2 = 0.986$ DW = 1.709 JARQUE – BERA = 3.43 (Prob. = 0.17) ARCH LM Test: F = 0.55 (Prob. = 0.45)	

Table A2.2, continued

№	*Equation / Identity*
24	CR – CR(-1) = 0.432(DEPR – DEPR(-1)) + 263(NQ – NQ(-1)) + (0.045)** (36)** + 137(NQ(-2) – NQ(-3)) + 0.263(DEPCB – DEPCB(-1)) - (14)** (0.043)** - 326645(DOLLAR(-4) – DOLLAR(-5)) – (65662)** - 66206(TARIF(-1) – TARIF(-2)) + 194495D07 - (22048)** (53417)** - 261995D10 + 204688D12 (73707)** (73679)** $R^2 = 0.818$ DW = 1.605 JARQUE – BERA = 1.34 (Prob. = 0.51) ARCH LM Test: F = 0.01 (Prob. = 0.91)
25	CV/DOLLAR = -0.378CV(-7)/DOLLAR(-7) + 0.51DEPV/DOLLAR + (0.071)** (0.058)** + 142NQ/DOLLAR + 79748D07 + 98606D08 – 68075D12 + (9.3)** (14489)** (17655)** (13533)** + 72187D14 (10714)** $R^2 = 0.992$ DW = 1.256 JARQUE – BERA = 1.37 (Prob. = 0.50) ARCH LM Test: F = 1.83 (Prob. = 0.18)

Table A2.2, continued

№	*Equation / Identity*
27	CH/P = 0.51CH(-1)/P(-1) + 0.344DEP/P + 1527W/CPI – (0.039)** (0.018)** (455)** - 65099DOLLAR/P + 32051(MIACR – (P – P(-4))/P(-4) – (8193)** (6224)** - 1872T – 19816D07 – 4683D08 – 26242D09 + 9788D14 – 8736D14Q4 (287)** (1689)** (1301)** (2175)** (2883)** (2807)** + 26305 (6881)** $R^2 = 0.998$ DW = 1.252 JARQUE – BERA = 1.16 (Prob. = 0.55) ARCH LM Test: F = 0.000373 (Prob. = 0.98)
28	IB/DI(-1) = 0.594IB(-4)/DI(-5) + 0.0000339NMRK(-5)CT(-5)/DI(-4) + (0.055)** (0.00000773)** + 0.15IO/DI(-1) – 0.06IO(-4)/DI(-5) + 0.027G/DI(-1) - (0.015)** (0.025)* (0.01)** - 3.52PIM/P – 5.42D09 – 0.84D12 + 1.83D13 – 3.33D14 – 1.51D14Q4 (0.89)** (0.31)** (0.31)** (0.37)** (0.29)** (0.36)** $R^2 = 0.992$ DW = 1.376 JARQUE – BERA = 2.89 (Prob. = 0.23) ARCH LM Test: F = 2.13 (Prob. = 0.15)

Table A2.2, continued

№	*Equation / Identity*
32	DOLLAR – DOLLAR(-1) = -0.93(PEXP_D – PEXP_D(-1)) – (0.08)** -0.73(PEXP_D(-1) – PEXP_D(-2)) + 0.44(PEXP_D(-2) – PEXP_D(-3)) (0.11)** (0.09)** + 1.628(PIM_D(-1) – PIM_D(-2)) – 0.0000109(CAP(-1) – CAP(-2)) - (0.213)** (0.00000359)** - 1.817(MIACR(-1) – MIACR(-2)) – 0.909(MIACR(-3) – MIACR(-4)) (0.48)** (0.18)** - 0.869(MIACR(-4) – MIACR(-5)) + 0.0000585(M(-2) – M(-3)) + (0.21)** (0.0000221)** + 0.0000848(M(-7) – M(-8)) – 0.307D12 + 0.369D13 + 3.155D14Q4 (0.0000257)** (0.055)** (0.139)** (0.135)** $R^2 = 0.888$ DW = 2.285 JARQUE – BERA = 0.17 (Prob. = 0.91) ARCH LM Test: F = 1.33 (Prob. = 0.25)

Table A2.2, continued

№	*Equation / Identity*
35	EXP/DOLLAR – EXP(-1)/DOLLAR(-1) = 119(PEXP_D – PEXP_D(-1)) + (7.8)** + 31.1(PEXP_D(-3) – PEXP_D(-4)) + (5.2)** + 0.26(NQ/DOLLAR – NQ(-1)/DOLLAR(-1)) - (0.009)** + 0.14(NQ(-1)/DOLLAR(-1) – NQ(-2)/DOLLAR(-2)) - (0.02)** - 0.07(IPD(-3)/DOLLAR(-3) – IPD(-4)/DOLLAR(-4)) - (0.005)** - 43.1(TARIF/DOLLAR – TARIF(-1)/DOLLAR(-1)) - (8.6)** - 12.0(P(-5)/DOLLAR(-5) – P(-6)/DOLLAR(-6)) - (4.3)** -0.43(EXP(-1)/DOLLAR(-1) – EXP(-2)/DOLLAR(-2)) (0.05)** $R^2 = 0.959$ DW = 1.969 JARQUE – BERA = 1.08 (Prob. = 0.58) ARCH LM Test: F = 0.15 (Prob. = 0.69)

Table A2.2, continued

№	*Equation / Identity*
37	IMP/DOLLAR – IMP(-1)/DOLLAR(-1) = -0.475(IMP(-1)/DOLLAR(-1) – IMP(-2)/ DOLLAR(-2)) - (0.027)** - 42.9(PIM_D(-4) – PIM_D(-5)) + (9.24)** + 0.138(NQ/DOLLAR – NQ(-1)/DOLLAR(-1)) + (0.002)** + 0.0997(NQ(-1)/DOLLAR(-1) – NQ(-2)/DOLLAR(-2)) + (0.006)** + 0.105(IPD/DOLLAR – IPD(-1)/DOLLAR(-1)) + (0.003)** + 0.03(IPD(-3)/DOLLAR(-3) – IPD(-4)/DOLLAR(-4)) - (0.003)** - 12.27(TARIF(-3)/DOLLAR(-3) – TARIF(-4)/DOLLAR(-4)) + (1.65)** + 29.7(P(-2)/DOLLAR(-2)) – P(-3)/DOLLAR(-3)) – (1.44)** - 32.3(P(-7)/DOLLAR(-7) – P(-8)/DOLLAR(-8)) - (1.20)** - 0.0828(S(-3)/DOLLAR(-3) – S(-4)/DOLLAR(-4)) (0.008)** $R^2 = 0.964$ DW = 2.191 JARQUE – BERA = 0.99 (Prob. = 0.60) ARCH LM Test: F = 0.28 (Prob. = 0.59)

Table A2.2, continued

№	*Equation / Identity*
41	(MIACR – (P – P(-4))/P(-4)) – (MIACR(-1) – (P(-1) – P(-5))/P(-5)) = - 0.39 (MIACR(-1) – (P(-1) – P(-5))/P(-5)) - MIACR(-2) – (P(-2) – P(-6))/P(-6) + 1.003((KEY – (P – P(-4))/P(-4)) –(KEY(-1) – (P(-1) – P(-5))/P(-5))) + 0.51((KEY(-1) – (P(-1) – P(-5))/P(-5)) – (KEY(-2) – (P(-2) – P(-6))/P(-6))) + 0.000297(M(-2)/P(-2) – M(-3)/P(-3)) - 0.13(DOLLAR(-2)/P(-2) – DOLLAR(-3)/P(-3)) - 0.13(DOLLAR(-3)/P(-3) – DOLLAR(-4)/P(-4)) - 0.000151(Q(-2) – Q(-3)) – 0.0000933(Q(-3) – Q(-4)) - 0.07(PEXP/P) + 0.21(PIM/P) (0.07)** (0.02) (0.07)** (0.0000424)** (0.04)** (0.04)** (0.0000234)** (0.0000234)** (0.01)** (0.04)** $R^2 = 0.845$ DW = 2.142 JARQUE – BERA = 0.34 (Prob. = 0.84) ARCH LM Test: F = 1.35 (Prob. = 0.25)

Table A2.2, continued

№	*Equation / Identity*
46	CPI – CPI(-1) = -0.181(CPI(-1) – CPI(-2)) – 0.411(CPI(-2) – CPI(-3)) + (0.08)* (0.07)** + 0.677(CPI(-4) – CPI(-5)) – 0.216(CPI(-7) – CPI(-8)) + (0.07)** (0.109)* + 0.001014(C – C(-1)) + 0.000443(C(-1) – C(-2)) - (0.000114)** (0.000211)* - 0.000725(C(-5) – C(-6)) + 0.155(PIM – PIM(-1)) + (0.000234)** (0.039)** + 0.126(PIM(-1) – PIM(-2)) + 0.126(PIM(-2) – PIM(-3)) + (0.056)* (0.039)** + 0.201(PIM(-3) – PIM(-4)) – 0.000149(SAVE – SAVE(-1)) – (0.051)** (0.0000651)* - 0.000161(SAVE(-1) – SAVE(-2)) – 0.000217(SAVE(-8) – SAVE(-9)) (0.0000566)** (0.0000593)** + 0.203 (0.07)** $R^2 = 0.998$ DW = 1.933 JARQUE – BERA = 0.57 (Prob. = 0.74) ARCH LM Test: F = 0.58 (Prob. = 0.44)
47	DI – DI(-1) = 0.68(DI(-4) – DI(-5)) + 0.177(P – P(-1)) + (0.018)** (0.014)** + 0.000385(I – I(-1)) – 0.78(PIM_D – PIM_D(-1)) + (0.00000396)** (0.10)** + 9.15(IMP/NQ – IMP(-1)/NQ(-1)) + 0.0039T – 0.39D09 (1.19)** (0.001)** (0.10)** $R^2 = 0.983$ DW = 1.549 JARQUE – BERA = 3.42 (Prob. = 0.18) ARCH LM Test: F = 1.31 (Prob. = 0.25)

Table A2.2, continued

№	*Equation / Identity*
48	PEN/P = 0.72PEN(-1)/P(-1) + 0.22PEN(-4)/P(-4) – 0.42PEN(-5)/P(-5) + (0.03)** (0.05)** (0.03)** + 0.15TARIF/P + 0.05PEXP/P + 0.08PEXP(-2)/P(-2) – 0.05PEXP(-6)/P(-6) + (0.01)** (0.007)** (0.01)** (0.01)** + 0.000314INTAX(-7)/P(-7) $R^2 = 0.878$ DW = 1.883 JARQUE – BERA = 2.72 (Prob. = 0.25) ARCH LM Test: F = 1.36 (Prob. = 0.24)

Notes: in parentheses there are standard errors of the parameters. Symbol * means significant at 95 % level;** – significant at 99 % level; R^2 – determination coefficient; DW – Durbin-Watson coefficient. The Breusch – Godfrey serial correlation lm test and heteroscedasticity test Breusch – Pagan – Godfrey are presented for OLS estimates and the ARCH LM test for ML – ARCH estimates. Jarque – Bera normality of residuals' test is presented for all estimates.

Appendix 3

Table A3.1. The impulse multipliers for main endogenous variables

Exogenous / Endogenous	Q	P	I
PEXP_D	+0.09	+0.04	+0.10
PIM_D	-0.28	+0.10	-0.34
N	+0.75	-0.07	+0.80
M	+0.09	+0.56	+0.04
KEY	0.00	-0.01	-0.01
CAP	0.00	0.00	0.00

Note: figures in the table rounded for two decimal places; reaction (multiplier) of the GDP (Q) and gross fixed capital formation (I) is shown in constant prices.

Appendix 4

Forecasts' results

Table A4.1. First forecast variant

Exogenous variable (average quarterly dynamics index)		
N	1,000	
PEXP_DOL	1,010	
PIM_DOL	1,0022	
M	1,025	
CAP	1,000	
Main endogenous variables (average year change, %)		
	Short-term (2015-2016)	Long-term (2015-2019)
Q	-1.4	-0.7
P	+6.7	+7.3
I	-3.0	-3.3

Notes: Dynamics of the GDP (Q) and gross fixed capital formation (I) is shown in constant prices.

Table A4.2. Other forecast variants, long-term (2015-2019)

Variant number	Exogenous variable (average quarterly dynamics index; capital account in billions of dollars; government consumption as % of the GDP)		Main endogenous variables (average year change, %)		
			Q	P	I
2	PEXP_DOL	1,05	+1.0	7.8	-1.3
	Diff. from 1st	*+0.04*	*+1.8*	*+0.5*	*+2.0*
3	PIM_DOL	1,025	-4.0	8.5	-7.2
	Diff. from 1st	*0.0228*	*-3.3*	*+1.2*	*-3.9*
4	M	1,05	0.0	+13.7	-2.7
	Diff. from 1st	*+0.25*	*+0.7*	*+6.4*	*+0.6*
5	G	22 % of the GDP	-1.2	+7.5	-8.6
	Diff. from 1st	*4 p.p. of the GDP*	*-0.5*	*+0.2*	*-5.3*

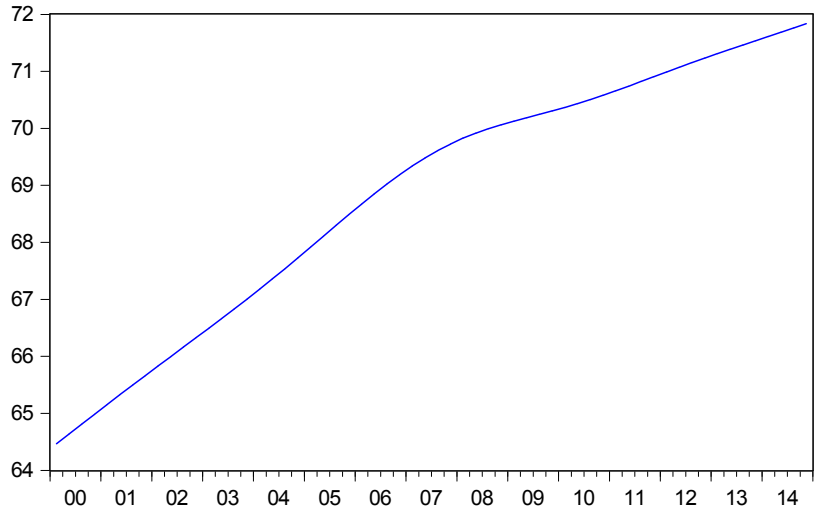
Notes: each forecast variant differs from first one only by the change in the dynamics of one exogenous variable. The figures in the table show how the change in the dynamics on one exogenous variable changes the dynamics of three main endogenous variables in comparison with the basic forecast variant.

Appendix 5

Graphic illustration for Section 6

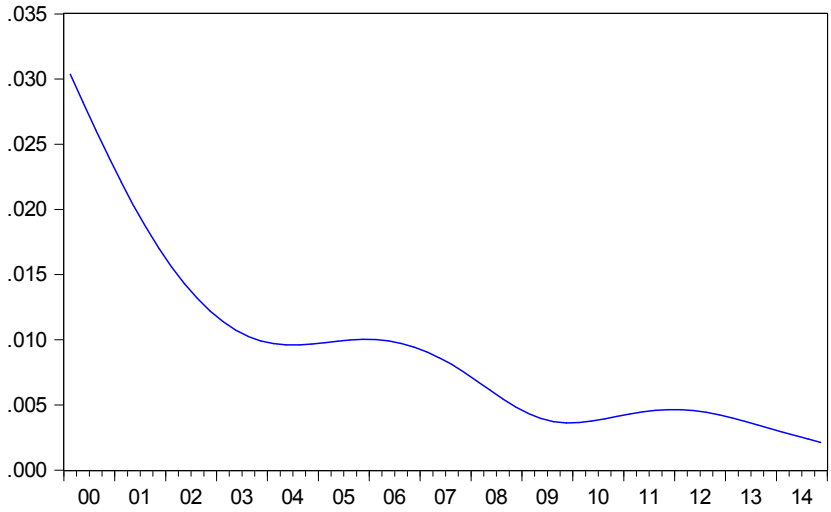
Picture A5.1

Number of employed in Russian Federation (millions of people), 2000-2014; smoothed by Hodrick – Prescott filter ($\lambda = 1600$)



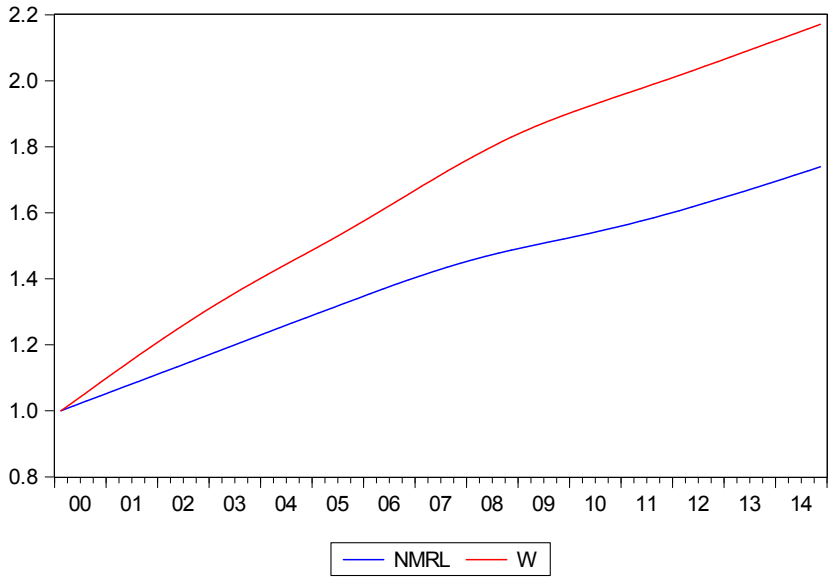
Picture A5.2

Annual growth rate of the number of employed in Russian Federation (%), 2000-2014; smoothed by Hodrick – Prescott filter (λ = 1600)



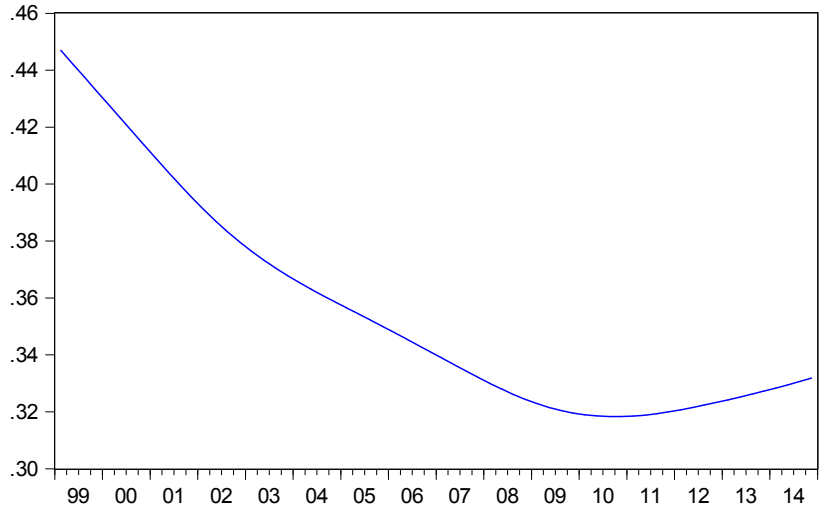
Picture A5.3

Net marginal revenue on labor (NMRL) and average gross wages (W) in real terms (Q1 2000 = 1; GDP deflator); smoothed by Hodrick – Prescott filter (λ = 1600)



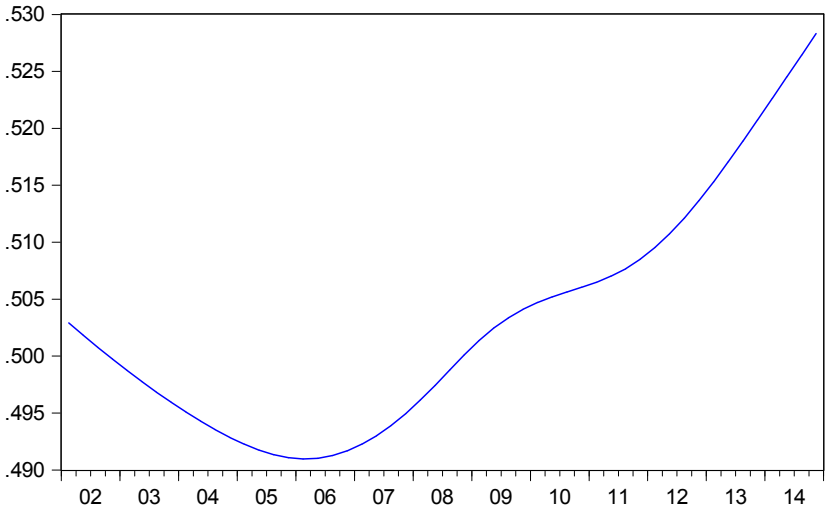
Picture A5.4

Gross profit as a share of the GDP; smoothed by Hodrick – Prescott filter (λ = 1600)



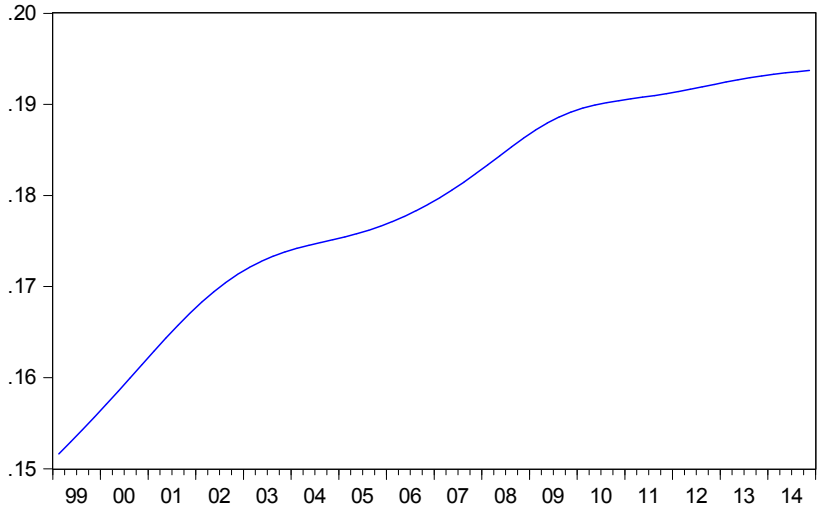
Picture A5.5

Consumer expenditures as a share of the GDP; smoothed by Hodrick – Prescott filter (λ = 1600)



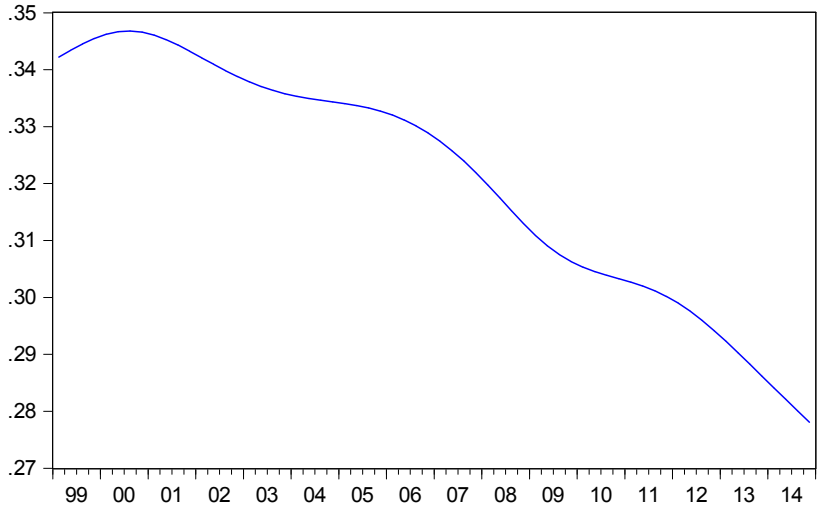
Picture A5.6

Government procurement as a share of the GDP; smoothed by Hodrick – Prescott filter (λ = 1600)



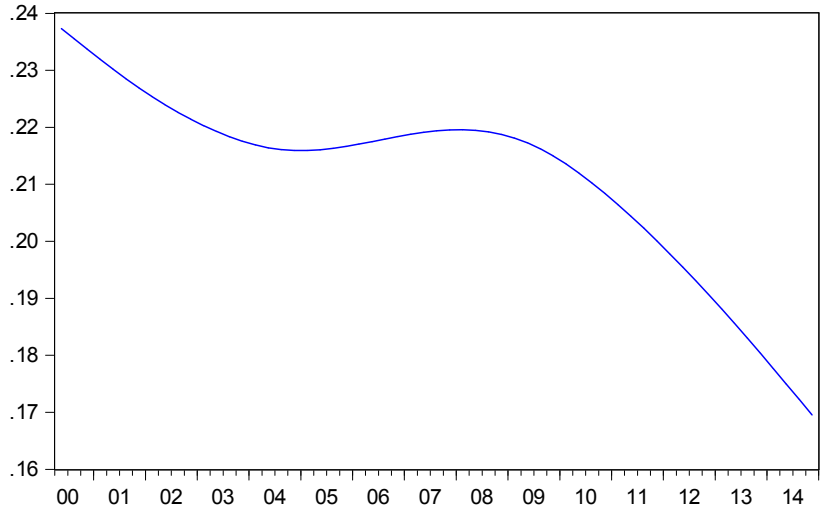
Picture A5.7

National savings as a share of the GDP; smoothed by Hodrick – Prescott filter (λ = 1600)



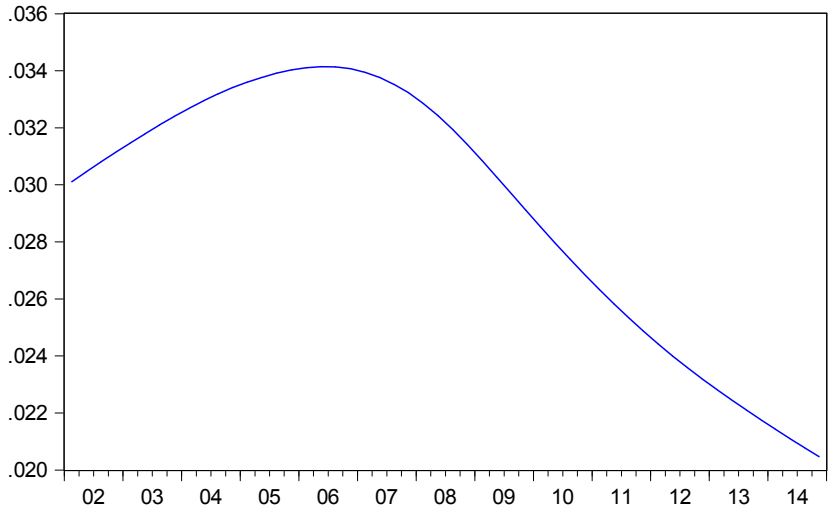
Picture A5.8

Government investment as a share of total gross fixed capital formation; smoothed by Hodrick – Prescott filter (λ = 1600)



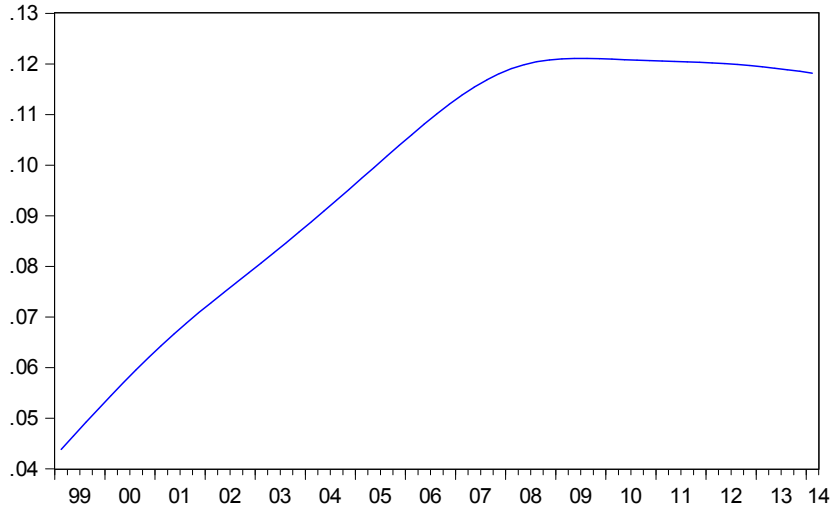
Picture A5.9

Investment by means of bank credits as a share of total gross fixed capital formation; smoothed by Hodrick – Prescott filter (λ = 1600)



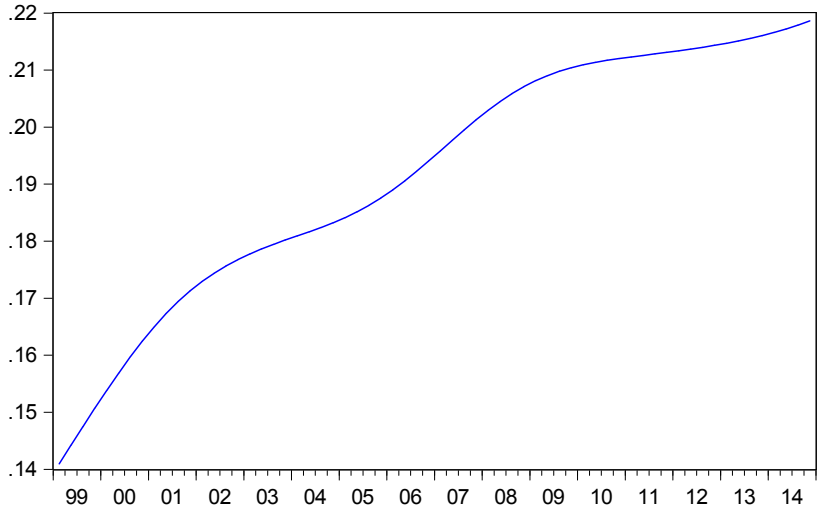
Picture A5.10

A ratio of gross fixed capital formation to the volume of fixed assets; smoothed by Hodrick – Prescott filter (λ = 1600)



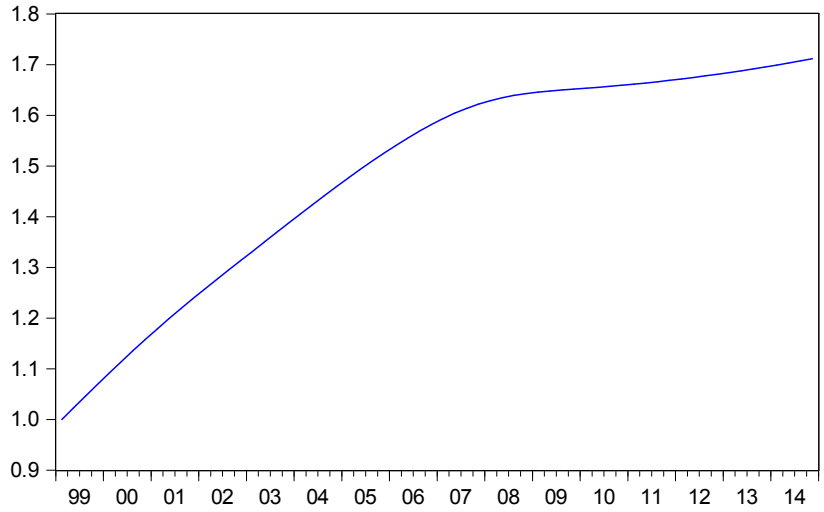
Picture A5.11

Gross fixed capital formation as a share of the GDP; smoothed by Hodrick – Prescott filter (λ = 1600)



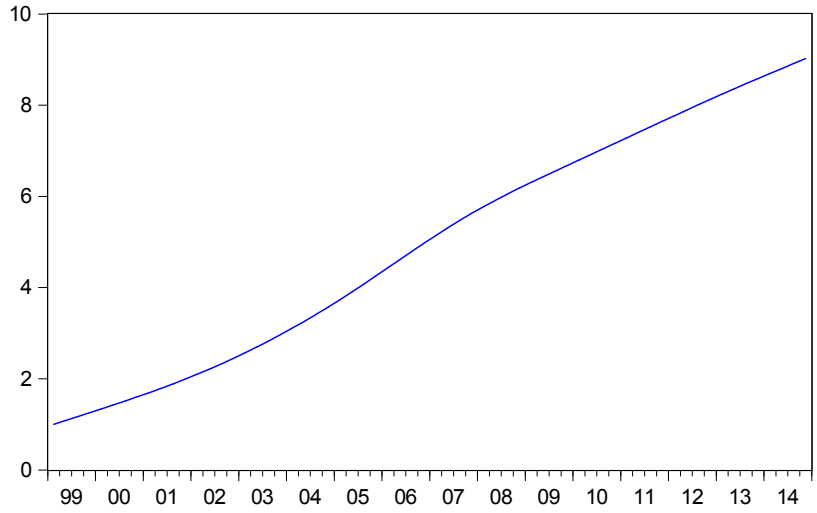
Picture A5.12

Total factor productivity of Russian economy index (Q1 1999 = 1); smoothed by Hodrick – Prescott filter (λ = 1600)



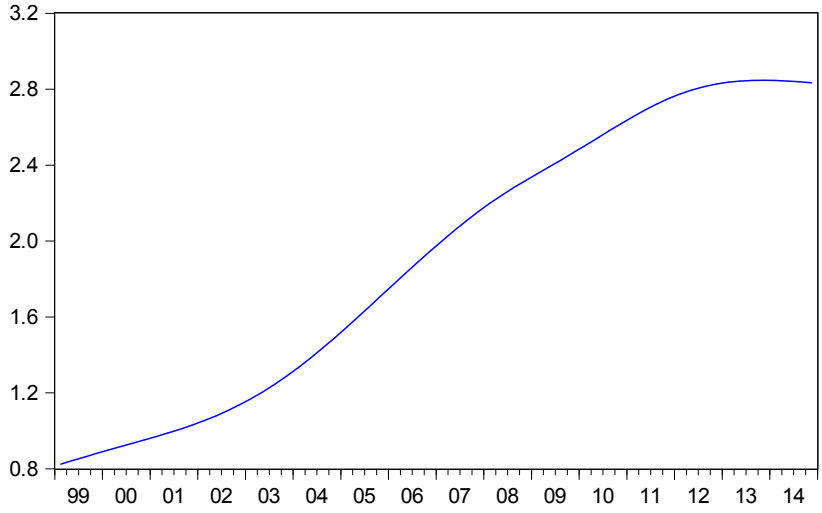
Picture A5.13

Real cash balance index (Q1 1999 = 1); smoothed by Hodrick – Prescott filter (λ = 1600)



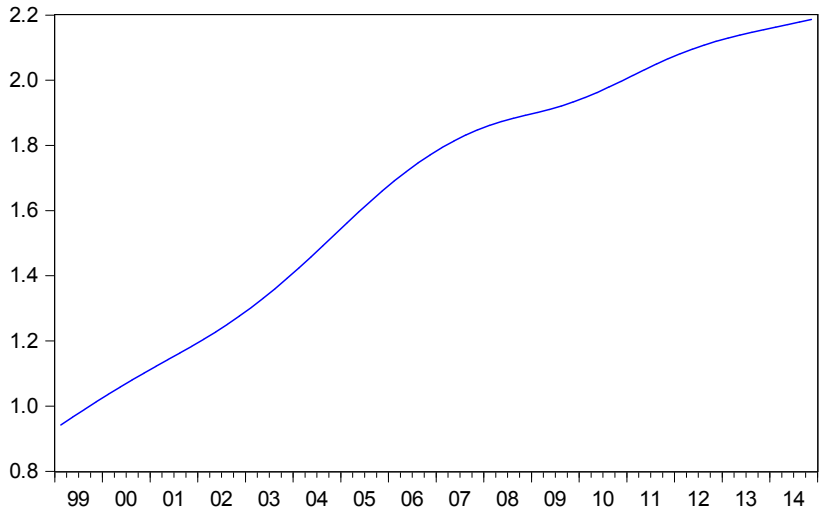
Picture A5.14

Dollar index of export prices (Q1 1995 = 1); smoothed by Hodrick – Prescott filter (λ = 1600)



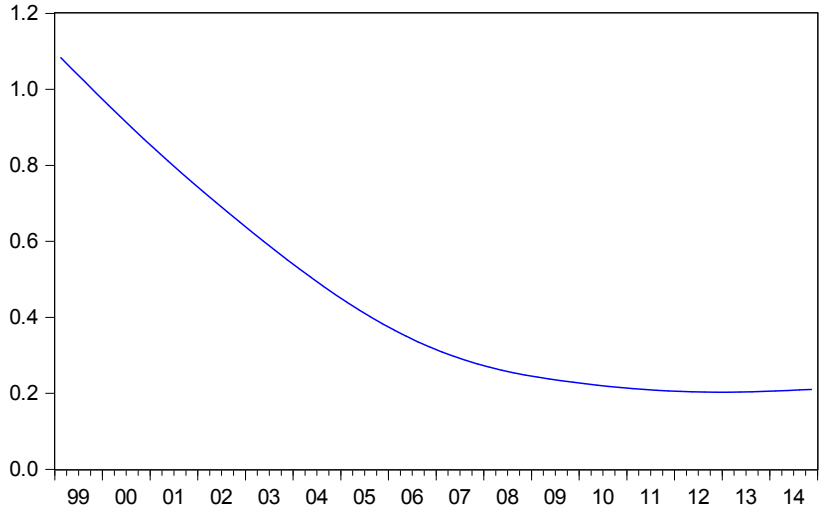
Picture A5.15

Terms of trade index for Russia (Q1 1995 = 1); smoothed by Hodrick – Prescott filter (λ = 1600)



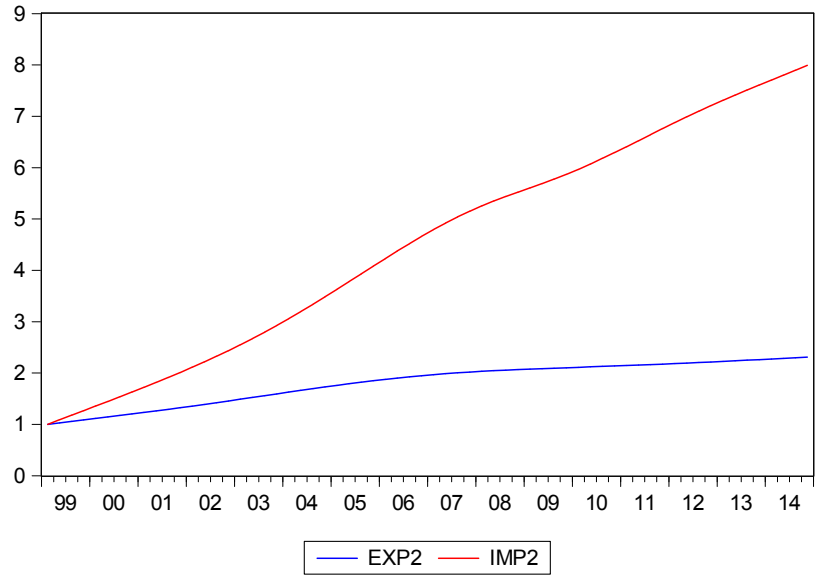
Picture A5.16

Real exchange rate of dollar index (the GDP deflator), Q1 1995 = 1; smoothed by Hodrick – Prescott filter (λ = 1600)



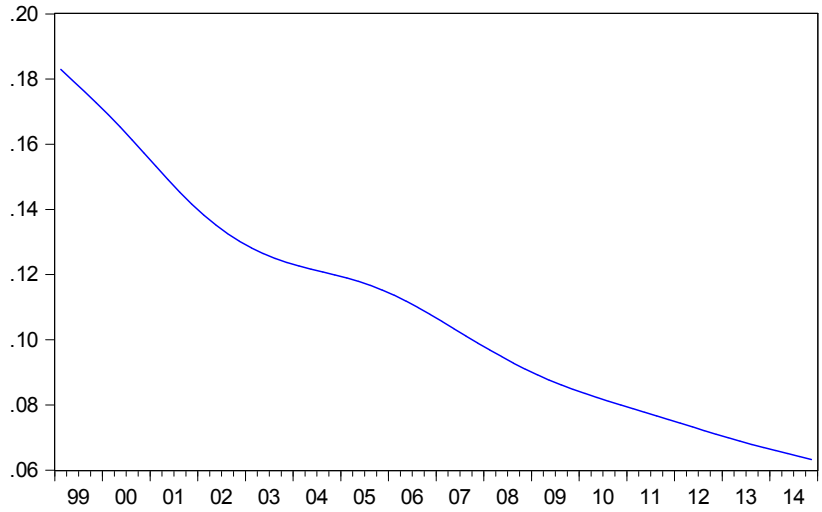
Picture A5.17

Export (EXP2) and import (IMP2) indexes of real growth (Q1 1999 = 1); smoothed by Hodrick – Prescott filter (λ = 1600)



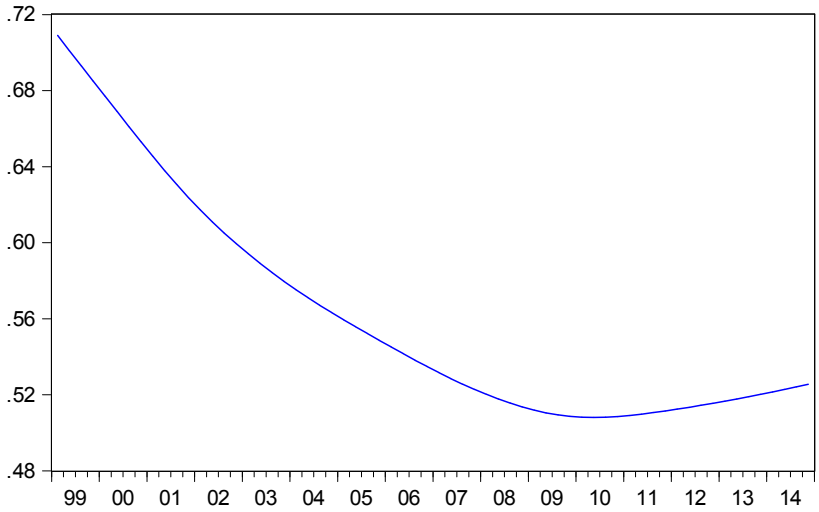
Picture A5.18

Net export as a share of the GDP; smoothed by Hodrick – Prescott filter (λ = 1600)



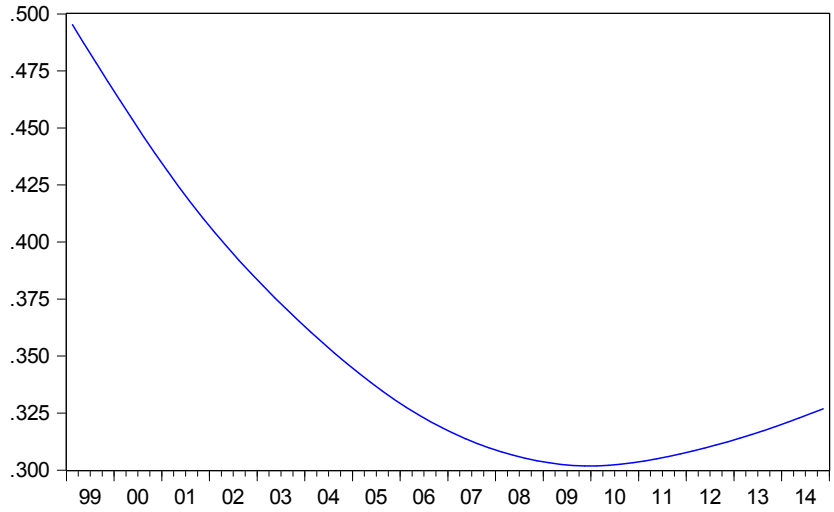
Picture A5.19

Openness of Russian economy index; smoothed by Hodrick – Prescott filter (λ = 1600)



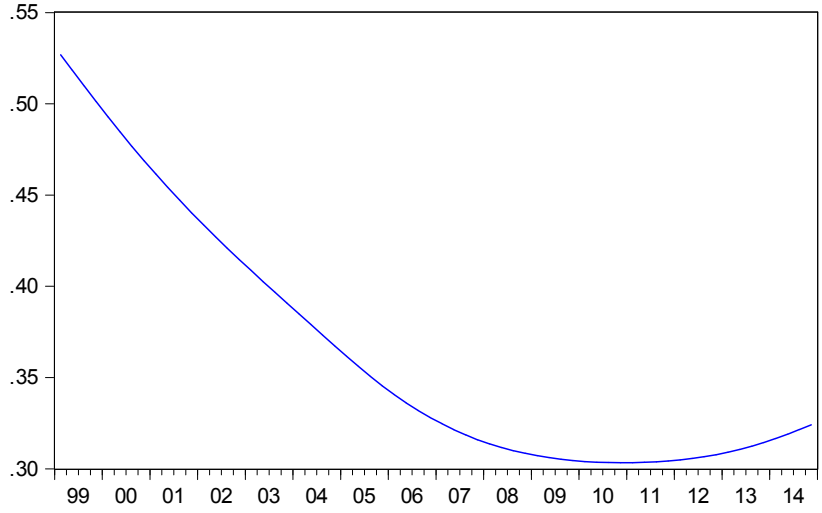
Picture A5.20

Openness of Russian economy index (net of oil export); smoothed by Hodrick – Prescott filter (λ = 1600)



Picture A5.21

A share of non-oil export in the total volume of export; smoothed by Hodrick – Prescott filter (λ = 1600)



Notes

[1]The GDP growth rates were 4.3 % in 2011, 3.4 % in 2012 and only 1.3 % in 2013, and only 0.6 % in 2014; see Rosstat's (2015a).

[2] This point of view is supported e.g. by Basdevant (2000) too.

[3] See Evans and Klein (1967, 1968); Rasche and Shapiro (1968), De Leeuw and Gramlich (1968), Ando, Modigliani and Rasche (1972); Data Resources, Inc. (1976), Ekstein (1983); Duesenberry et al. (1965, 1969), Fromm (1971), Fromm and Klein (1975); review and references in Intriligator et al. (1996, pp. 430-56), Intriligator (2007, pp. 204-7).

[4] OLS gives consistent estimates for such type of models, see e.g. Green (2008, p. 372), Intriligator et al. (1996, pp. 336-9, 388-9), Pindyck and Rubinfeld (1998, p.346-48) on the use of fully recursive models.

[5] See Johnston and DiNardo, (2007, pp. 316-7) on the widely used practice of the OLS estimation of structural equations.

[6] With only constant and quadratic trend function.

[7]Schwartz info criterion for lags, tau and z – statistics, 5 % MacKinnon p-values were used.

[8] Tau and z – statistics, 5 % MacKinnon p-values were used.

[9] When ML – ARCH estimates were used correlogram of residuals with Q-statistics (Box – Pierce – Ljung statistics) was used to test autocorrelation.

[10] ARCH test was used for ML-ARCH estimates (1 lag of square residual and regressor in test equation) and Breusch – Godfrey – Pagan test for OLS, TSLS and GLS estimates (regressores of equation in test equation).

[11] The dummies were used for the points where breaks were detected.

[12] We used automatic lag length based on Schwartz info criterion; and 5 % MacKinnon p-values.

[13] Among the other tests there are: Chow forecast tests for 4, 8 and 12 forecast points; Ramsey 1, 2 and 3 specification tests;. Recursive tests were performed to test for parameters' stability. The residuals were tested for normality by Jarque – Bera test besides.

[14] Variances of residuals were used here as weights for such tests.

[15] Presample variance: backcast with parameter 0.7; starting coefficient values OLS / TSLS; Marquardt optimization algorithm.

[16] We used such proxy as official statistics of profitability is not credible and the corresponding variables were not significant probably due to this reason.

[17] As the model is fully recursive the equations and identities are numbered in the order in which the model is solved as a whole.

[18] Here we mean a lag between a fixation of investment and statement of fixed assets in accounting books. In this connection it is worth mentioning that investment in residential and non-residential construction account for about 60 % of total investment in fixed assets in Russia.

[19] Nevertheless it is worth mentioning that the ratio of average wages to net marginal revenue on labor increased from 76 % in 2000 to 95 % now. That means that Russian labor market moves steadily to equilibrium and the strength of this factor becomes smaller.

[20] Abba Lerner gave a similar argument about capital when he wrote that the main force that increases or reduces the fixed capital amount is the difference between the marginal revenue on capital and the interest rate (see Lerner, 1944, p.335).

[21] A gross fixed capital formation deflator is included in this equation as a separate variable because a direct deflating of fixed capital yields unstable estimates. A similar approach we can find in Benedictow et al., eq.7.

[22] See, for example, Pindyck and Rubinfeld (2009), p.197.

[23] If we just not use so-called “frontier” production functions; see, for example, Aigner e. a. (1977)

[24] This trend can be calculated on the basis of Rosstat (2015a) data, see page http://www.gks.ru/free_doc/new_site/business/prom/moch.htm; the calculation of capacity utilization is complicated by the fact that labor input in Russian statistics is calculated as the number of employees, not as the number of hours worked, and doesn’t reflect the intensity of labor use therefore. If we pay attention on the specifics of Russian labor market where employer respond on the fall of demand usually not by layoffs but by reduction of salaries *actually paid* (including the *hidden*, illegal one) the formally employed workforce is mostly not fully utilized.

[25]A discussion of the problem of “export-led growth” and terms of trade as a factor of growth is presented in Findlay (2007, particularly pp. 215-26). The necessity to consider the role of demand in economic growth was specifically mentioned by Solow (2005). We say here about the *direct* impact of demand on production; its *indirect* impact may take place via production factors’ input.

[26] A *long-term* elasticity of output on capital and labor calculated by means of this equation are equal to 0.336 and 0.664 respectively when we use the formula given in Jonston and DiNardo (2007), pp.245-247.

[27] The indicator of unemployment turned to be insignificant in this equation that can be considered as a manifestation of the specifics of Russian labor market.

[28] About 20 % of employees in Russia work in state-owned companies. Detailed discussion on the subject one can find in World Bank (2013, 2014b).

[29] The real interest rate was insignificant in this equation; see a more detailed comment about it below.

[30] It is interesting that in this equation two dummies with significantly positive signs are presented. They reflect a panic jump of consumer expenditures in the periods of rapid ruble depreciation, in Q4 2008 and Q4 2014.

[31] The real interest rate was insignificant in this and in other equations of the model (Benedictow et al. got the same result). We explain this first by inaccuracy of data. The Bank of Russia record only officially declared but not effective interest rates while the latter include commission, insurance, fees for account maintenance, etc. All these additional payments usually constitute a large proportion of fees for loan maintenance. The second explanation may be weakness of Russian financial system. The investment financed by bank loans account for less than 13 % and financed by securities' market for less than 2 % of total volume of investment in fixed capital. Third explanation may be high demand for money in Russia and its weak sensitivity to interest rates. In these circumstances the effect of "crowding out" of private investment by government expenditures may be strong what we just see in this equation.

[32] The same result was found by Barro (1991, 1996, and 1997) and by Sachs and Warner (1995) in cross country regressions. Alesina et al. (1998, 2005) showed a presence an "economies of scale" in government consumption (that is their decrease as a share of economy) as result of economic growth. In Alesina et al. (2005) cross-country model government consumption is a significantly negative variable for growth.

[33] The impact of the banking system on economic growth was studied in many works. We mention here only those we consider the most important such as Levine (2005), Beck and Levine (2004), Orphanides and Solow (1990), World Bank (2002).

[34] Levine et al. (2000) studied such type of regression on cross-country data.

[35] See e.g. La Porta, Lopez-de-Silanes and Shleifer (2000) on this subject.

[36] A discussion devoted different measures of the evaluation of predictive accuracy of models see in Intriligator, Bodkin and Hsiao (1996, pp. 523-7), in Fair (2005, pp. 1984-93) and in Pindyck and Rubinfeld (1998, ch.13-14).

[37] The conventional methodology of the multiplier use in non-linear models is described in Klein (1983, pp. 57-69 and pp. 134-44), Pindyck and Rubinfeld (1998, ch.14).

[38] The important role of demographic factors for economic growth is typical not only for Russia. See e.g. Barro and Lee, 1994.

[39] The forecasts' figures don't take into account the actual data gathered for Q1 2015 as the latter are preliminary. But if these preliminary data are close to reality and nothing will improve during 2015 year the recession in Russian economy will be much more severe than shown in tables A4.1-4.2 due to 50 % upward jump of ruble import prices as a consequence of ruble devaluation.