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An econometric model of Russian economy and green growth aspects

Introduction

This article focuses on the environmental and economic dynamics in the Russian Federation and the relationship between them.

This topic is covered in the writings of scholars such as Nordhaus W. D. [4], Brock W. A. and Taylor M. S. [1], Grossman G. M. and Krueger A. B. [2], Solow R. M. [7], Stokey N. [8] and others.

The focus of these works concerned with the effect of economic growth and structure of the economy on the environment, and the impact of the cost to restore the environment for economic growth.

In this paper, we focus on these aspects in relation to the Russian Federation, focusing primarily on:

• the degree of influence of Russia's economic growth on the environment;

• consistency of the structure of the Russian economy in terms of ecological requirements;

• the adequacy of the costs of environmental protection in Russia;

• the impact of growth of Russian economy on the environment;

• the degree of influence of environment on growth in the future.

Describing the state of the environment in Russia, we primarily consider the pollution of air and water.

We used statistical data on the Russian Federation as a whole, as well as its regions and individual cities. These data were taken from the official website of the Federal State Statistics Service of Russia (Rosstat), www.gks.ru.

In order to predict the economic dynamics in Russia, we used our previously developed econometric model, which was published in [3].

Section 1. Spending on environmental protection in Russia

Spending on environmental protection in Russia, their dynamics and structure are shown in Table 1.

Table 1

The structure of the total cost of environmental protection
in the Russian Federation for 2003 - 2009 as a share of GDP, %[1]

Indicator	*2003.*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
In total, as a proportion of GDP,%	1,3%	1,2%	1,1%	1,0%	0,9%	0,9%	0,9%	0,8%
Including:								
Protection of air	0,28%	0,27%	0,25%	0,23%	0,19%	0,19%	0,15%	0,18%
Share in total costs	*21,4%*	*23,2%*	*23,0%*	*23,4%*	*21,7%*	*20,8%*	*17,5%*	*21,5%*
Sewage treatment	0,58%	0,51%	0,49%	0,41%	0,38%	0,39%	0,42%	0,38%
Share in total costs	*44,3%*	*44,3%*	*45,0%*	*43,1%*	*43,0%*	*43,2%*	*47,2%*	*45,4%*
Waste management	0,11%	0,12%	0,11%	0,10%	0,08%	0,10%	0,10%	0,09%
Share in total costs	*8,6%*	*10,0%*	*9,7%*	*10,1%*	*9,6%*	*10,9%*	*11,3%*	*11,1%*
Protection and rehabilitation of soil, ground-water and surface water	0,08%	0,05%	0,06%	0,06%	0,06%	0,07%	0,05%	0,04%
Share in total costs	*5,7%*	*4,6%*	*5,7%*	*6,5%*	*7,3%*	*7,4%*	*5,4%*	*4,6%*
Conservation biodiversity and habitat	0,09%	0,07%	0,06%	0,06%	0,07%	0,06%	0,06%	0,05%
Share in total costs	*6,9%*	*6,0%*	*5,4%*	*6,2%*	*7,3%*	*7,2%*	*6,3%*	*6,2%*
other	0,17%	0,14%	0,12%	0,10%	0,10%	0,09%	0,11%	0,09%
Share in total costs	*13,1%*	*11,8%*	*11,1%*	*10,8%*	*11,1%*	*10,4%*	*12,3%*	*11,1%*

This table allows the following conclusions.

1. In the Russian Federation, in contrast to developed countries, as well as contrary to the requirement to improve the quality of life, the costs of environmental protection are reduced relative to GDP.

2. Approximately two thirds of all spending on environmental protection in Russia goes on air and waste water treatment.

3. The cost structure for environmental protection in Russia is almost unchanged and there is only a certain increase in the proportion of expenditure on waste management.

The data presented in Table 1 reflect the costs of environmental protection, both capital and current, taken as a sum. If we consider only operating costs, their dynamics is presented in Table 2.

[1] Source: Rosstat, site www.gks.ru, author's calculations.

Table 2

The structure of current expenditure on environmental protection in the Russian Federation for 1997 – 2010, as a share of GDP, %[2]

Year	*Total*	*Sewage treatment*	*Protection of air*	*Waste management*	*Protection and rehabilitation of soil*
1997	1,4%	0,86%	0,39%	0,14%	0,03%
1998	1,4%	0,91%	0,27%	0,15%	0,03%
1999	1,0%	0,60%	0,22%	0,11%	0,02%
2000	0,9%	0,55%	0,24%	0,11%	0,02%
2001	0,9%	0,53%	0,18%	0,12%	0,03%
2002	0,8%	0,52%	0,17%	0,11%	0,03%
2003	0,8%	0,51%	0,20%	0,10%	0,02%
2004	0,7%	0,45%	0,17%	0,10%	0,02%
2005	0,7%	0,39%	0,16%	0,09%	0,02%
2006	0,6%	0,35%	0,15%	0,09%	0,02%
2007	0,5%	0,32%	0,13%	0,08%	0,02%
2008	0,4%	0,25%	0,11%	0,07%	0,02%
2009	0,5%	0,29%	0,08%	0,08%	0,02%
2010	0,4%	0,25%	0,10%	0,07%	0,02%

As we have seen, current expenditure on environmental protection in Russia fell to very low values (0.4 % of GDP by 2010). It should also be noted that Russian statistics included in these costs (other than generally accepted) also the cost of maintenance of state natural reserves and national parks, protection and reproduction of animals, in research and development, and to education in the environmental field.

It should be noted that OECD countries' expenditures on the environment today is much larger than Russia's ones. The costs (both capital and current) in these countries are equal to 1-2 % of GDP. The greatest costs have countries such as Austria (1.7-1.8 % of GDP), Germany (1.6 %), and Denmark (1.6 %).[3] In addition, in relation to GDP, these expenditures in most OECD countries at least do not decrease, which also distinguishes them from Russia.

If we estimate the dynamics of the costs of environmental protection in Russia in real prices, deflated by GDP deflator, in 2004-2010 they decreased by 15 %, while GDP in real terms grew by 35% during this period. All this shows a disregard for environmental protection in the Russian society.

Next, consider the allocation of costs to the environment by economic activities. Relevant data are given in Tables 3 and 4 (note that they relate only to current costs). Thus, in Table 3 shows the costs of environmental protection in the %% to 1 ruble of value added. Because data on value added are available only for the integrated economic activities, Table 4 provides data on more detailed nomenclature, but

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[2] Source: Rosstat, site www.gks.ru, author's calculations.
[3] See Pollution abatement control and expenditure: www.oecd.org/statistics

on a 1 ruble of products shipped (so they can not be fully comparable with the data of Table 3).

Table 3

Current expenditure for environmental protection by economic activity for the period 2005-2009, per 1 ruble of value added, %[4]

Activity / Year	*2005*	*2006*	*2007*	*2008*	*2009*
Total	0,77%	0,71%	0,62%	0,52%	0,54%
agriculture	0,05%	0,07%	0,06%	0,06%	0,06%
mining	1,51%	1,65%	1,35%	1,34%	1,26%
manufacturing	2,01%	1,76%	1,67%	1,49%	1,69%
production and distribution of electricity, gas and water	5,52%	5,14%	4,74%	3,18%	3,35%
transport and communications	0,16%	0,19%	0,21%	0,17%	0,18%
other community, social and personal services	0,78%	0,73%	0,67%	0,82%	1,05%

Table 3 allows the following conclusions.

1. The highest unit costs for environmental protection have such kind of economic activity as "production and distribution of electricity, gas and water" (especially such sub-industry as "collection, purification and distribution of water"). Next come the "manufacturing" and "mining". We have to make sure that this is the most "dirty" industries of the Russian economy, and that's why they spend the largest amount of money for treatment.

2. Unit costs for environmental protection declined in these three types of economic activity and we can assume that this had not good influence on environment. Other sectors, while spending relatively little, increased unit costs of protection.

3. As the share of mining and manufacturing in GDP declined in recent years, this was another one reason for the reduction of unit costs for environmental protection.

[4] Source: Rosstat, site www.gks.ru, author's calculations

Table 4

Current expenditure for environmental protection
by economic activity,
per 1 ruble of products shipped in 2009, %,[5]

mining - total	0,75%
including:	
mining and quarrying of energy producing materials	0,68%
mining and quarrying, except fuel and energy	1,32%
manufacturing - total	0,58%
including:	
manufacture of food products, beverages and tobacco	0,05%
wood processing and manufacturing of wood products	0,17%
pulp and paper production, publishing and printing	1,32%
coke and petroleum	0,47%
chemical production	1,80%
production of other nonmetallic mineral products	0,29%
manufacture of basic metals and fabricated metal products	1,28%
manufacture of transport equipment	0,30%
production and distribution of electricity, gas and water	1,50%

According to Table 4, the high unit costs for environmental protection provide such type of activity as "mining and quarrying, except of energy." In Russia this activity includes the production of ferrous and nonferrous metals, gold, diamonds, precious stones and building materials, as well as raw materials for fertilizer production. Among manufacturing industries, the highest unit costs have the chemical, pulp and paper and metal production. We shall see further also that they are the most "dirty" industries of the Russian economy. The reduction in pulp and paper and metallurgical production as a share of total manufacturing partly explains the decrease in unit costs of environmental protection.

Now consider the regional data on current expenditure on environmental protection per 1 ruble of gross regional product (GRP). They are presented in Table 5.

[5] Source: Rosstat, site www.gks.ru, author's calculations

Table 5

Current expenditure for environmental protection
Per 1 ruble of gross regional product
by federal districts of Russia in 2009, %[6]

Federal district	*Total*	*Including:*		
		Sewage treatment	*Protection of air*	*Waste management and soil protection*
All Russia's	0,57%	0,35%	0,10%	0,10%
Central	0,29%	0,21%	0,05%	0,04%
North-Western	0,63%	0,38%	0,12%	0,11%
Southern	0,44%	0,32%	0,07%	0,05%
Volga	0,82%	0,55%	0,15%	0,11%
Urals	0,88%	0,54%	0,14%	0,10%
Siberia	0,90%	0,36%	0,21%	0,30%
Far East	0,37%	0,24%	0,04%	0,05%

The data in Table 5 indicate that the highest specific total (current) costs of environmental protection have Siberian, Ural, and Volga and North-West federal districts. In addition, we note that increasing the share of Central and Southern federal districts, with their relatively low unit cost of protecting the surrounding environment in Russia's GDP leads to a decrease of this index in the whole Russia.

Compare the data in Table 5 with the structure of the economy of federal districts, both as regards the value added (Table 6), and shipped products for individual products.

Table 6

The three most important economic activities
in the federal districts of Russian Federation [7]

Federal district	*First place*	*Second place*	*Third place*
All Russia's	Wholesale and retail trade	Manufacturing	Real estate, renting
Central	Wholesale and retail trade	Real estate, renting	Manufacturing
North-Western	Manufacturing	Wholesale and retail trade	Real estate, renting
Southern	Wholesale and retail trade	Manufacturing	Transport and communications
Volga	Manufacturing	Wholesale and retail trade	Mining
Urals	Mining	Manufacturing	Wholesale and retail trade
Siberia	Manufacturing	Transport and communications	Wholesale and retail trade
Far East	Mining	Transport and communications	Construction

Note. Column 2 is an economic activity that takes 1st place in the structure of gross value added in the region, in column 3, respectively, the one that is in 2nd place, and in column 4, respectively, the 3d.

Thus, the highest unit costs for environmental protection have federal districts where manufacturing or mining dominate.

[6] Source: Rosstat, site www.gks.ru, author's calculations
[7] Source: Rosstat, site www.gks.ru, author's calculations

The following table (see Table. 7) illustrates the types of manufacturing and extractive industries, which occupy the greatest weight in the economy of federal districts.

Table 7

The three most important types of extractive and manufacturing industries in the federal districts of Russian Federation[8]

Federal district	*First place*	*Second place*	*Third place*
Central	Manufacture of leather, leather products and footwear	Textile and clothing manufacture	Pulp and paper production, publishing and printing
North-Western	Wood processing and manufacturing of wood products	Pulp and paper production, publishing and printing	Production of electrical, electronic and optical equipment
Southern	Manufacture of food products, beverages and tobacco	Production of other nonmetallic mineral products	Textile and clothing manufacture
Volga	Chemical production	Manufacture of transport equipment	Manufacture of rubber and plastic products
Urals	Mining and quarrying of energy producing materials	Manufacture of basic metals and fabricated metal products	Coke and petroleum
Siberia	Manufacture of basic metals and fabricated metal products	Wood processing and manufacturing of wood products	Mining and quarrying, except fuel and energy
Far East	Mining and quarrying, except fuel and energy	Mining and quarrying of energy producing materials	Wood processing and manufacturing of wood products

Note. Column 2 is an economic activity, among manufacturing or extractive industries, in which federal district occupies the largest share in total products shipped for this type of activity carried out in Russia, among others in its activities in the field of extraction or processing. Column 3 - the type of activity, which occupies the second place, and in column 4, respectively, third.

So, in the economy of the Siberian, Ural, Volga and North-Western districts with the largest share of costs to protect the surrounding environment wood processing and pulp and paper industry, chemical and rubber products, metallurgy, mining, coke and petroleum, and equipment production play a significant role.

Next, consider the costs of environmental protection in more detailed geographical terms - the individual subjects of the federation. This gives additional information because the subjects of the federation, members of the federal district, may be highly heterogeneous in terms of economic structure. Table 8 shows a list of regions where operating costs for environmental protection are higher than 1 % of the GRP.

[8] Source: Rosstat, site www.gks.ru, author's calculations

Table 8

Regions of Russia, spending on environmental protection more than 1 % of gross regional product (current costs) [9]

Region	*Federal District*	*Current costs on environmental protection per 1 ruble of GRP*
Krasnoyarsk	Siberian	1,91%
Murmansk	North-Western	1,47%
Bashkortostan Republic	Volga	1,40%
Karelia Republic	North-Western	1,38%
Archangelsk	North-Western	1,23%
Lipetsk	Central	1,21%
Yaroslavl	Central	1,16%
Khanty – Mansiisk Autonomous Region	Urals	1,11%
Sverdlovsk	Urals	1,01%
Chelyabinsk	Urals	1,00%
Irkutsk	Siberian	1,00%

Regions with high costs of environmental protection specialize in manufacturing, mining, and transport and communication services. In the structure of their products shipped mining and quarrying, except fuel and energy, metal production, wood processing and pulp and paper, machinery and equipment production dominate.

Section 2. Air pollution

We now consider the direct contamination of the environment, starting with the emissions polluting the atmosphere. These dynamics will be visible in the following table (see Table. 9).

Table 9

Emissions of air pollutants
motor vehicles and stationary sources
for 2000 – 2009, thousand tons [10]

Indicator / Year	*2000*	*2005*	*2006*	*2007*	*2008*	*2009*
Released pollutants the atmosphere of substances - all	32301	35835	35723	36978	37447	36095
per 1 million rubles of GDP, tons	1,30	1,07	0,99	0,94	0,91	0,95
including: by motor vehicles	13481	15410	15155	16341	17344	17074
per 1 million rubles of GDP, tons	0,54	0,46	0,42	0,42	0,42	0,45
by stationary sources	18820	20425	20568	20637	20103	19021
per 1 million rubles of GDP, tons	0,76	0,61	0,57	0,53	0,49	0,50

Note. GDP in the calculation was adopted in 2008 prices.

The data in Table 9 suggest the following conclusions.

[9] Source: Rosstat, site www.gks.ru, author's calculations
[10] Source: Rosstat, site www.gks.ru, author's calculations

1. Air emissions per 1 million rubles of gross domestic product declined in the period 2000-2009. However, since 2005, it mainly concerns the emissions from stationary sources, i.e., factories and other economic activities. The share of emissions from stationary sources fell from 58 % to 53 % for the period from 2000 to 2009.

2. Emissions from road transport rose by 27 % compared with 2000 and by 11 % compared with 2005. The increase in the number of cars owned by citizens was 69 % for the period 2000-2009.and 31 % for the period 2005-2009.

3. Emissions from stationary sources grew by only 1 % by 2009 compared to 2000 and decreased by 7 % compared with 2005. With GDP for the period from 2005 to 2009 grew by 14%. So we can expect that the reduction of emissions from stationary sources has occurred due to changes in GDP structure.

Consequently, it makes sense to consider the contribution of certain economic activities to air pollution that has been done in Tables 10 and 11.

Table 10

Emissions of air pollutants,
emanating from stationary sources,
tons per 1 million rubles of value added (in 2008 prices)[11]

Activity / Year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Total	0,71	0,67	0,62	0,57	0,58	0,56
agriculture	0,10	0,09	0,08	0,08	0,08	0,10
mining	1,79	1,81	1,92	1,69	1,59	1,50
manufacturing	1,32	1,22	1,14	1,11	1,21	1,09
production and distribution of electricity, gas and water	3,92	4,09	4,10	4,32	4,21	4,17
transport and communications	0,77	0,73	0,71	0,76	0,87	0,76
other community, social and personal services	0,12	0,10	0,09	0,11	0,18	0,23

Table 11

The structure of the emission of pollutants,
emanating from stationary sources
by economic activity, %[12]

Activity / Year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Total	100%	100%	100%	100%	100%	100%
agriculture	0,7%	0,6%	0,6%	0,6%	0,7%	0,7%
mining	30,1%	29,3%	30,3%	27,7%	27,5%	27,2%
manufacturing	35,5%	34,8%	34,9%	34,0%	33,4%	33,6%
production and distribution of electricity, gas and water	19,5%	21,2%	20,4%	22,2%	21,8%	22,6%
transport and communications	10,2%	10,5%	10,7%	12,3%	13,7%	12,7%
other community, social and personal services	0,3%	0,3%	0,3%	0,3%	0,5%	0,6%

[11] Source: Rosstat, site www.gks.ru, author's calculations
[12] Source: Rosstat, site www.gks.ru, author's calculations

Thus, the most "dirty" in terms of emissions per 1 million rubles of economic activity - is "the production and distribution of electricity, gas and water." In this case the emission intensity of this activity grew until 2008.This is followed by "mining" and "manufacturing", but these industries show a rather marked reduction of specific emissions. They show the greatest contribution to air pollution in Russia besides, but the share of these economic activities in the total emissions reduced. Decrease in the proportion of these activities in the GDP also helps to reduce emissions. In contrast, the proportion of emissions due to the "production and distribution of electricity, gas and water" and "transport and communications" increased. These industries have not yet achieved a marked reduction of specific emissions.

Analysis of the impact structure mining and manufacturing industries, as well as production and distribution of electricity, gas and water to air pollution is presented in Tables 12 and 13. As we can see, the most "dirty" in terms of specific emissions sectors - such as mineral extraction, and, above all, fuel and energy resources, manufacture of basic metals, manufacture of other nonmetallic mineral products (this includes the production of glass, ceramics and building materials), and the production and distribution of electricity, gas and water. The lion's shares of air-polluting emissions make mining and quarrying of energy producing materials and metallurgy industry. The reduction in the latter in the total manufacturing industry shipped products helps to reduce total emissions to the atmosphere.

Table 12

Emissions of air pollutants,
emanating from stationary sources
tons per 1 million rubles of products shipped, 2010 [13]

mining - total	0,85
including:	
mining and quarrying of energy producing materials	0,90
mining and quarrying, except fuel and energy	0,50
manufacturing - total	0,37
including:	
manufacture of food products, beverages and tobacco	0,04
wood processing and manufacturing of wood products	0,35
pulp and paper production, publishing and printing	0,26
coke and petroleum	0,22
chemical production	0,25
production of other nonmetallic mineral products	0,54
manufacture of basic metals and fabricated metal products	1,33
manufacture of transport equipment	0,06
production and distribution of electricity, gas and water	1,27

[13] Source: Rosstat, site www.gks.ru, author's calculations

Table 13

The structure of the emission of pollutants,
emanating from stationary sources
by type of mining and manufacturing industries
as well as production and distribution of electricity, gas and water
% of total emissions[14]

Type of activity / Year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
mining - total	30,1%	29,3%	30,3%	27,7%	27,5%	27,2%
including:						
mining and quarrying of energy producing materials	27,6%	26,8%	27,8%	25,3%	25,6%	25,2%
mining and quarrying, except fuel and energy	2,5%	2,5%	2,5%	2,4%	1,9%	2,0%
manufacturing - total	35,5%	34,8%	34,9%	34,0%	33,4%	33,6%
including:						
manufacture of food products, beverages and tobacco	0,7%	0,7%	0,7%	0,7%	0,8%	0,7%
wood processing and manufacturing of wood products	0,4%	0,4%	0,4%	0,4%	0,4%	0,4%
pulp and paper production, publishing and printing	0,8%	0,8%	0,7%	0,7%	0,8%	0,8%
coke and petroleum	4,1%	3,7%	4,0%	4,1%	3,5%	3,8%
chemical production	1,7%	1,8%	1,8%	1,7%	1,7%	1,8%
production of other nonmetallic mineral products	2,3%	2,4%	2,5%	2,3%	2,1%	2,2%
manufacture of basic metals and fabricated metal products	23,6%	23,3%	23,0%	22,4%	22,6%	22,4%
manufacture of transport equipment	0,6%	0,6%	0,5%	0,5%	0,4%	0,5%
production and distribution of electricity, gas and water	19,5%	21,2%	20,4%	22,2%	21,8%	22,6%

Next, we consider the structure of emissions by regions of Russia.

Consider the data of the specific emissions in tons per 1 million of gross regional product by federal district (see Table.14). Indicators listed in the table are to lead to the conclusion that the most "dirty" in terms of emissions and in relation to population and gross regional product are the Urals and Siberian federal districts. Their high pollution stems, of course, primarily from stationary sources. Reduction of the proportion of these districts in Russia's GDP helps to some extent to reduce total emissions to the atmosphere in the country. Also note that the higher than average pollution from stationary sources the Northwestern District has.

[14] Source: Rosstat, site www.gks.ru, author’s calculations

Table 14

The structure of the population,
gross regional product
and emissions of pollutants
by federal districts of Russia, 2009, %[15]

Federal district	*Popula-tion*	*Gross re-gional prod-uct*	*Emission of pollutants - total*	*including*	
				from motor vehi-cles	*from stationary sources*
All Russia	*100,0%*	100,0%	100,0%	100,0%	100,0%
Central	*26,2%*	35,7%	17,3%	27,2%	8,3%
North-Western	*9,5%*	10,6%	10,4%	9,3%	11,4%
Southern	*16,2%*	8,7%	9,4%	15,3%	4,1%
Volga	*21,2%*	15,3%	16,2%	19,2%	13,5%
Urals	*8,7%*	13,7%	19,0%	9,3%	27,7%
Siberia	*13,8%*	10,6%	23,0%	14,8%	30,4%
Far East	*4,5%*	5,4%	4,7%	4,8%	4,6%

Ten regions with the highest emissions per 1 million rubles of GRP are presented in Table 15.

Table 15

Regions
with the highest (total) specific emissions to the atmosphere
per 1 million rubles of GRP, tons, 2009 [16]

Region	*Federal district*	*Emissions per 1 million rubles of GDP*
Krasnoyarsk	Siberian	3,76
Kemerovo	Siberian	3,32
Vologda	North-Western	2,54
Ingushetia Republic	Southern	2,41
Komi Republic	North-Western	2,33
Orenburg	Volga	2,22
Altai Republic	Siberian	2,22
Lipetsk	Central	2,20
Astrakhan	Southern	2,11
Chelyabinsk	Urals	2,09

Regions presented in table have a high proportion of metallurgy, mining, wood processing and pulp and paper industries, machinery and equipment in their economies. We calculated a Spearman's rank correlation coefficient on a sample of Russian regions (83 points) between the specific releases to air and unit costs for the protection of air. It is equal only to 0.28. When we took only the emissions from sta-

[15] Source: Rosstat, site www.gks.ru, author's calculations
[16] Source: Rosstat, site www.gks.ru, author's calculations

tionary sources, its value jumped to 0.48, but that is still too low. Both results reflect a certain disregard for the protection of air in many Russian regions.

We have estimated regression of atmospheric emissions from stationary sources per 1 million rubles of GRP on a sample of Russian regions (83 points). It is presented in table 16.

Table 16

Regression of pollutant emissions into the atmosphere
from stationary sources per 1 million rubles of GRP, 2009 year

Dependent variable	*Independent variables (regressores)(*					
ESQ =	+0.447DNW	+0.604DSIB	+14.05METAL	+0.015MINE	-7.73MINER	+0.32
t-statistics	3.603	5.428	8.730	6.098	-3.429	5.385
R^2 = 0.682		F = 33.05				

Legend:

ESQ -emissions of pollutants into the atmosphere from stationary sources, tons per 1 million rubles of GRP;

MINE - the proportion mining in the GRP;

METAL - the region's share in total Russian metallurgical production;

MINER - the region's share in total Russian production of other nonmetallic mineral products;

DNW - a dummy variable for the North-Western Federal District;

DSIB - a dummy variable for the Siberian Federal District;

R^2 - coefficient of determination;

F – Fisher statistics.

Regression clearly shows a strong positive dependence of emissions from stationary sources per 1 million rubles of GRP on the region's share in total Russian volume of metallurgical production and on the share of mining in gross regional product, but the negative dependence on the fraction of the region in the production of nonmetallic mineral products. At the same time the increased emissions per 1 million rubles of GRP the Northwestern (but St. Petersburg) and Siberian federal districts show.

Regression of total emissions (in thousand tons) is significantly and positively correlated with the gross regional product, the share of the region in all-Russian production and processing of wood, metals and mining and quarrying of energy producing materials. It negatively depends on the fraction of the region in all-Russian production of nonmetallic mineral products. Siberian federal district again shows the increased emissions here, negative parameters have dummy variables for Moscow and St. Petersburg. In such regression the coefficient of determination is equal to 0.917 and the Fisher statistics to 101.9.

Therefore, development of export industries, as mining and quarrying of energy producing materials and metallurgy, as well as timber export will mean a further deterioration of air quality in the today’s model of Russia’s development. And the victims of it will be, first and foremost, Siberian, Ural and North-Western districts, specializing in those activities.

Now consider the amount of emissions per capita in the regions of Russia. Table 17 shows the ten regions with the highest emissions in 2009.

Table 17

Ten regions with the largest emissions
polluting the atmosphere (total),
per capita, kg, 2009 year [17]

Region	*Federal district*	*Per capita pollution, kg*
Nenets Autonomous Region	North-Western	4333
Yamalo-Nenets Autonomous Region	Siberian	1903
Khanty - Mansi Autonomous Region	Urals	1628
Krasnoyarsk	Siberian	972
Komi Republic	North-Western	739
Kemerovo	Siberian	603
Chukotka Autonomous Region	Far East	592
Archangelsk	North-Western	451
Vologda	North-Western	445
Orenburg	Volga	435

The first three rows of the table are occupied by under populated regions with large amounts of oil and gas extraction- Nenets, Yamalo-Nenets and Khanty-Mansi autonomous regions, and then there are regions mostly of Siberia and North-Western districts with high proportion of metallurgical production, mining and wood processing.

We have estimated a regression of emissions per capita from stationary sources on data sample by regions of Russia (83 points):

ESN = 0.000349QN + 1562.2LUMBER + 2529.5METAL +
(4.352) (2.443) (6.173)
1216.5MINE1 + 899.9MINE2 – 2910.5MINER – 77.3OTHER1 +
(5.728) (2.122) (-4.732) (-3.320)
486.1DKHANT + 2995.5DNEN + 98.7DNW + 105.3DSIB +
(4.614) (12.120) (3.058) (3.957)
1186.9DYAMAL + 99.77
(10.933) (2.819)

R^2 = 0.980
F = 287.7

ESN - emissions of pollutants into the atmosphere per capita from stationary sources, kg;

QN - GDP per capita;

[17] Source: Rosstat, site www.gks.ru, author's calculations

LUMBER - the region's share in total Russian wood processing;

MINE1 - region's share in total Russian production of energy minerals;

MINE2 - region's share in total Russian production of non-energy minerals;

METAL - the region's share in total Russian metallurgical production;

MINER - the region's share in total Russian production of other nonmetallic mineral products;

OTHER1 - share activities "other community, social and personal services" in the GRP

DNW - a dummy variable for the North-West Federal District;

DSIB - a dummy variable for the Siberian Federal District;

DKHANT - a dummy variable for the Khanty-Mansi Autonomous region;

DNEN - a dummy variable for the Nenets Autonomous region;

DYAMAL - a dummy variable for the Yamalo-Nenets Autonomous region;

t-statistics are given in parentheses.

Regression clearly shows a positive dependence of air emissions per capita (from stationary sources) on the gross regional product per capita, the region's specialization in wood processing, metallurgy, mining operations. High levels of emissions per capita Northwestern and Siberian federal districts and the Nenets, Yamalo-Nenets and Khanty-Mansi autonomous regions with smaller population have.

Russian statistics also provides data on emissions of pollutants into the atmosphere per capita in Russian cities, but only to those who are either administrative center, or have a population of over 100 thousand of people. Ten cities with the greatest volume of emissions from stationary sources per capita are presented in Table 18.

The most severe environmental conditions, as evidenced by the data in Table 18, there was in the city of Norilsk. This city is the second largest in the world by population, after Murmansk, a city within the Arctic Circle and Russia's largest producer of copper, nickel and cobalt. Life expectancy in the Norilsk is to 10 years less than the Russian average, cancer are twice more likely than the average for Russia. There are also mass respiratory diseases, blood, cardiovascular diseases, mental disorder.

Table 18

Ten cities with the highest emissions
per capita from stationary sources, 2009 [18]

City	*Population, thousand*	*Region*	*Federal district*	*Main activities*	*Emissions per capita, kg*
Norilsk	202	Krasnoyarsk	Siberian	Mining and production of nickel, copper and cobalt, mining of precious metals	9692,4
Narian - Mar	20	Nenets Autonomous Region	North-Western	Oil	4525,8
Mezhdurechensk	104	Kemerovo	Siberian	Coal	1317,8
Cherepovets	310	Vologda	North-Western	Ferrous metallurgy, chemistry	981,5
Novotroitsk	101	Orenburg	Volga	Ferrous metallurgy	839,5
Angarsk	241	Irkutsk	Siberian	Chemistry, petroleum	765,6
Leninsk - Kuznetskii	105	Kemerovo	Siberian	Coal	744,0
Orsk	240	Orenburg	Volga	Non-ferrous metallurgy, machine building, petrochemicals	602,5
Lipetsk	502	Lipetsk	Central	Ferrous metallurgy, machine building	588,6
Magnitogorsk	410	Chelyabinsk	Urals	Ferrous metallurgy	587,2

Finally, let's have a brief look at the statistics of air emissions from road transport. In Russia as a whole these emissions are growing faster than emissions from factories, due to the rapid increase in the number of cars owned by citizens. Rank correlation coefficient between the number of cars owned per 1000 citizens and emissions in the atmosphere due to road transport per capita in the regions of Russia (83 points) is 0.675. The regression results are presented in table 19.

Table 19

Regression of pollutant emissions into the atmosphere
from cars, 2009 year

Dependent variable	*Independent variables (regressores)(*					
EA =	+0.291AUTO	-343.1DM	+24.8DSIB	-97.0DSP	+0.044N	4.64E-05Q
t-statistics	7.728	-6.484	3.184	-3.512	4.930	5.183
R^2 = 0.987		F = 957.0				

Legend:

EA -emissions of pollutants into the atmosphere from road transport, thousand of tons;

AUTO – total quantity of cars in the region, thousand;

DM - a dummy variable for the Moscow City;

DSIB - a dummy variable for the Siberian Federal District;

DSP - a dummy variable for the St. Petersburg City;

N – population, thousand;

Q – gross regional product, million of rubles;

[18] Source: Rosstat, site www.gks.ru, author's calculations

R^2 - coefficient of determination;
F – Fisher statistics.
E-05 means 10 in minus 5 degree.

Section 3. Water pollution

We now consider the contamination of water resources; statistics of the dynamics of this process is presented in the following table (see Table. 20).

Table 20

The volume of wastewater discharge in the Russian Federation, billion cubic meters [19]

Indicator / Year	*2000*	*2005*	*2006*	*2007*	*2008*	*2009*
Volume of wastewater discharge total	20,3	17,7	17,5	17,2	17,1	15,9
Per 1 thousand rubles of GDP, cubic meters	0,82	0,53	0,48	0,44	0,41	0,42

According to Table 20, we see that the dumping of polluted waste water in Russia is reduced, both in absolute volume and per thousand rubles of GDP. To analyze the causes of these dynamics we have calculated the structure of the discharge by economic activity, as shown in the following two tables (see table 20 and 21).

Table 21

Wastewater discharge to surface waters by economic activity in 2009 (per 1 thousand rubles of value-added, VA in 2008 prices, cubic meters)[20]

Activity	*Per 1 thousand rubles of VA*	*Share in the total discharge, %*
Total	0,48	100,0
agriculture	0,58	5,5
mining	0,31	6,4
manufacturing	0,52	17,2
production and distribution of electricity, gas and water	8,97	55,6
transport and communications	0,01	0,3
other community, social and personal services	3,77	11,9

[19] Source: Rosstat, site www.gks.ru, author's calculations
[20] Source: Rosstat, site www.gks.ru, author's calculations

Table 22

Wastewater discharge to surface waters by economic activity in 2009 (per 1 thousand rubles of shipped products, cubic meters)[21]

Activity	*Per 1 thousand rubles*	*Share in the total discharge, %*
mining - total	**0,20**	**6,4**
including:		
mining and quarrying of energy producing materials	0,11	3,1
mining and quarrying, except fuel and energy	0,95	3,3
manufacturing - total	**0,19**	**17,2**
including:		
manufacture of food products, beverages and tobacco	0,02	0,4
wood processing and manufacturing of wood products	1,23	1,7
pulp and paper production, publishing and printing	1,49	4,7
coke and petroleum	0,03	0,5
chemical production	0,57	3,8
production of other nonmetallic mineral products	0,08	0,3
manufacture of basic metals and fabricated metal products	0,26	3,8
manufacture of transport equipment	0,20	1,4
production and distribution of electricity, gas and water	**2,89**	**55,6**
including:	-	
generation, transmission and distribution of electricity, gas, steam and hot water	-	5,9
collection, purification and distribution of water	-	49,7

Thus, we see that the main water pollution comes from the activity of "production and distribution of electricity, gas and water", and within it - in the first place, "the collection, treatment and distribution of water". The second place is occupied by manufacturing. Among the manufacturing sectors the most "dirty" in terms of polluted waters are the pulp and paper production and wood processing, chemical industry and metallurgy. The share of "dirty" manufacturing industries gradually declined, reducing the pollution of water resources. At the same time pollution increased with increasing of the proportion of the most "dirty" activity - the "production and distribution of electricity, gas and water."

We now carry out an analysis of polluted water per capita and per 1 thousand rubles of GRP in Russian regions. Information about federal districts are given in the following table (see Table. 23).

[21] Source: Rosstat, site www.gks.ru, author's calculations

Table 23

Polluted wastewater
in the federal districts of Russian Federation
per capita (cubic meters) and per 1 thousand rubles of GRP (cubic meters)[22]

Federal district	*per capita (cubic meters)*	*per 1 thousand rubles of GRP (cubic meters)*
All Russia	111,7	0,494
Central	96,9	0,314
North-Western	210,6	0,831
Southern	80,8	0,666
Volga	88,8	0,544
Urals	138,6	0,387
Siberia	120,0	0,693
Far East	131,7	0,490

The data in Table 23 indicate that the most polluted waters, both per capita and per thousand rubles of GRP has a North-Western federal district, which specializes mainly in mining, wood processing and pulp and paper industries, as well as metallurgy and machine building. Next on discharges per capita are the Urals, Far Eastern and Siberian federal Districts, and what about per 1 thousand rubles of GRP that are Siberian, Southern and Volga.

The following table shows the structure of waste water discharged by federal districts of Russia (see Table. 24).

Table 24

The structure of the wastewater discharge of Russia, 2009, %[23]

Federal district	*Population*	*Gross regional product*	*Wastewater discharge*
All Russia	**100,0%**	**100,0%**	**100,0%**
Central	26,2%	35,7%	22,7%
North-Western	9,5%	10,6%	17,9%
Southern	16,2%	8,7%	11,7%
Volga	21,2%	15,3%	16,9%
Urals	8,7%	13,7%	10,7%
Siberia	13,8%	10,6%	14,8%
Far East	4,5%	5,4%	5,3%

The table clearly exhibited a high degree of water pollution in the first place in the Northwestern district, and is followed by the Siberian Federal District.

Below is a table which presents ten regions with the highest volume of polluted water per capita and per 1 thousand rubles of GRP (sees Table 25).

[22] Source: Rosstat, site www.gks.ru, author's calculations
[23] Source: Rosstat, site www.gks.ru, author's calculations

Table 25

Ten regions of the Russian Federation with the highest level of wastewater discharge per capita
(cubic meters) and per 1 thousand rubles of GRP (cubic meters)[24]

Regions with greatest wastewater dis-charge per capita	*Wastewater discharge per capita*	*Regions with greatest wastewater dis-charge per 1 thou-sand rubles of GRP*	*wastewater discharge per 1 thousand rubles of GRP*
Murmansk	421	Rep. Karelia	1,789
Archangelsk	331	Murmansk	1,744
Rep. Karelia	278	Rep. Kalmikya	1,465
Kemerovo	264	Kemerovo	1,456
Irkutsk	256	Irkutsk	1,405
St. Petersburg City	240	Rep. Karachayevo - Cherkessia	1,374
Chelyabinsk	197	Rep. Nothern Ossetia - Alania	1,351
Leningrad	192	Ivanovo	1,317
Magadan	180	Archangelsk	1,285
Sverdlovsk	178	Chelyabinsk	1,224

We see that the regions with the highest discharge of polluted water per capita specialize in mining, wood processing and pulp and paper production and metallurgy.

Regression of wastewater discharge according to the regions of Russia is given in Table 26.[25]

Table 26

Regression of wastewater discharge

Dependent variable	*Independent variables (regressores)(*				
W =	+553.6DSP	+2612.3METAL	+0.076N	2975.7PAPER	-14.82
t-statistics	4.963	5.115	6.321	4.974	0.79
R^2 = 0.845		F = 104.7			

Legend:
W - polluted waste water, million cubic meters;
METAL - the region's share in total Russian metallurgical production;
PAPER - the region's share in total Russian pulp and paper industry;
N – population, thousands.
DSP - a dummy variable for the city of St. Petersburg;

Regression equation clearly shows that the total discharge depends positively on the region's population, the proportion of the region in total Russian metallurgical and pulp and paper industry.

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[24] Source: Rosstat, site www.gks.ru, author's calculations

[25] White's heteroscedasticity test for this regression shows its presence (the F-statistic is equal to 6.6 in the test works without cross terms, and 5.5 with them. But our attempts to estimate the regression with the elimination of heteroscedasticity did not give satisfactory results.

Statistical data on Russian cities allow us to evaluate polluted waste water per capita in these cities. The following table (see Table. 27) lists the 10 most contaminated (in terms of wastewater) cities. It should be noted that this statistic is available only for the cities with population over 100 thousand people.

Table 27

Ten Russian cities with the highest discharge of contaminated waste water per capita, thousand cubic meters, 2008 [26]

City	*Population, thousand*	*Region*	*Federal district*	*Main activity*	*Discharge of contaminated waste water per capita, cubic meters*
Angarsk	241	Irkutsk	Siberian	Chemistry, petroleum refining	0,87
Bratsk	250	Irkutsk	Siberian	Non-ferrous metallurgy, pulp and paper industry, chemistry, electricity	0,80
Magnitogorsk	410	Chelyabinsk	Urals	Ferrous metallurgy	0,63
Achinsk	110	Krasnoyarsk	Siberian	Non-ferrous metallurgy, petroleum refining	0,53
Mezhdurechensk	104	Kemerovo	Siberian	Coal	0,47
Vladivostok	578	Primorski	Far East	Mechanical engineering, electricity	0,45
Pervouralsk	134	Sverdlovsk	Urals	Ferrous metallurgy	0,42
Syktyvkar	236	Komi Republic	North-Western	Wood processing, pulp and paper production	0,42
Nizhnii Tagil	373	Sverdlovsk	Urals	Ferrous metallurgy, mechanical engineering	0,42
Norilsk	202	Krasnoyarsk	Siberian	Mining and production of nickel, copper and cobalt, mining of precious metals	0,38

The data in Table 27 indicate that four of these ten cities (as shown above) are also included in the top ten cities with the highest air pollution (Angarsk, Magnitogorsk, Norilsk and Mezhdurechensk).

Note that most "dirty" cities in Russia by dumping polluted water are specializing in metal production, pulp and paper industry, chemical and oil refining, coal mining, and machinery building.

[26] Source: Rosstat, site www.gks.ru, author’s calculations

Section 4. Pollution and economic growth

Patterns of economic growth in Russia can be studied as produced on the basis of the above analysis, and through an econometric model, a full description of which is given in Appendix 1.

The model was estimated on quarterly data for the 1995-2009 period (i.e. 60 points) and includes 21equations and 11 of the identities that describes the relationship between 41 variables, 7 of which are exogenous and 34 - endogenous. Exogenous variables include: the number of economically active population, export price index, money supply, exchange rate, the payment of income tax, taxes on imports and production and value of government procurement. Among the endogenous variables are: gross domestic product, investment in fixed assets from various sources (net return and depreciation, bank loans, the state budget), bank loans and deposits, employment and price indexes.

The model showed that among exogenous variables the most powerful influence on the endogenous ones have three of them, namely the number of economically active population, the export price index and money supply.

Let us examine the relationship of influence of exogenous variables on endogenous ones with environmental trends in Russia.

It is clear that among these three variables the most significant relationship to the environment export has. This is due to the fact that in the structure of Russian exports the largest share "dirty" industries have (see Table. 28).

Table 28

Commodity structure of Russian exports in 2000 and 2010, %[27]

Indicator	*2000*	*2010*
Export - al	100	100
including:		
foodstuffs and agricultural raw materials (except textile)	1,6	2,3
mineral products	53,8	68,8
chemical products, rubber	7,2	6,3
hides and skins, fur and articles thereof	0,3	0,1
wood, pulp and paper products	4,3	2,5
textiles, textile products and footwear	0,8	0,2
metals, precious stones and articles thereof	21,7	13,0
machinery, equipment and vehicles	8,8	5,7
other products	1,5	1,1

The data in Table 28 indicate that over the past 10 years the share of mineral products increased significantly in Russia's exports. The vast majority of them are crude oil, petroleum products and natural gas. Also a high proportion of metals,

[27] Source: Rosstat, site www.gks.ru

chemical products (mainly fertilizers) and wood take place in exports. The preceding exposition shows clearly that the further development of Russia's exports, while maintaining its current structure poses a threat of further environmental degradation. In particular this applies to the Urals, Siberian and North-Western districts - the main producers of export products in Russia.

Below there are the results of two scenarios of the ecological situation in Russia in the next five years: inertial and export-oriented.

In the inertial variant structure of the economy has the same dynamics as it changed in the period 2005-2010.

In the export-oriented scenario mining production grow twice as fast as GDP, export-oriented manufacturing - two times faster than all manufacturing industries combined. The share of agriculture in GDP remains constant at the level of 2010 (in 2008 prices). It is also assumed that earlier rates of change in emissions per 1 million rubles of GDP and the products shipped will be the same. In other words, we do not assume any acceleration of technological progress in air and water cleaning. GDP growth is assumed to be 4% per year.

Table 29

Emissions of pollutants into the atmosphere
(due to stationary sources)
and contaminated water into surface water bodies:
forecast for the inertial and export-oriented scenarios

Indicator	*2010 fact*	*2015, inertial variant*	*2015, export-oriented variant*
Emissions to air (stationary sources), thousand tons	19115,6	17730,1	22201,6
Polluted waters billion cubic meters	15853,6 (2009 year)	17608,4	19946,1

As we see, in the inertial scenario emissions from stationary sources are reduced by 7 %, as they declined in the past. If Russia will develop intensively its existing export industries and the global economic situation will contribute to this, the emissions will increase by 16 %, which will exacerbate an already precarious ecological situation (especially as emissions from road transport are likely to grow further in the short term). Knowing the regional structure of Russian export industries we can forecast, that Urals and Siberian federal districts will suffer in the first place.

Wastewater discharges in the inertial scenario increase by 11 % by 2015 compared to 2009. In the export-oriented scenario, they are increasing by 26 % compared to 2009. The Northwestern federal district will suffer especially, in this scenario as well as Siberian and Ural region.

Another strong exogenous variable model, as outlined above, is the economically active population. We have not received evidence of a direct effect of the emission levels on fertility and mortality: the relevant variables were insignificant or very weak in the regressions constructed on regional data. The percentage of people over working age and vodka consumption per capita have strongest increasing influence on the mortality rate. Food production has negative impact on mortality rate. The birth rate is mostly affected by the proportion of young people in the total population.

At the same time we found some evidence of *indirect effects* of air emissions on the population figures using dummy variables. In the regression equation of mortality dummy variables for the North-Western and Siberian districts indicate increased mortality. In the equation for fertility, they show a lower fertility rate for the Northwest District (but St Petersburg). We know from the previous statement that these (as well as the Ural district) are the most environmentally sensitive region of Russia.

There are also other warning signals that environment will limit future economic growth and threatens the quality of life of Russians. Russia has only 8.4 % of clean energy in her total energy balance while 91 % of fossil fuel and she produces only $3.1 of GDP per 1 kg of oil equivalent (2-3 times less than developed countries). Russia has 15 per 1000 crude death rate that is near to Africa’s one. Some specialists think that it is partly due to poor environmental conditions. Russia is expected to lose 13 million of her population in next 20 years.

Consequently, Russia has the sense to increase the costs of environmental protection not only to improve the quality of life, but also for further growth.

If we return to Table 1, it shows that the share of expenditure on environmental protection has fallen to below 1 % of GDP. The model allows to assess what are the consequences if Russia spends on environmental protection a 1 % of GDP in addition to the current level of costs, i.e. bring them to the level of developed countries. To simplify the situation, we assume that these charges direct and irrevocable deduction from investments in fixed capital, i.e. pure deduction from growth.

The results are presented in the following table.

Table 30

Falling rates and the absolute values of GDP
and investment in fixed assets
due to release an additional 1% of GDP on environmental protection

Indicator	*2012*	*2013*
GDP, rate of growth	-0.3%	-0.7%
GDP, absolute value	-0,2%	-0,9%
Investment in fixed capital, absolute value	-29%	-26%

GDP losses, as we see, are not very large in 2012, but gradually increase in 2013. Loss of investment is much more - they make up more than ¼ of their absolute volume. It is clear that in fact these losses will be smaller because environmental costs are not irrevocable expenses. In addition, they enhance the quality of life, improving, albeit with a lag, the quality of the labor force and increases in total factor productivity.

Conclusion

The modern model of economic growth in Russia, with its heavy dependence on commodity exports and environmentally dangerous products may lead to further deterioration of the environment. Improving the world market for Russian export industries may worsen the ecological situation in it, especially in the regions specializing in the relevant industries. Potentially, this could exacerbate the demographic situation in Russia.

To overcome such tendencies Russia should increase the expenditures for environmental protection, at least, to reverse the trend of decline its share of GDP as it was in recent years. In the future it is desirable to return to the level equal to about 1.5 % of GDP, as was the case in the early 2000s. It is necessary to reconstruct these types of industries as metallurgy, mining, pulp and paper production, to make them less environmentally hazardous. The country should increase the share of agricultural and engineering products in exports, but in the long term - the "clean" from an environmental point of view of industries (especially electronics).

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Appendix 1. Econometric model of Russian economy: variables and equations

Table A. 1

List of variables of the model

	Symbol	Variable	Unit
		Exogenous variables	
1)	N	Economically active population, age 15-72	Million
2)	PEXP	Ruble export prices' index, Q1 1995 = 1,000	
3)	M	Money aggregate M2, national estimation, on the end of quarter	Billion of rubles
4)	INTAX	Indirect taxes paid, quarterly	Billion of rubles
5)	PTAX	Corporate income tax paid, quarterly	Billion of rubles
6)	BASCUR	"Basket" ruble exchange rate; weights: American dollar = 0.55, euro – 0.45	Ruble
7)	G	Government purchases	Billion of rubles
		Endogenous variables	
8)	K	Fixed capital (assets), beginning of quarter, current prices	Billion of rubles
9)	I	Total investment in fixed capital, quarterly, current prices	Billion of rubles
10)	L	Total employment, quarterly average	Million
11)	SW	Wages' share in GDP	
12)	Q	GDP in 1995 year' prices, quarterly	Billion of rubles
13)	P	GDP deflator, Q1 1995 = 1,000	
14)	PQ	GDP, current prices	Billion of rubles
15)	W	Gross wages per 1 employee, quarterly	Thousand of rubles
16)	WL	Total wages paid in the economy, quarterly	Billion of rubles
17)	C	Household consumption, current prices, quarterly	Billion of rubles
18)	MRK	Marginal revenue on fixed capital, yearly	Ruble / ruble
19)	MRL	Marginal revenue on labor, quarterly	Thousand of rubles per employee
20)	ROK	Gross profit, current prices, quarterly	Billion of rubles
21)	NROK	Net profit + depreciation, current prices, quarterly	Billion of rubles
22)	IA	Investment in fixed capital from depreciation, current prices, quarterly	Billion of rubles
23)	NNROK	Net profit, current prices, quarterly	Billion of rubles
24)	IROK	Investment in fixed capital from net profit, current prices, quarterly	Billion of rubles
25)	IG	Investment in fixed capital from state budget, current prices, quarterly	Billion of rubles
26)	RDEPRP_H	Households' ruble deposits deflated by CPI	Billion of rubles
27)	DEPVP_H	Households' currency deposits	Billion of rubles
28)	RDEPVP_H	Households' currency deposits deflated by CPI	Billion of rubles
29)	TVP	Average term of households' currency deposits	Days
30)	TVF	Average term of companies' currency deposits	Days
31)	DEPRF_H	Companies' ruble deposits	Billion of rubles
32)	RDEPRF_H	Companies' ruble deposits deflated by CPI	Billion of rubles
33)	DEPVF_H	Companies' currency deposits	Billion of rubles
34)	RCR	Ruble loans to companies deflated by CPI	Million of rubles
35)	CV	Currency loans to companies	Million of rubles
36)	RCT	Total loans to companies deflated by CPI	Million of rubles
37)	IB	Investment in fixed capital from bank loans, current prices, quarterly	Billion of rubles

38)	CPI_C	CPI calculated from national accounts' system, Q1 1995 = 1,000	
39)	CPI	CPI from www.macroforecast.ru, Q4 1999 = 100,0	
40)	DI	Gross fixed capital formation deflator, Q1 1995 = 1,000	
41)	RI	Total investment in fixed capital deflated by gross fixed capital formation deflator, quarterly	Billion of rubles
		Auxiliary variables	
	T	Time trend	
	DXY	Dummy with 1 from Q1 of the year XY and 0 before it	
	DXYZ	Dummy with 1 from QZ of the year XY and 0 before it	
	D95_98	Dummy with 1 from Q1 1995 to Q4 1998, 0 after it	
	DD084	Dummy with 1 in Q4 2008 and 0 in other points	
		Symbols	
	(-k)	Lag of k degree	
	LN	Natural logarithm	
	E(-N)	10 in degree -N	
	X	Multiplication	
	/	Division	

Table A.2
Estimates equations of the model

№	Equation	R^2	DW	F
1.	K = 0,928K(-1) + 3,761I(-1) + 1191,0 – (0,036)** (1,222)** (397,5)** - 1990,2D073 (756,8)*	0,998	1,680	12730,3
2.	L = 0,742L(-1) -0,227L(-2) + 0,725N – 0,0269RI(-1) + 0,0156RI(-2) (0,122)** (0,113)* (0,104)** (0,0068)** (0,0068)* – 10,031SW(-1) - 14,9 (2,578)** (5,297)**	0,959	1,915	169,6
3.	LN(Q/L) = 0,2088LN(K/L) + 0,0157PEXP + (0,049)** (0,0029)** + 0,575LN(Q/L)(-1) – 0,436LN(Q/L)(-2) + (0,086)** (0,075)** + 0,555LN(Q/L)(-4) – 0,524LN(Q/L)(-5) + (0,071)** (0,087)** + 0,060D95_98 – 0,080D08 + 0,197 (0,012)** (0,013)** (0,087)*	0,992	2,242	649,6
4.	P = 0,002795C(-1) – 0,001673C(-2) + (0,000249)** (0,000279)** +0,000727(M – M(-1)) + 0,001955I(-2) + (8,07E-05)** (0,000175)** +0,223PEXP + 0,103PEXP(-1) + 0,00043(PTAX + (0,031)** (0,028)** (0,000134)** + INTAX) + 0,155T – 0,578D064 + 0,704 (0,0107)**(0,145)** (0,081)**	0,999	1,841	8862,9
5.	PQ = P x Q			
6.	MRK = 0,2088(4PQ)/K			
7.	MRL = 0,7912(PQ)/L			
8.	W = 0,2077MRL + 0,349W(-1) + 0,348W(-2) + (0,020)** (0,096)** (0,087)** +0,0057 (0,029)	0,999	1,964	12210,5
9.	WL = W x L			
10.	SW = WL/PQ			
11.	C = 0,125C(-2) + 0,344C(-4) + 0,205PQ + (0,033)** (0,035)** (0,014)** +0,090PQ(-1) + 34,25 (0,015)** (11,97)**	0,999	1,699	13154,3
12.	ROK = PQ – WL - INTAX			
13.	NROK = ROK - PTAX			

14.	IA = 0,360IA(-2) + 0,627IA(-4) + 0,392(MRK x NROK) + (0,099)** (0,075)** (0,079)** +0,705(MRK x NROK)(-1) -0,859(MRK x NROK)(-2) – 2,4 (0,134)** (0,198)** (0,46)	0,988	1,494	861,4
15.	NNROK = NROK - IA			
16.	IROK = 0,937(MRK x ROK) +0,365IROK(-2) – 0,421IROK(-3) + (0,054)** (0,078)** (0,035)** + 0,730IROK(-4) – 0,480IROK(-6) + 61,4D07 + 14,1 (0,042)** (0,110)** (12,0)** (3,55)**	0,994	1,890	1324,1
17.	IG = 0,0397(PQ – G) - 0,133IG(-2) – 0,320IG(-3) + 0,795IG(-4) – (0,002)** (0,029)** (0,031)** (0,035)** - 0,158IG(-5) +75,8D07 + 3,2 (0,033)** (10,4)** (3,7)	0,994	2,058	1318,2
18.	RDEPRP_H = (1,05 - 0,681D084)RDEPRP_H(-1) + (0,011)** (0,064)** + 0,282D084PQ/CPI + 0,1 (0,030)** (0,099)	0,996	0,992 2,196	1,846 1631,6 1859,0
19.	RDEPVP_H = (0,950 – 0,408D083)RDEPVP_H(-1) + (0,033)** (0,053)** + 58,15D083(BASCUR/CPI)(-1) – 0,126D083PQ/CPI + 0,162 (3,67)** (0,010)** (0,076)*	0,989	1,897	850,9
20.	TVP = 0,973TVP(-1) + 4,025BASCUR – 0,014D083DEPVP_H – (0,012)** (0,746)** (0,003)** - 101,3 (21,0)**	0,996	2,139	3414,2
21.	RDEPRF_H = (1,119 – 0,783D081)RDEPRF_H(-1) + (0,030)** (0,053)** + 0,169D084PQ/CPI + 2,53DD084 + 0,02 (0,011)** (0,312)** (0,06)	0,994	1,873	1615,0
22.	DEPVF_H = 0,570DEPVF_H(-1) + 70,34D07BASCUR – (0,049)** (9,43)** - 1566,4D07 + 97,4 (264,1)** (17,0)**	0,990	2,174	1288,4
23.	TVF = (0,599 – 0,509D07)TVF(-1) + (8,25 – 18,88D07)BASCUR + (0,126)** (0,147)** (3,32)* (4,53)** + 1238D07 – 86,0 (146,6)** (88,9)	0.978	2,243	322,6
24.	RCR = (0,864 – 0,485D082)RCR(-1) + 0,308*1000*RDEPRP_H + (0,054)** (0,129)** (0,075)** + 15141,2D082 – 59,6 (3779,4)** (125,4)	0,999	2,041	7418,8
25.	CV = 0,593D074CV(-1) – 0,900D074CV(-2) + (0,107)** (0,094)** + 0,492*1000DEPRF_H + (0,036)** + (0,278 + 0,326D074)*1000DEPVF_H + 0,780*1000DEPVP_H + (0,053)** (0,133)* (0,118)** + 1697,8D074TVF + (524,0)** + 831,4TVP – 1351366D074 – 108482,2 (184,6)** (542886)* (26863)**	0,999	2,170	5261,2
26.	RCT = RCR + CV/CPI			
27.	IB = 0,125(MRK)(RCT)(CPI)/1000 + 0,909IB(-4) – 233,6D091 – (0,016)** (0,070)** (13,8)** - 1,2 (3,9)	0,988	1,953	1040,7
28.	CPI_C = 1,465CPI_C(-1) – 0,621CPI_C(-2) + (0,107)** (0,113)** + 0,000197I(-1) – 0,001395Q(-2) + 0,043T +	0,999	2,170	8740,7

	(6,30E-05)** (0,000542)* (0,0137)** + 0,806 (0,196)**			
29.	CPI = 18,066CPI_C – 0,336 (0,080)** (0,786)	0,999	1,415	50785,1
30.	DI = 0,606DI(-1) + 0,790DI(-4) – 0,705DI(-5) + (0,072)** (0,048)** (0,089)** + 0,137DI(-8) + 0,000143M + 0,182PEXP(-1) – (0,057)* (2,23E-05)** (0,038)** - 0,456D05 + 0,734 (0,123)** (0,137)**	0,999	1,546	6244,9
31.	I = 1,012(IA + IROK + IG + IB)			
32.	RI = I/DI			

Comments. Here in the table R^2 is determination coefficient, DW – Durbin – Watson coefficient, F – Fischer's statistics, the standard errors of parameters are given in parentheses. One asterisk means that parameter is significant at 95 % level; two asterisks that it is significant at 99 % level.