

Construction of the Dynamic Input - Output Model with Balance of Payments Block

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2010

The research was executed under financial support of the Russian Fund of Fundamental Researches, the project
10-06-00286 a

Objectives of the research

- ❑ Construction of the Dynamic Input - Output Model with Balance of Payments Block (DIOM BP)
- ❑ Forecasting of Russian economy development using the Dynamic Input - Output Model with Balance of Payments Block

The problems which have been decided (partly)

- developing theoretical scheme of the DIOM;
- developing mathematical description of the DIOM BP;

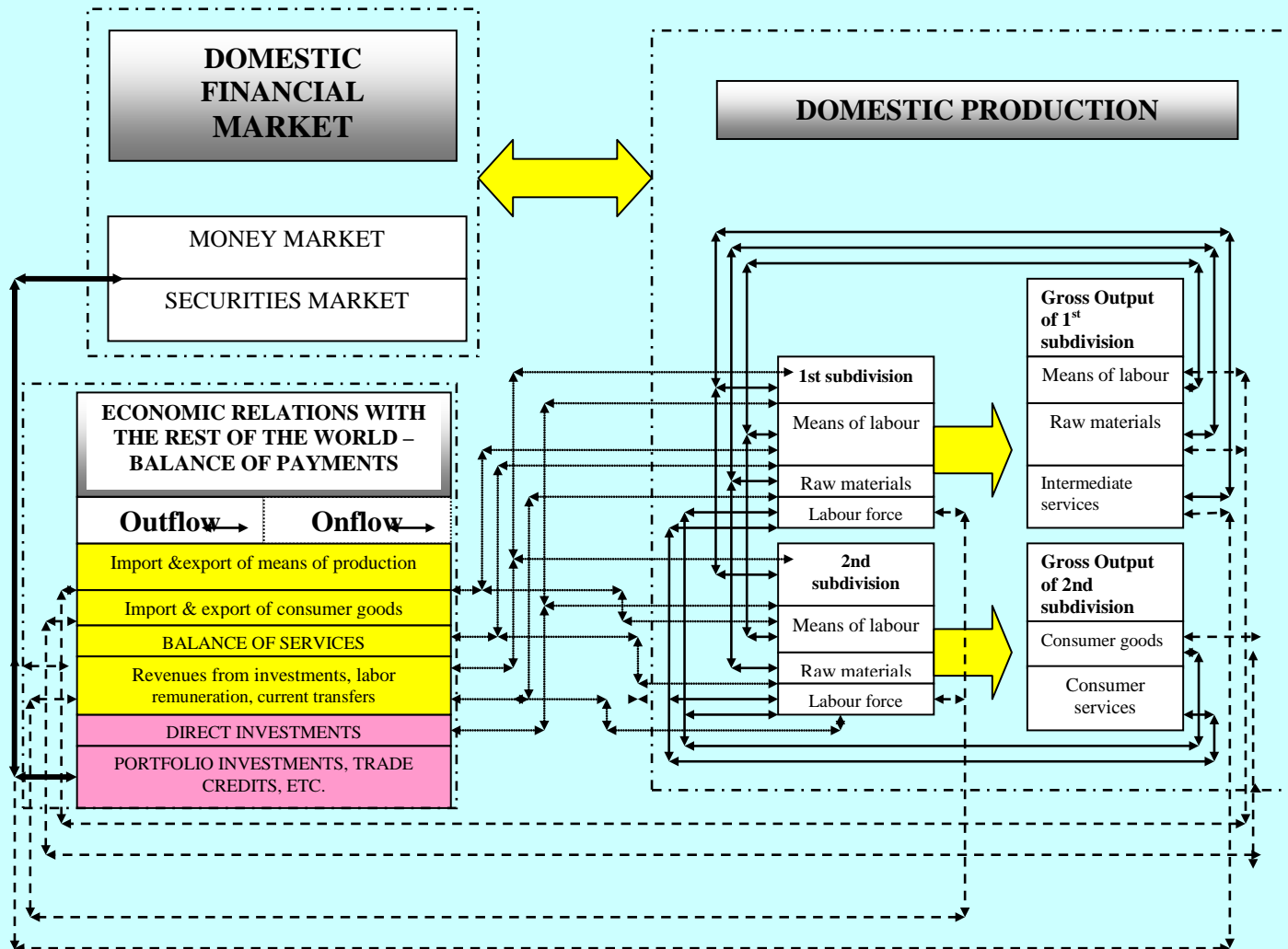
- construction of the regression models for export and import of Russian economy ;

- forecasting of Russian economy export and import for the period 2010 – 2012 ;

- construction of the regression model for Capital and Financial Accounts of Balance of Payments of Russian economy;

- forecasting of Capital and Financial Accounts of Balance of Payments of Russian economy for the period 2010 – 2012;
- forecasting of Russian economy development for the period 2010 – 2012 using DIOM BP

Theoretical scheme of the Dynamic Input – Output Model with Balance of Payments Block



Mathematical description of the Dynamic Input – Output Model with Balance of Payments Block with Fuzzy Parameters

Equation for investments

$$K_{ij}^*(t) = \sum_{u \geq 0} K_{ij}(t, t+u) + \sum_{u \geq 0} R_{ij}(t, t+u), \quad i = 1, \dots, k, j = 1, \dots, k + k' + n + n', \quad (1)$$

k – number of asset-building sectors (production of machines, equipment, structures) in the first subdivision;

k' – number of non-asset-building sectors (production of raw materials, fuel, electricity etc.) in the first subdivision;

$k+k'$ – total number of sectors in the first subdivision;

n – number of asset-building sectors in the second subdivision;

n' – number of non-asset-building sectors in the second subdivision;

$n+n'$ – total number of sectors in the second subdivision;

$k+k'+n+n'$ – total number of sectors in the economy;

$K_{ij}(t, t+u)$ - domestic investments of type i in sector j in year t into the facilities put into operation in $t+u$ time period;

$R_{ij}(t, t+u)$ - foreign investments of type i in sector j in year t into the facilities put into operation in $t+u$ time period;

$K_j^*(t)$ - total investments in sector j in the t time period;

$$R_{ij}(t, t+u) = R_{ij}^d(t, t+u) + R_{ij}^p(t, t+u) + R_{ij}^l(t, t+u)$$

The input of fixed assets $B_{ij}(t)$ in sector j during t time period is formed from the used product of i asset-building sector

$$B_{ij}(t) = \sum_{u \geq 0} K_{ij}(t-u, t) + \sum_{u \geq 0} R_{ij}(t-u, t), i = 1, \dots, k, j = 1, \dots, k + k' + n + n', \quad (2),$$

$B_{ij}(t)$ - fixed assets of i type in sector j put in service in the t time period

The size of domestic investments $K_{ij}(t, t+u)$ into the layer of construction-in-progress introduced during $t+u$ time period is calculated through the input of fixed assets in this period

$$K_{ij}(t, t+u) = \mu_{ij}(t, u) \sum_{i=1}^k B_{ij}(t+u), i = 1, \dots, k, j = 1, \dots, k + k' + n + n', \quad (3)$$

$\mu_{ij}(t, u)$ - ratio showing which part of fixed assets input in sector j in time period $t+u$ is formed due to domestic investments of type i in the t time period so as

$$\mu_{ij}(t, u) = K_{ij}(t, t+u) / \left(\sum_{i=1}^k B_{ij}(t+u) \right);$$

The size of foreign investments $R_{ij}(t, t+u)$ into the layer of construction-in-progress introduced during $t+u$ time period is calculated through the input of fixed assets in this period

$$R_{ij}(t, t+u) = \rho_{ij}(t, u) \sum_{i=1}^k B_{ij}(t+u), i = 1, \dots, k, j = 1, \dots, k + k' + n + n', \quad (4)$$

$\rho_{ij}(t, u)$ - ratio showing which part of fixed assets input in sector j in time period $t + u$ is formed due to foreign investments of type i in the t time period so as

$$\rho_{ij}(t, u) = R_{ij}(t, t + u) / \left(\sum_{i=1}^k B_{ij}(t + u) \right);$$

Recurrent ratios for re-computing construction-in-progress

$$N_{ij}(t) = N_{ij}(t-1) - \sum_{u=1}^{\theta_{ij}-1} K_{ij}(t-u, t) + \sum_{u=1}^{\theta_{ij}-1} K_{ij}(t, t+u) - \sum_{u=1}^{\theta_{ij}-1} R_{ij}(t-u, t) + \sum_{u=1}^{\theta_{ij}-1} R_{ij}(t, t+u)$$

$$i=1, \dots, k, j=1, \dots, k+k'+n+n', \quad (5)$$

$N_{ij}(t)$ - construction-in-progress of fixed assets of type i in sector j by the end of time period t ;

Recurrent ratios for determining the size of fixed assets of i type in branch j aged u by the end of time period t

$$F_{ij}(t,0) = B_{ij}(t), \quad F_{ij}(t,u) = F_{ij}(t-1,u-1) \cdot (1 - \kappa_{ij}(t,u)) + Bij(t),$$

$$i=1, \dots, k, \quad j=1, \dots, k+k'+n+n' \quad (6)$$

$\kappa_{ij}(t,u)$ - replacement rate of fixed assets of i type in sector j aged u in the t time period ;

$F_{ij}(t,t-u)$ - fixed assets of i - type of sector j introduced in the period $t-u$ by the end of year t ;

The gross output $x_j(t)$ of j asset-building sector during t time period is determined by the formula

$$x_i(t) = \sum_{j=1}^n K_{ij}^*(t) + S_i(t) + \gamma_i(t), \quad i=1, \dots, k, \quad (7)$$

The balance between production and utilization of the output of non-asset-building sectors of the first subdivision looks as follows

$$x_i(t) = \sum_{j=1}^n a_{ij}(t)x_j(t) + S_i(t) + \gamma_i(t), \quad i=k+1, \dots, k' \quad (8)$$

$S_i(t)$ net export of i product in the period t ,

Formula for forming the output of the second subdivision sectors are presented as

$$x_i(t) = Q_i(x_i(t-1), S_i(t-1), \lambda, t) + S_i(t), \quad i=k+k'+1, \dots, n+n' \quad (9)$$

Q_i is images synthesizing the structure and dynamics of consumer goods and services (normally these are monotonously growing functions of λ parameter.)

Labour resources limits are described by the system of inequalities

$$\sum_{j=1}^n c_{hj}(t) \cdot x_j(t) \leq L_h(t), \quad h = 1, \dots, l. \quad (10)$$

$c_{hj}(t)$ - ratios of labour intensiveness of a sector j for the h type of labour resources in the t time period;

$L_h(t)$ - size of h - type of labour resources that can potentially be employed in the economy in t time period;

Fixed assets constraints are described by the system of inequalities

$$b_{ij}(t) \cdot x_j(t) \leq F_{ij}(t), \quad i=1, \dots, k, j=1, \dots, k+k'+n+n'. \quad (11)$$

$b_{ij}(t)$ - ratios of capital intensity of a sector j for the i -type of fixed assets in the t time period ;

$F_{ij}(t)$ - fixed assets of i – type of sector j by the end of time period t ;

Modeling of the Balance of Payments

The following functions were built

- ✓ Export of Russian economy;
- ✓ Import of Russian economy;
- ✓ Capital and Financial accounts of the Balance of Payments of Russian economy

The data preparation

- Quarterly time series for the period 1999 – 2009 were used.
- All time series have been checked on stationarity (Dickey – Fuller criterion) and, if necessary, first differences of the time series were used.

Modeling of current account.

Export function.

- Oil prices (Brent), \$US/barrel;
- GDP;
- \$US/Ruble exchange rate;
- Euro/Ruble exchange rate;

$$\Delta Ex(t) = a_0 + a_1 \cdot \Delta Oil(t) + a_2 \cdot \Delta GDP(t) + a_3 \cdot \Delta Dol(t) + a_4 \cdot \Delta Evro(t) + \varepsilon_t$$

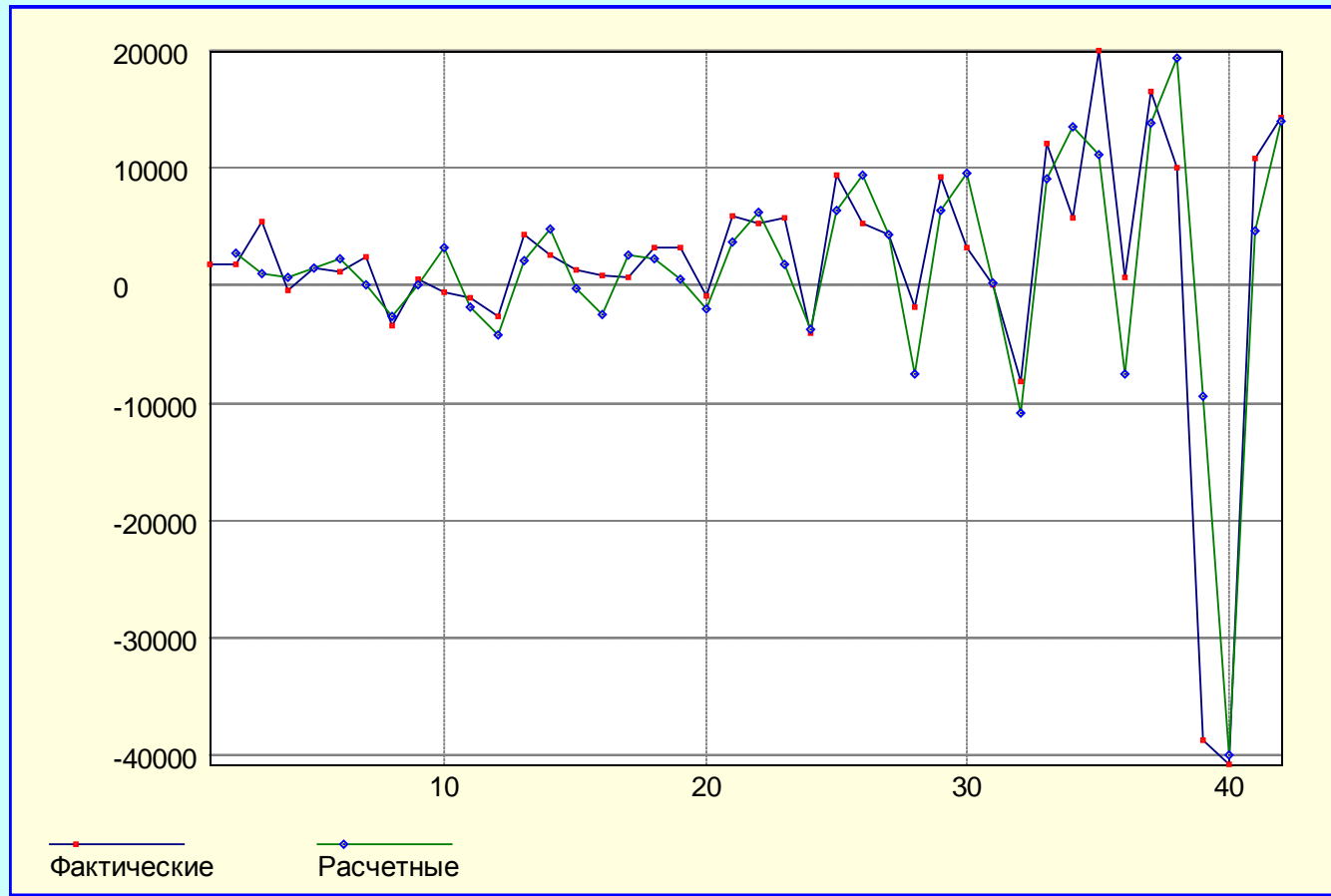
- $\Delta Ex(t)$ – export increase in the time period t;
- $\Delta Oil(t)$ – oil price (Brent) increase in the time period t;
- $\Delta Dol(t)$ - \$US/Ruble exchange rate increase in the time period t;
- $\Delta Evro(t)$ - Euro/Ruble exchange rate increase in the time period t.

Results for export function

- $R^2_{adj} = 69,253\%$, $R^2 = 70,790\%$
- $DW = 1,664$
- $F(2,38) = 46,04678$ [0,0000]

Independent variables	Reg. coefficients	Standard error	t-statistic value	t-statistic significance level
$\Delta GDP(t)$	9,746	1,903	5,122	[0,0000]
$\Delta Oil(t - 1)$	251,172	116,070	2,164	[0,0368]
КОНСТАНТА	-927,785	1018,383	-0,911	[0,3680]

Actual (blue line) and estimated (green line) export increase in Russia in 1999-2009, \$US mln



Import function

- GDP;
- \$US/Ruble exchange rate;
- Euro/Ruble exchange rate;
- Disposable income per capita, rub per month

$$\Delta Im(t) = b_0 + b_1 \cdot \Delta GDP(t) + b_2 \cdot \Delta Dol(t) + b_3 \cdot \Delta Evro(t) + b_4 \cdot Inc(t) + \varepsilon_t$$

Где

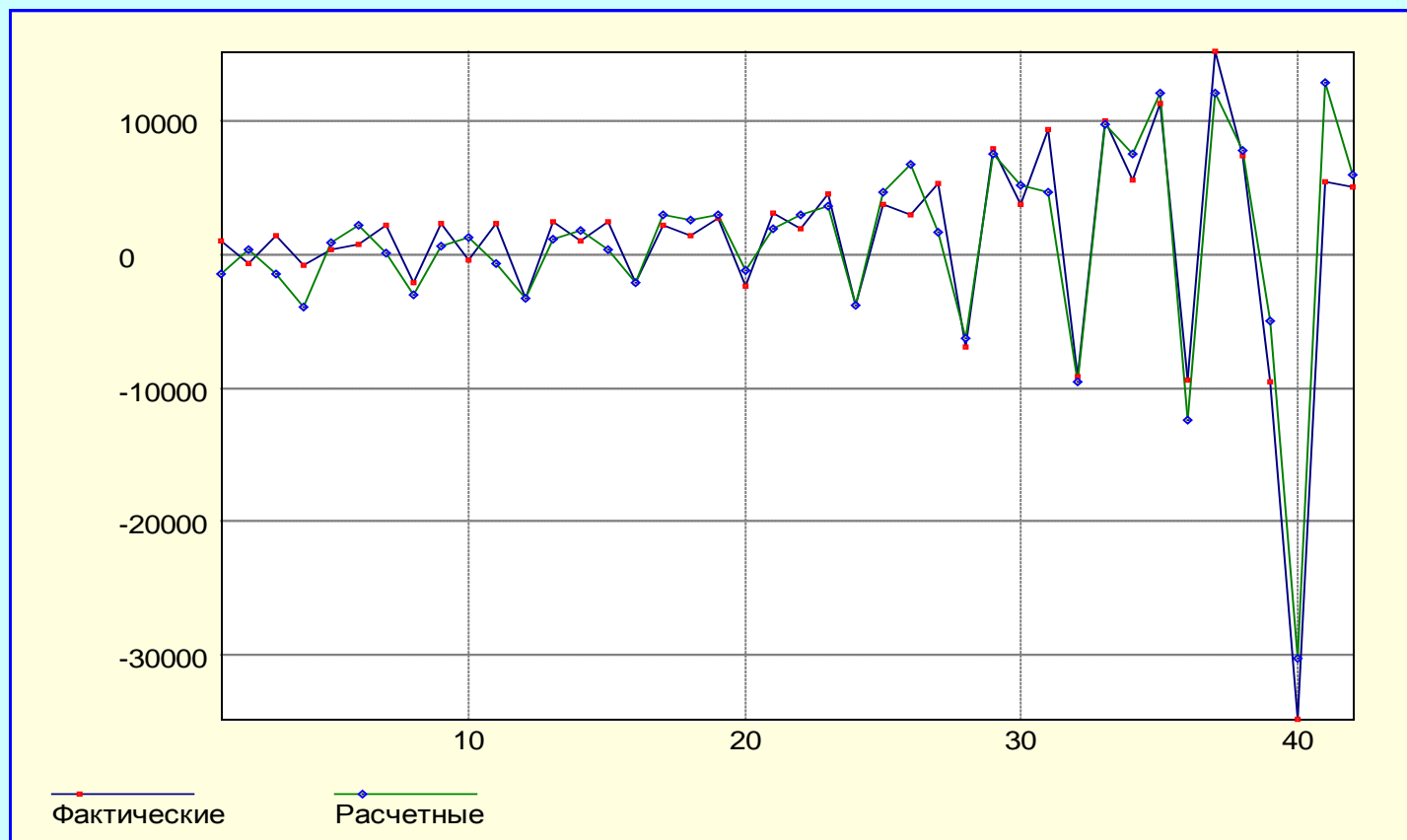
- $\Delta Im(t)$ - import increase in the time period t;
- $\Delta Inc(t)$ - disposable income increase in the time period t

Results for import function

- $R2_{adj} = 89,59\%$, $R2 = 90,352\%$
- $DW = 1,6204$
- $F(3,38) = 118.6193 [0.0000]$

Independent variables	Reg. coefficients	Standard error	t-statistic value	t-statistic significance level
$\Delta Dol(t)$	-1393,226	337,642	-4,126	[0,0002]
$\Delta Inc(t)$	2,193	0,425	5,164	[0,0000]
$\Delta GDP(t)$	4,937	0,962	5,133	[0,0000]
КОНСТАНТА	-707,840	435,018	-1,627	[0,1120]

Actual (blue line) and estimated (green line) import increase in Russia in 1999-2009, \$US mln



Modeling of capital and financial accounts

- ❑ The following data series have been use in research
 - ✓ RTS index;
 - ✓ DJIA;
 - ✓ MIBOR;
 - ✓ Oil prices (Brent);
 - ✓ USA Treasury Bonds percent (2, 5, 7 years);
 - ✓ GDP;
 - ✓ \$US/Ruble exchange rate.
- ❑ Data since 4 quarter 1995 till 3 quarter 2009

$$\begin{aligned} Cap.Acc.(t) = & c_0 + c_1 \cdot \Delta GDP(t) + c_2 \cdot \Delta Oil(t) + c_3 \cdot \Delta Dol(t) + c_4 \cdot \Delta Evro(t) + \\ & + c_5 \cdot Treas_i(t) + c_6 \cdot MIBOR(t) + c_7 \cdot RTSI(t) + c_8 \cdot DJIA + \varepsilon_t \end{aligned}$$

Results for capital and financial accounts function

□ $R^2_{adj} = 72,85\%$, $R^2 = 85,00\%$

□ $DW = 1,715$

□ $F(2,38) = 34,99$ [0,0000]

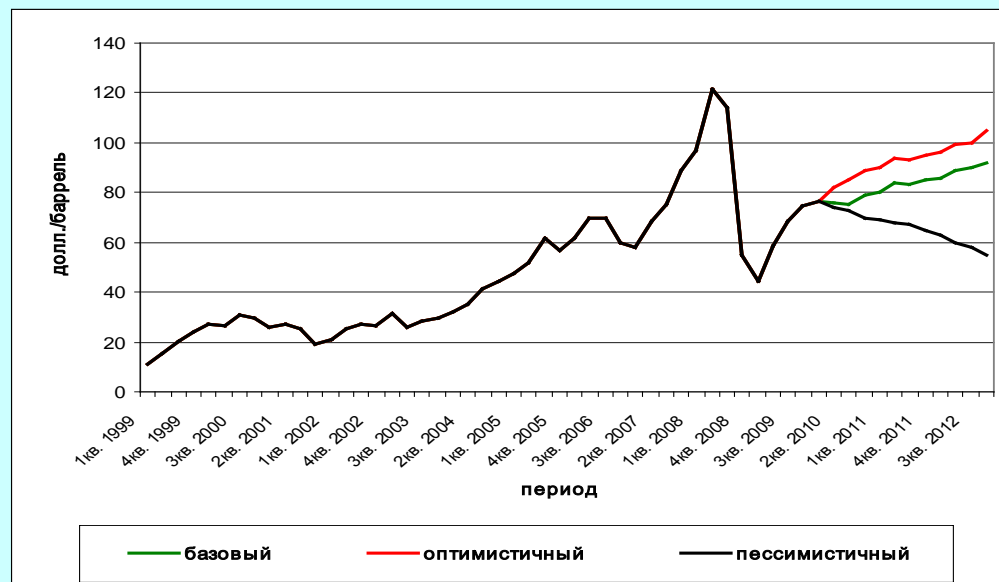
Independent variables	Reg. coefficients	Standard error	t-statistic value	t-statistic significance level
$\Delta GDP(t)$	12,892	3,301	3,905	[0.0004]
$\Delta RTSI(t)$	88,414	9,902	8,929	[0.0000]
$\Delta Oil(t - 3)$	768,796	208,719	3,683	[0.0008]
Константа	-10381,443	2305,426	-4,503	[0.0001]

Main hypotheses underlying various estimates based on the Dynamic Input - Output Model for the years 2010-2012

The following scenarios of the development of the Russian economy were studied: *basic, optimistic and pessimistic.*

Oil (Urals) price in different scenarios, end of the year, \$US/barrel.

Scenario	2010	2011	2012
Basic	70	74	81
Optimistic	89-90	95-98	100-105
Pessimistic	70	65	55

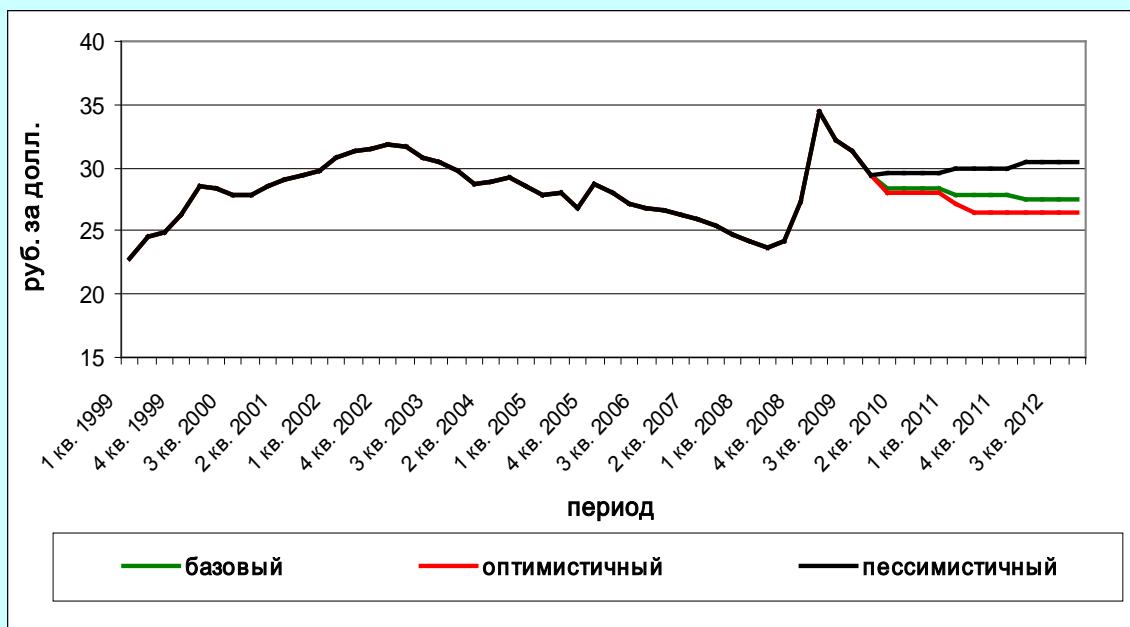


Households real income's growth rate,%.

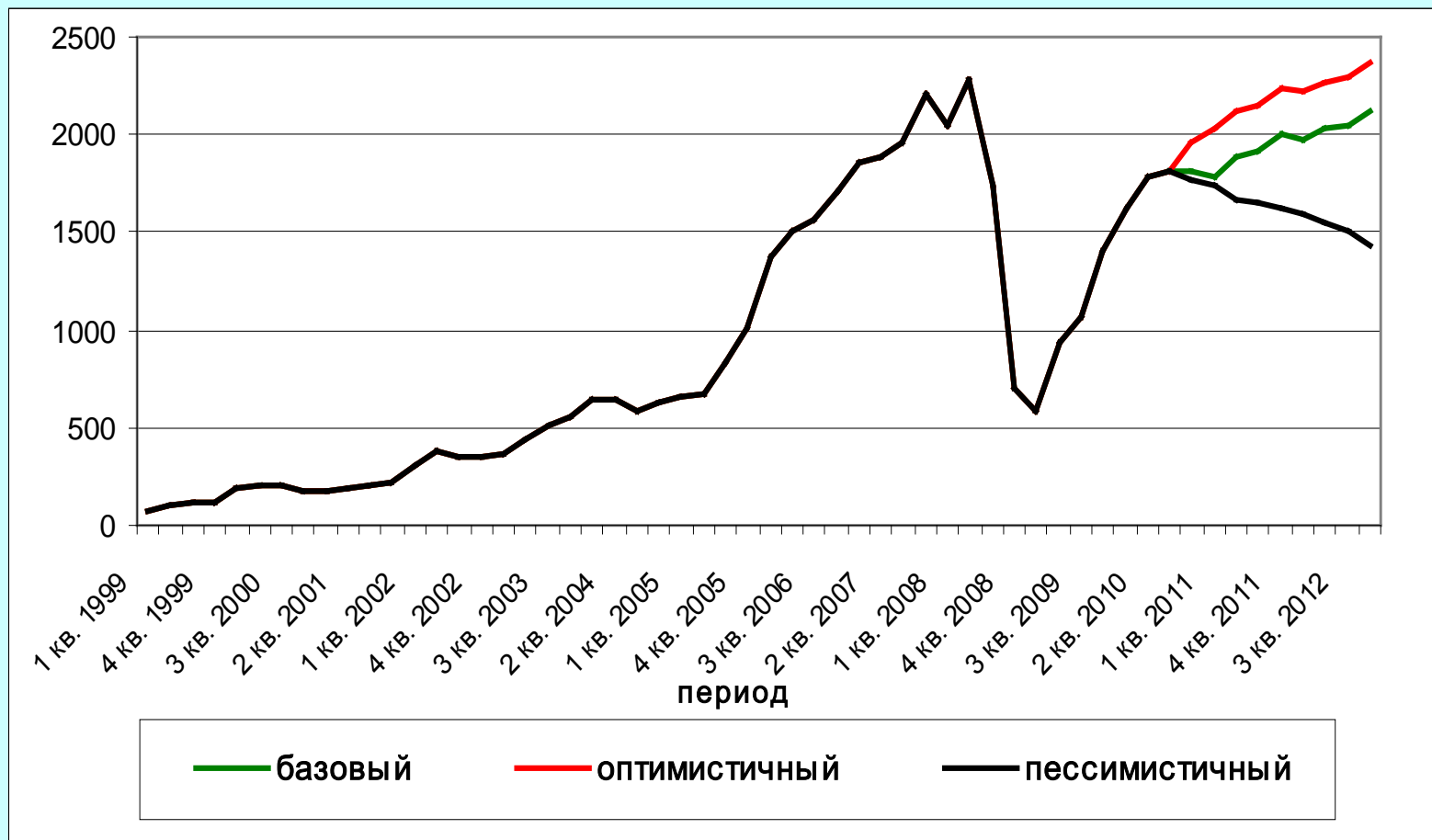
Scenario	2010	2011	2012
Basic (data of the Ministry of Economic Development of Russia)	103,0	105,0	101,5
Optimistic	103,3	105,6	102,0
Pessimistic	102,5	103,0	101

\$US/Ruble exchange rate in different scenarios.

Scenario	2010	2011	2012
Basic	28,3	27,8	27,5
Optimistic	28	27,2	26,5
Pessimistic	29,5	30	30,5

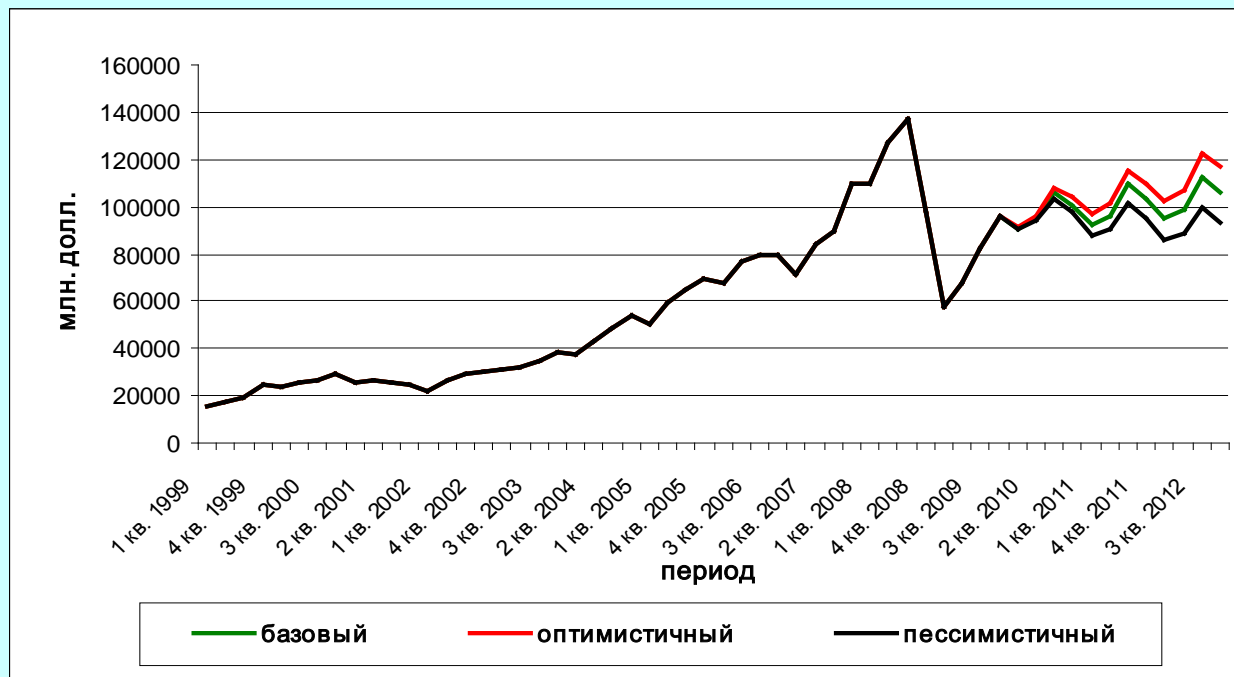


Actual and forecasting RTS index in 3 scenarios



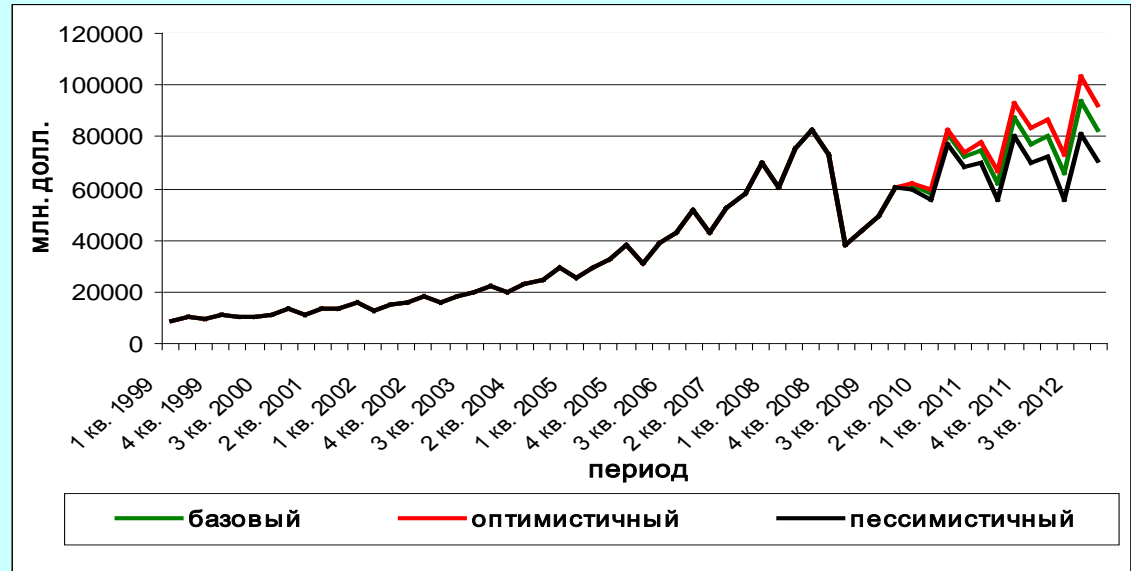
Russian economy export quarterly forecast for 2010-2012, \$US mln

	Russian export , \$us mln		
	basic	optimistic	pessimistic
1 q. 2010	90742,99	90999,18	90224,96
2 q. 2010	95518,76	96057,41	94433,57
3 q. 2010	105651,17	108048,05	103362,63
4 q. 2010	100801,63	104465,61	97994,78
1 q. 2011	92604,01	96854,82	87805,21
2 q. 2011	96444,66	101465,25	90630,61
3 q. 2011	109426,65	115510,69	101560,79
4 q. 2011	103339,85	110042,96	95187,37
1 q. 2012	95041,99	102325,51	85881,32
2 q. 2012	98633,47	106980,64	88288,30
3 q. 2012	112667,34	122708,65	99961,35
4 q. 2012	106393,42	117083,32	92865,10



Russian economy import quarterly forecast for 2010-2012, \$US mln

Russian import , \$us mln			
	basic	optimistic	pessimistic
1 q. 2010	61164,39	61712,125	59230,123
2 q. 2010	58205,45	59566,899	55480,914
3 q. 2010	80688,445	82568,691	77353,149
4 q. 2010	72072,232	73967,941	68562,489
1 q. 2011	74822,59	77568,525	69699,969
2 q. 2011	61722,306	66418,08	55712,946
3 q. 2011	87029,426	93084,194	79905,864
4 q. 2011	77124,483	83210,184	70100,718
1 q. 2012	80560,81	86847,41	72139,109
2 q. 2012	65693,581	72770,687	55399,773
3 q. 2012	93775,146	103097,14	81117,119
4 q. 2012	82792,452	91965,175	70765,147



Net Capital and Finance accounts of the Balance of Payments of Russian economy's quarterly forecast for 2010 - 2012, \$US mln

Capital and Finance accounts of the Balance of Payments of Russian Federation, \$us mln			
	basic	optimistic	pessimistic
1 q. 2010	4542,0303	4880,8878	3856,8433
2 q. 2010	33968,043	34341,646	33217,855
3 q. 2010	29321,506	29786,027	28394,298
4 q. 2010	-426,75695	-79,666446	-1112,322
1 q. 2011	-18100,7	-12711,944	-19947,383
2 q. 2011	-5702,5342	11047,799	-10599,984
3 q. 2011	7653,587	17498,28	1219,4881
4 q. 2011	-7666,0127	-6847,1916	-24349,293
1 q. 2012	-15609,522	-14841,813	-23676,973
2 q. 2012	2933,3581	4340,2265	-8184,3089
3 q. 2012	7839,5955	10080,425	3635,2763
4 q. 2012	-12797,003	-11939,129	-23632,384



Growth rate of main Russian economy's indexes in 2008 – 2012, % (Results of forecasting using the Dynamic Input – Output Model of Russian Economy)

		2008	2009	2010	2011	2012	2012/2008
		actual	actual	forecast	forecast	forecast	
GDP	Basic	105,60%	92,00%	103,00%	103,50%	104,0%	102,00%
	Optimistic	105,60%	92,00%	104,07%	106,07%	107,08%	108,75%
	Pessimistic	105,60%	92,00%	101,07%	102,07%	103,07%	97,82%
Gross output of 1 st subdivision	Basic	99,10%	89,87%	97,49%	99,62%	100,50%	87,72%
	Optimistic	99,10%	89,87%	98,84%	101,68%	103,00%	93,03%
	Pessimistic	99,10%	89,87%	89,66%	95,70%	97,73%	75,36%
Gross output of 2nd subdivision	Basic	109,18%	95,70%	112,19%	109,19%	108,69%	127,42%
	Optimistic	109,18%	95,70%	112,68%	112,41%	112,40%	136,25%
	Pessimistic	109,18%	95,70%	96,05%	109,75%	108,20%	109,15%
Fixed Capital Investments	Basic	109,80%	83,00%	99,77%	110,79%	113,99%	104,58%
	Optimistic	109,80%	83,00%	101,69%	112,64%	114,73%	109,08%
	Pessimistic	109,80%	83,00%	97,67%	108,50%	113,27%	99,63%
Net export	Basic	64,00%	158,00%	81,58%	91,25%	90,03%	105,89%
	Optimistic	64,00%	158,00%	86,60%	87,98%	93,61%	112,69%
	Pessimistic	64,00%	158,00%	83,57%	85,24%	88,09%	99,15%

**Gross output growth rate for main industries of Russian economy in 2008 – 2012 ,
%. (Results of forecasting using the Dynamic Input – Output Model of Russian
Economy)**

		2008	2009	2010	2011	2012	2012/2008
		actual	actual	forecast	forecast	forecast	
Machine building industry	Basic	102,92%	67,30%	104,21%	114,26%	118,24%	94,75%
	Optimistic	102,92%	67,30%	106,59%	118,12%	119,43%	101,20%
	Pessimistic	102,92%	67,30%	100,29%	110,83%	115,94%	86,73%
Capital construction	Basic	113,20%	83,00%	100,84%	111,32%	114,36%	106,55%
	Optimistic	113,20%	83,00%	102,61%	113,35%	115,13%	111,14%
	Pessimistic	113,20%	83,00%	98,26%	109,30%	113,16%	100,87%
Industry without machine building	Basic	101,75%	89,20%	101,03%	100,49%	100,42%	90,94%
	Optimistic	101,75%	89,20%	101,97%	102,86%	103,45%	96,79%
	Pessimistic	101,75%	89,20%	99,15%	99,10%	99,53%	87,23%
Non-asset-building construction (current repairs)	Basic	112,62%	85,00%	101,02%	101,21%	101,47%	88,18%
	Optimistic	112,62%	85,00%	102,02%	103,58%	104,57%	93,93%
	Pessimistic	112,62%	85,00%	99,17%	99,73%	100,55%	84,53%
Agriculture	Basic	110,80%	101,20%	103,56%	100,94%	100,40%	106,21%
	Optimistic	110,80	101,20%	104,01%	103,69%	103,61%	113,08%
	Pessimistic	110,80	101,20%	101,50%	100,05%	99,67%	102,43%
Transport and Communications	Basic	107,40%	88,46%	99,65%	100,49%	100,76%	89,26%
	Optimistic	107,40%	88,46%	100,83%	102,51%	104,05%	95,14%
	Pessimistic	107,40%	88,46%	98,11%	98,84%	99,89%	85,69%
Trade	Basic	109,050%	94,50%	108,37%	110,93%	113,11%	128,50%
	Optimistic	109,050%	94,50%	109,47%	113,36%	116,73%	136,89%
	Pessimistic	109,050%	94,50%	106,54%	109,31%	112,19%	123,47%
Production of services	Basic	104,80%	95,70%	108,77%	107,23%	106,80%	119,21%
	Optimistic	104,80	95,70%	109,56%	109,90%	110,31%	127,11%
	Pessimistic	104,80	95,70%	106,77%	105,97%	105,96%	114,73%

Main results and conclusions

1. Russian economy's GDP recovery to the level higher than 2008 with big probability will be in 2012 (in accordance with two scenarios).
2. In accordance with our forecast it's difficult to expect the recovery of 1st subdivision output in the period under consideration.
3. 2nd subdivision recovery is expected in 2010 and will increase essentially till the end of the period under consideration.
4. Fixed capital investments will restore only in 2012.
5. We expect low net export growth after 2009.
6. Among industries we expect weak recovery in industry, including machine building industry, non-asset-building-construction and in transport and communications.
7. Trade and services production will restore already in 2010-2011.

Thank you!