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The spatial structure of the Russian economy and the multipolar world

The wiiw Balkan Observatory

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This study has been developed in the framework of research networks initiated and monitored by wiiw under the premises of the GDN–SEE partnership.

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The spatial structure of Russian economy and multipolar world[1]

Abstract. There have been several poles of development: USA, Europe, and China are formatted in the world economy. How does the multipolar world economy influence the Russian region's development? How does the spatial structure of Russian economy develop under the multipolar world economy?

The studies based on the main results of new economic geography and gravity theory concerning the spatial concentration of production, the core and periphery formation in the economy of countries and large regions. We propose the econometric model for the study and test of the spatial concentration factors in the Russian economy.

We have researched the basic macro parameters of Russian regions' development: output, employment, investment, and population income. Main attention has been focused on the influence of multipolar structure of world economy on the Russian economy. One more significant factor in the research has become the consequences of the world financial crises.

Results of estimation give proof to significant influence of world economic poles on spatial development of Russian economy. Small changes in the world economy can cause significant shock in economy of the Russian regions: industrial production, investment, and income. The eastern and western parts of the Russian Federation have different poles of gravity. They have different reaction to the changes in world economy poles. The economy of the European regions of the country is more influenced by economy of the European Union. Pressure of the Chinese and American economy on the eastern and western regions of Russia is similar according to the direction, but differs according to the strength of influence. Nevertheless, economy of China and economy of the USA more positively influence the economy of regions of the Russian Federation.

Influence of geographical position of regions is proved by gravitational variables. The hypothesis about influence of expectations concerning development of the global economy poles on macro parameters of Russian regions has found evidence. In particularly, the hypothesis concerning negative expectations connecting with the economy of the European Union and the USA has confirmed. The world financial crisis has significantly affected the Russian economy.

Key words: multipolarity; investment; expectations; crises; agglomeration theory.

Introduction. Nowadays there are some geopolitical and economical scenarios of the world organization: unipolarity, bipolarity, and multipolarity. Military, historical, geopolitical and economical aspects of multipolarity are considered. Concepts of "pole", "centre of force", "multipolar world" are frequently used in the studies of the world spatial structure.

A lot of publications and opinions confirm that the multipolar world structure is forming. For example, in 2009 in Davos during the worldwide economical forum V.V. Putin said that "… the unipolar arrangement of world economy will be changed to the system based on the collaboration of several large centres" (Путин В.В., 2009). S. Dyrka emphasizes that "the unipolar world with the domination of the USA has ended and there is the beginning of the multipolar (supranational and supra state) world" (Дырка С., 2008, p. 32). The researches of globalization processes focus on the establishment "of centres of influence connecting with the internationally organized financial capital"; their establishment is accompanied by "the good, capital and services movement over the

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whole planet" (Абылгазиев И.И., Ильин И.В. 2009, p. 47). Discussing the questions of the number of world poles, A.N. Chumakov considers that the unipolar world is delusion: "…on the background of the global financial and economical crisis it is more and more clear that it is impossible to govern the world global system even in one economical sphere from the one centre. The world community, presented by national states, is the multipolar system."(Cite for: Абылгазиев И.И., Ильин И.В. 2009, p. 54).

There are more and more calls to the understanding of the unity of native, social, economical, technological and other connections in the whole world. Formation of multipolar world establishes the need to take into account "the direct pressure of local competitors, and also the indirect pressure of external rivals" (Дырка С., p. 33). Analyzing the quality characteristics of globalization processes, A.B. Veber remarks: "there are some elements of net global management in such areas as the maintenance of peace and safety, world finance, world trade…. As the whole it is characterized by fragmentariness, multiplicity of decision-making and influence centres, the extremely unbalanced distribution of power and resources …" (Cite for: Абылгазиев И.И., Ильин И.В.2009, p. 48).

The question about the economic multipolarity is also controversially interpreted. For example, S. Dyrka names the "absence of the world economic leader" as one of the basic modern social-economical processes and simultaneously considers that "… the elements of global economy are becoming more and more connected between themselves"(ДыркаС., p. 32). S. Dyrka said that intellectual potential is the reason of breach of "the geographical links of traditional world economy and classical divisions generated by it". The economically dominated forces are able to create, mobilize and organize the main factor that is the intellectual potential at any place and even in any space (Дырка С., p. 32). K.A. Gezalov thinks that the globalization "transforms the area of organization of public relations and transnational interaction between states, economical and social systems", it leads to the establishment of the new type of competition …, it cardinally changes the social-economy orders in the world; … it influences… the economic perspectives of every country; it transforms the state's functions…" (Cite for: Абылгазиев И.И., Ильин И.В.2009, p. 52). V.E. Melnichenko and V.V. Snakin emphasises that "The globalization is shown in the destruction of local connections and switching to the connections of the other hierarchical level" (Cite for: Абылгазиев И.И., Ильин И.В.2009, p. 58). Within the factors leading the world community to the new state, V.Kaliuzhniy specifies the economical, political and military state powers, globalization and unification of world economy that are accompanied by the weakness of the national state sovereignty; the establishment of the transnational corporations and net structures on the political stage"(КалюжныйВ., 2009, p,75).

The unipolarity of the world is connected to the economical, political and military power of the USA. But there is an opinion that the world domination does not create the strong economical and political structure and it will be possible just to have "the transitional condition of global policy, dividing two different geopolitical ages" (Калюжный В., 2009, p,75 – 76).The world with the necessity returns to the traditional system of 'balances of powers' and multipolar structure.

Such scientists as S. Cohen, R. Klein, A. Bogdanov and others, and leaders of several states (including the Russian Federation) proves that the guaranteeing of structurally sustainable world system can be mostly achieved only by its multipolarity and balance.

The main arguments are the following: (Калюжный В., 2009, p,75 – 76).

– polycentric configuration of the world order model is able to guarantee the global sustainability and stability due to the geopolitical regions, within which there are the global centres of power and the low level of entropy, that are able to establish the equilibrium and balanced development of the whole geopolitical system;

– the power centres represented by the huge nations have the significant volume of potential energy, being in the state of global collaboration, and expand their influence beyond their borders.

V. Kaliuzhnyiy marks out the following concurrent economic zones of internal economic integration: North American Free Trade Agreement (NAFTA), the zone of "the big Chinese economy», the European Union, the Russian Federation with the zone of the CIS, Japan and the group of countries from the Association of South-East Asian Nations (ASEAN), the trading block of South America (MERCOSUR) (Калюжный В., 2009, p. 78). The author points out that both economical and other factors including ethno cultural ones, participate in the formation of multipolar world. During the last ten years "the multipolarity is becoming a reality of modern world system". (Калюжный В., 2009, p. 78). The consolidation of European countries is intensifying; some states are becoming stronger, including China, India, and Brazil.

Analysing the configuration of the future multipolar world, T.R. Gareev, Yu.M. Zverev and A.P. Klemeshev marks out the following centres: 1) Northern America (USA); 2) the European Union; 3) East Asia where the main role will be played by China. (Гареев Т.Р., Зверев Ю.М., Клемешев А.П., 2004).China is considered as the one of the new world leaders (Дырка С., 2008, p. 33). A.B. Veber remarks that "The result of globalization is the economical antagonism between countries that is increasing with the desire of developed and developing countries to provide their economical growth and during the struggle for access to the limited natural resources, the gap of levels and quality of life between northern and southern countries, economical increase of China and India (Абылгазиев И.И., Ильин И.В.2009, p. 53).

So there is establishment of the new configuration of the world order and new geopolitical and economical paradigm of development. In the conditions of the transition state there is the straggle between the centres of power for their interests and influence in the world. Therefore for Russia it is important to ensure its own geopolitical and economical interests, and save stable development.

What will Russia meet in the forming multipolar world? The Conception of geopolitical development of country for the period until 2050 says that the Russian geopolitical interests include the strengthening of continentalism as the world order system with formation of the multipolar world. The strategy of national security of the Russian Federation until 2020 directly says about the transformation of Russia into the world nation, the activity of which will be aimed at the provision of strategic stability and mutually beneficial partner relationships under conditions of the multipolar world (Стратегия, 2009).

We are interested in the issues of economic development of Russia, and taking into account the large territory of country we are interested in the issues of economic development of Russian regions in the conditions of the multipolar world.

The rating of the world countries based on GDP and prepared by the World Bank is interesting in order to determine the centres of the world economy. The part of this rating is presented in Table 1. Another table (Table 2) provides the results of comparison of countries' GDP by parity of purchasing capacity prepared by the Russian Statistics Committee.

In the given research with the help of economical model there was the estimation of the influence of multipolar world economy on the formation of spatial structure of Russian economy, location of production, investment and employment. Theoretical base for researches was the concept of spatial concentration, the new economic geography and formation of the core-periphery structures, and gravity theory of the economy location.

Theoretical researches of the spatial concentration and formation, the core-periphery structures in macro regions economy, for example, in Europe or certain countries, may be found in works written by P. Krugman, R. Baldwin, R. Forslid, M. Fujita, G. Ottaviano. J-F.Thisse, and other researchers in the field of new economic geography (Krugman P. 1991b, R.E. Baldwin, R. Forslid, et al, 2003, Fujita M. Thisse J-F., 2002).

Table 1 – The rating of countries and territories according to the amount of GDP in 2011, (Source of data: The World Bank, 2012)

Place in the world	Economy	GDP ($ mln.)
	The whole world	69971,51
9	**Russia**	**1857,77**
	The leaders of world economy:	
1	**The USA**	15094,0
2	**China**	7298,097
3	**Japan**	5867,154
	EU (total indicator)	19333,21
	Including:	
4	Germany	3570,556
5	France	2773,032
7	Great Britain	2431,589
	Other countries:	
6	Brazil	2476,652
10	India	1847,982
15	South Korea	1116,247

Table 2 – The main results of international comparison of GDP in 2005 г., (Source of data: Россия и страны, 2010)

	GDP according to PPC, milliard dollars of the USA
Russia	1697,5
EU 27	13018,5
USA	12376,1
Japan	3870,3
China	NA
Germany	2514,8

The New Economic Geography (NEG) as the theoretical conception researches the following problems: Why there is the establishment of heterogeneous economical spatial structure? Why do the regions equally endowed by natural and labour recourses develop differently? Why there is the establishment of industrial centres and agrarian periphery? As an explanation NEG uses not only the mobility of goods, but also the production factors mobility, allowing the monopolistic competition, non-zero trade costs, the increasing return to scale and external economies arising during the process of spatial concentration.

Considering the core-periphery models by Krugman P. (1991a, 1991b), Baldwin R., Forslid R., Martin P. Ottaviano G., Robert-Nicound F. (2003), Matsuyama K. (1991), Fujita M., Krugman P. Venables A. (2001) A.V. Sidorov (2011) the authors prove that the processes of the spatial mobility of resources and production may have the character of the sustainable tendency or suddenly change direction. Initial condition in both cases may be an external push that removes the economy from its primary position. The works listed above have demonstrated that if equilibrium is stable then the economy returns to initial position to the equal spatial distribution, but if economy is in unstable equilibrium then the spatial structure will be changed, and the economy will removes to the other equilibrium.The presence of several equilibrium both stable and unstable is the characteristic feature of NEG models. The equal spatial distribution of production as well as the core-periphery outcome

with spatial concentration of production are both possible. P.Krugman and A. Venables have theoretically researched the issues of globalization and position of certain states in the NEG framework. The given result of NEG allows to formulate and to teste the hypothesis that the spatial structure of the world economy is the external factor for Russia. The changes in the spatial structure of world economy influence the modern spatial structure of the Russian economy.

The works made by the author earlier have proved the presence of the stable tendencies of spatial concentration of production and investment in the Russian Federation during the period of reforms (Лапо В.Ф., 2012). The processes of spatial concentration are also continuing in the post-reform period. The calculation of the indexes of the spatial concentration of population and employment evaluated with the Herfindal-Hirshman index according to the mid-annual regional data is shown on Fig. 1.

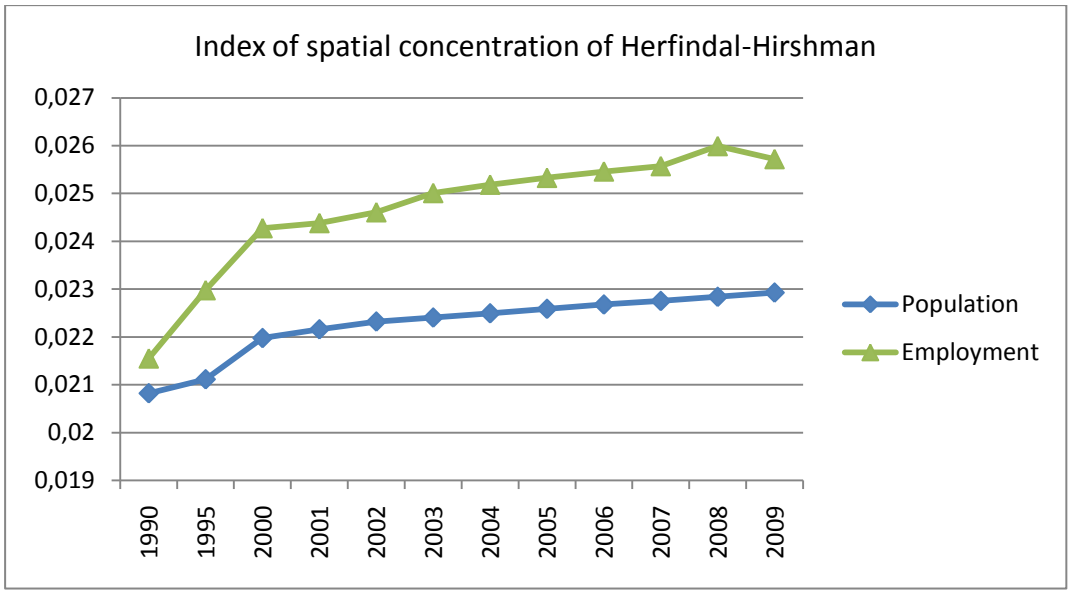

Figure1 –Dynamics of spatial concentration of population and employment in the Russian Federation. (Calculated according to the data of the Russian Statistics Committee (Регионы, 1996 – 2010)

The main distinction of Russia from the other countries is the large spatial length of territory. The significant structural changes of the Russian economy during the period of reforms are accompanied by the processes of spatial concentration of production in the certain regions. There is the gradual formation of multilevel core-periphery economic structure in Russia (Fig 2). The first level corresponds to the state economy; the second level corresponds to the economy of Russian regions that also have the core-periphery structure. The similar processes take place, for example, in Krasnoyarsk Territory. If, from the one hand, Krasnoyarsk Territory is the periphery region in the structure of Russian economy, so it has internal core-periphery structure. Krasnoyarsk city and Krasnoyarsk agglomeration forming around it are creating the core of territory development that attracts all regional recourses, and first of all the labour recourses. Other parts of the territory can be considered as the region periphery (Bukharova E.B., Vorontsova I.P., Lapo V.F., 2011).

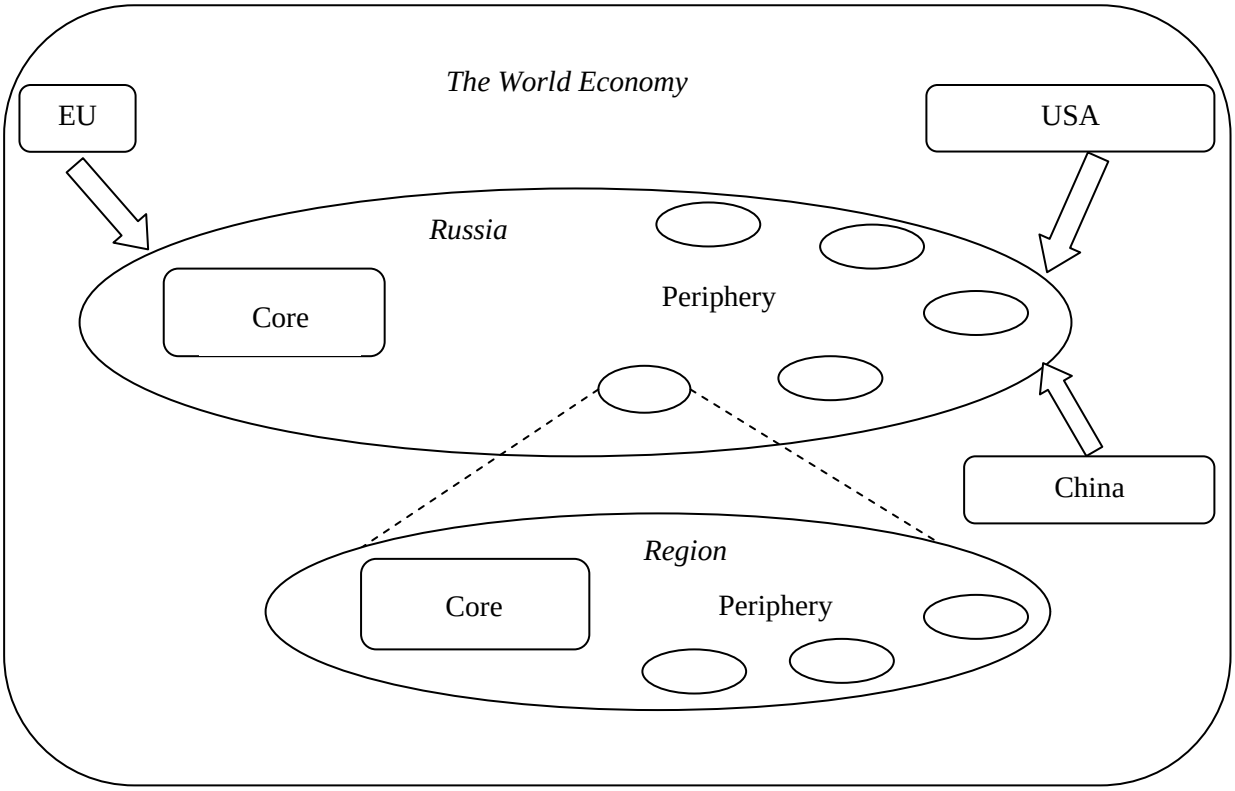

Figure 2 – Multilevel core-periphery spatial structure of economy

However, there is the level of spatial concentration of production corresponding to world economy and external to the Russian economy. In the world economy there is the formation of centres concentrating the main part of the world production, investment, and scientific researches. These centres of world economy are the poles of attraction of labour resources and investment. They can be considered as the cores of the world economy. There are several such centres, poles or cores. The universally recognized centres are the USA, European countries and Japan. During the last ten years China begins to play the leading role on the global arena (see Table 1). At the same time China is the nearest eastern neighbor of Russia, and significantly influences the Russian economy along with the traditional world leaders. The increasing impact of foreign countries on the Russian economy is confirmed by the dynamics of the foreign countries' investment (see Tables 3 – 4). For example, the table data shows that investment from China to Russia are several times bigger than investment from Japan. Import from China to Russia is in 3.2 times more than import from Japan. Export from Russia to China is in 2.4 times exceeds the export to Japan.

Despite of some general tendencies, the economies of western and east regions of Russia is developing unequally (Fig. 3 – 4).There are many reasons, but we want to emphasize the influence of the world economy poles. Probably, this influence is not equal on the west and east parts of Russia. We can propose that the European centre of the world economy have more impact on the development of the European part of the Russian Federation. And, for example, China has stronger influence on the development of the eastern parts of Russia.

The processes of spatial concentration in the Russian economy are determined by the spatial concentration of capital and investment (Лапо, 2011).This specific treatment differs the processes of the Russian geographical concentration from the processes of the spatial economical structuring in other world regions. We propose that Russian economy, having large and complex spatial structure, in its turn, is influenced by the spatially unequal world economy. The centres of world economy are

those external factors that affect and determine the spatial shift in the spatial structure of the Russian economy. Similar analysis of the spatial structure of the Russian economy varying under the influence of multipolar world economy has not been conducted within the framework of new economic geography.

Table 3 – Investment of foreign countries into the Russia economy, $ mln. (Source of data: Россия и страны, 2010)

	2000	2002	2004	2005	2006	2007	2008	2009
1	2	3	4	5	6	7	8	9
Total	9944	17621	32094	47477	42064	96125	69987	63192
Europe								
the Netherlands	1130	962	4997	8600	6286	17519	10682	10574
Luxemburg	195	1154	5277	13779	5783	10740	5957	10143
Great Britain	465	2141	6864	8031	6602	25014	13291	5295
Cyprus	1221	1902	2790	3244	5419	12193	10984	4170
Germany	1330	3688	1398	2704	2754	2848	6073	4042
Switzerland	773	1299	1430	1889	1720	5105	2657	2834
France	716	1124	2292	1250	2874	6343	4030	2151
Belarus	0,4	25	281	419	561	813	1974	1468
America								
USA	1508	1067	1644	969	1030	1737	1262	1289
Asia								
China	15	62	60	115	354	229	361	9606
Japan	116	441	151	160	679	457	772	2817

Table 4 – Foreign direct investment of foreign countries into the Russian economy, $ mln.(Source of data: Россия и страны, 2010)

	2000	2002	2004	2005	2006	2007	2008	2009
1	2	3	4	5	6	7	8	9
Total	3694	2455	5648	9731	7445	18783	11160	6880
Europe								
Germany	209	158	192	321	346	767	1614	813
Cyprus	545	275	352	233	718	2031	2370	1201
the Netherlands	511	302	3441	6954	3768	12831	2795	1130
France	70	19	131	335	183	462	448	447
Asia								
India	0,0	1	2	1,0	346	219	312	396
China	2	9	2	3	98	172	90	203
Japan	107	260	52	49	75	63	21	142
America								
USA	1162	546	294	230	283	184	169	162

The economical problems of the USA and Europe economy and the presence of new global leaders could be the external push for the Russian economy and affect not only the macro parameters but also the spatial location of the economy. The Russian crises in 1998 and the world financial crises in 2008 could increase or change the tendency of spatial concentration.

The following problem has been determined: to reveal the modern tendencies in the formation of spatial structure of the Russian economy, to research the influence of centres of world economy on the processes of spatial development, to find the significant changes in the spatial structure of the Russian economy connected with the crises processes.

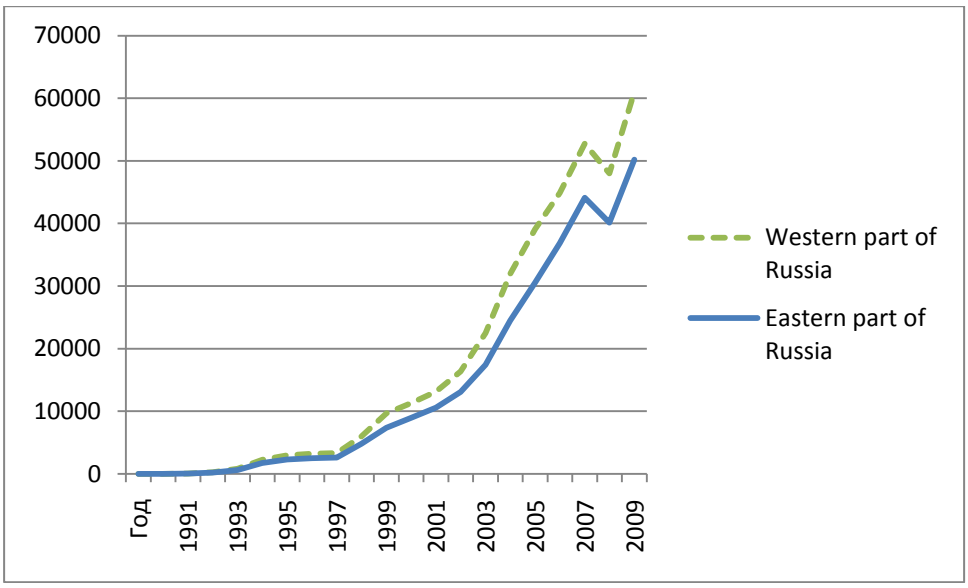

Figure 3 – Dynamics of the production output in the Eastern and Western parts of the Russian Federation (in times, calculated in nominal prices taking into account the denomination of 1997.Source of data: Регионы 1996 – 2010)

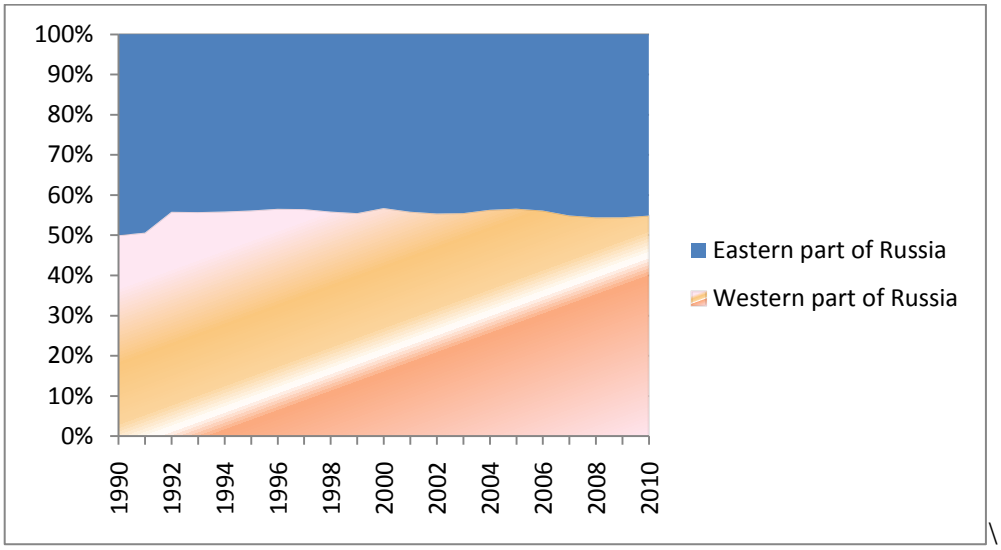

Figure4 – Change of the industrial output unit weight in the Eastern and Western parts of the Russian Federation in the whole country production. Calculated by data: Регионы 1996 – 2010)

In one of the works on the simple core-periphery model, P. Krugman (1991c) has shown a role of expectations in changing of a path of spatial concentration. However the empirical testing of the expectations impact on the spatial economic structure had not been conducted not during the researches of the Russian economy, not in the foreign one. The researches of the expectation impact on the spatial structure of the Russian economy by econometric models are presented in the works of V.F. Lapo (2004, 2005, 2010, 2012). The research of the expectations impact on the processes of geographical concentration in Russia connected with the development of the poles of world economy was not conducted.

Most part of empirical studies of spatial concentration is dedicated to the proving of existence scale economies, increasing return and agglomeration effects. Dumais G., Ellison G., Glaeser E.

(2002), Kim (1995) have conducted studies relating to the USA. Using the data about wage, G.H. Hanson (1997, 1998) has studied the increasing return and agglomeration in Mexico. G.H. Hanson has used the elements of gravity theory as the base for research. The USA was considered as the centre of attraction. However Mexico is not the representative object of studies because there is absent the second world centre of economy attraction. And the territorial scale of Mexico is not comparable with territory of the Russian Federation.

The researches relating to the European Union can be found in the works of (Bruelhart M., Trionfetti F., 1999); Bruelhart M. (2001); Davis D.R., Weinstain (1999), etc. More than 70 countries are covered by studies of Antweiler W., Treer D. (2002). Most part of the given studies has used the data of international trade, added value or industrial employment. The studies experience of the European economy also cannot be considered as the direct analogue because the united Europe is an example of the large economy that itself is the gravity centre.

The alternative approach to the study of the spatial structure of economy is the spatial econometrics that is becoming more popular nowadays (Anselin, L.1988,Anselin L., Center B. 1999, LeSage James, Pace R. Kelley 2009).Using the Moran's criterion in the models of spatial econometrics the number of researchers have conducted analysis of spatial convergence of the Russian regions ((Зверев Д.В., Коломак Е.А. 2010, Коломак Е.А. 2010, Луговой О. et al. 2007). The models of spatial econometrics allow imitating the joint development of country regions, but do not give the priority under the including of external subjects into the model.

The influence of multipolar world on spatial concentration in Russia is practically not considered in econometric models as well as the impact of expectations about the development the multipolar world economy and its impact on spatial location of economy in the Russian Federation. It is interesting to estimate impact of crises on the tendencies of spatial concentration. Therefore, the work presents the econometric model for the research of the multipolar world economy influence on the development of the Russian regions. The model includes the investor expectations determined by the development of multipolar world, influence of the crisis in 1998 and the world financial crisis in 2008 – 2009.

Methodology of research

The world leading countries affect on the whole world economy, including the economy of the Russian regions. This impact spread in several directions: by the geographical location and by the formation of stream of the goods, capitals, employment and investment.

In our research we mark out three poles of world economy: European Union countries that border with the Russian Federation in the west, China bordering with eastern regions of the Russian Federation, and the USA. The Russian Chukchi Peninsula and American Alaska are separated only by the Bering Strait. But the economy of the USA being the world financial centre, largest consumer and producer of material and spiritual values, affects the whole world economy. The USA currency plays the leading role in the world economy. Therefore, the economy of Russia depends not only on the world oil prices, but on the course of dollar, in which these prices are nominated. In addition, during the last years the USA economy has become one of the poles of instability of global economy.

We propose that economic processes in the poles of world economy differently determine the development of the Russian regions.

We will introduce the designations.

Indexes: i is an index of region, $i = 1, 2, \ldots, n$; t is an index of year, $t = 1, 2, \ldots, T$.

Simultaneously dependent variables that describe the dynamics of regional development:

$\ln y_{it}$ is a logarithm of industrial output of the Russian regions;

$\ln I_{it}$ is a logarithm of investment into economy of the Russian regions;

$\ln E_{it}$ is a logarithm of mid-annual employment in economy of the Russian regions;

lnW_{it} is per capita monetary income of population in the Russian regions.

Explanatory variables. We suppose that both the expected and the actual indexes of the poles of world economy will have the significant impact. Producers and investors in the Russian regions can be guided by the expected parameters of the world economic development. The influence of the contemporary variables can be considered as an adaptation of expectation to the modern conditions.

Therefore, the expected variables of the development of world economy poles have been included in the model together with the contemporary variables. The group of the expected external variables is marked as $\left(\boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext-exp}}\right)$:

ln $gdpc_{t+1}$ is a logarithm of expected level of GDP in China in year t+1;

ln $gdpu_{t+1}$ is a logarithm of expected level of GDP in the USA in year t+1.

The European Union in this research is presented by Germany as one of the most developed countries in the union:

ln $gdpg_{t+1}$ is a logarithm of expected level of GDP in Germany in year t+1.

We assume the expectations to be rational.

The group of **observable** in year t **external variables**$(\boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}})$includes the following:

ln $gdpc_t$is a logarithm of GDP in China in year t;

ln $gdpg_t$ is a logarithm of GDP in Germany in year t;

ln $gdpu_t$ is a logarithm of GDP in the USA in year t.

Other observable external variables are the following:

dol_t is mid-annual exchange ratio of dollar to rouble;

oil_t is mid-annual price of oil.

Next group of variables is the **internal variables**, characterizing geographical position of the Russian regions $\left(\boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}}\right)$and variables taking into account the crises periods. We have estimated the differences of geographical position of the Russian regions relatively to external bounds using the gravity variables:

ln *distance-*w_{it} is a logarithm of distance from the center of region up to the western border of Russia multiplied by transport tariff;

ln *distance-*o_{it} is a logarithm of distance from the center of region up to the east border of Russia multiplied by transport tariff;

*reg*1, *reg*2, …, *reg*7 are dummy variables for the federal districts of the Russian Federations that have allowed to separate the impact of external variables on the eastern and western regions of country. The west group of regions includes the regions in the federal districts: Central, Povolzhskiy, Northwest, Southern, North-Caucasian. The other districts: Siberian, Far East and Ural - form the group of eastern regions.

The dummy variable $d8d9_t$ is included in order to take into account the influence of the world financial crisis in 2008 – 2009, and variable $d1998_t$ is included in order to take into account the Russian crisis in 1998.

The next group of variables is the **controlled variables**$(\boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}})$ modeling the dynamics of regional macro indicators;

oildob is an oil and gas extraction. Endowment by the natural recourses is the evident factor for location of extracting industries and investment;

$kmigr_{it}$ is the rate of migration of population. The indicator includes both types of regional migration: between regions and from the abroad.

kep_{it} is a birth rate;

ln $peop_{it}$ is a logarithm of mid-annual population;

$citizen_{it}$ is the relative density of urban population. This variable takes into account the urbanization level in regions;

ln $retail_{it}$ is per capita turn of retail trade.

studdoly is the share of students in population. The variables of population and students share characterise the quality of the regional labor resources.

The following hypotheses have been tested by the model:

1. The poles of the world economic development significantly impact on the territorial structure of the Russian economy.

2. The western and eastern parts of the Russian Federation have the different poles of gravity: 1) the economy of the European Union countries can serve as the gravity pole for economy of the regions from the European part of Russia; 2) the rapidly growing economy of China can be the gravity pole for economy of Ural, Siberia and Far East, and gives the powerful push to their further development; 3) the economy of the USA can be the gravity pole for the regions both from the European, and the Asian parts of Russia.

If the hypotheses is true then the correlation between the regional production, employment, investment, per capita monetary income and indicators of the maltipolar world economy should be significant.

3. The expectations concerning the development of the centres of world economy significantly influence the macro indicators of the Russian regions.

4. The world financial crisis has made great impact on the economy of the Russian regions.

Both external and internal variables, calculated in their national units participate in the study. The using of industrial prices indexes to the aggregated indicators including in the model creates some difficulties. But correction with the help of price indexes during the relatively long period can lead to huge distortions. Therefore the model included the variable of the mid-annual exchange ratio of dollar to rouble that should take into the account the dynamics of inflation in Russia and takes the inflation trend. Besides, as the correlation analysis shows, the exchange ratio of dollar to rouble in dynamics rather strongly correlates with the industrial price indexes (see Table 5).

Table 5 – Coefficients of the price indexes correlation in the Russian Federation with the exchange ratio of dollar (according to the data from 1991 to 2010). (Calculated by: Российский, 1996 – 2010).

Price index	Exchange ratio of dollar
Industrial Producer Price Index	0,736854317
Consumer Price Index	0,644895882
Agricultural Producer Price Index	0,66139908
Building Price Index	0,735611084
Transport Tariff Price Index	0,78101543

The basic variant of model has the following form:

$$\ln y_{it} = \alpha_0 + \alpha_1 \ln y_{it-1} + \alpha_2 \ln I_{it} + \alpha_4 \ln E_{it} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext-exp}} \alpha_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}} \alpha_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}} \alpha_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}} \alpha_{\boldsymbol{cont}} + \alpha_6 d8d9_t + \alpha_7 d1998_t + \mu_{yi} + \varepsilon_{it};$$

$$\ln E_{it} = \beta_0 + \beta_1 \ln E_{it-1} + \beta_3 \ln I_{it-1} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext-exp}} \beta_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}} \beta_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}} \beta_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}} \beta_{\boldsymbol{cont}} + \beta_6 d8d9_t + \beta_7 d1998_t + \mu_{Ei} + w_{it}; \quad (1)$$

$$\ln I_{it} = \delta_0 + \delta_3 \ln I_{it-1} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext-exp}} \delta_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}} \delta_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}} \delta_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}} \delta_{\boldsymbol{cont}} + \delta_6 d8d9_t + \delta_7 d1998_t + \mu_{Ii} + \nu_{it};$$

$$\ln W_{it} = \gamma_0 + \gamma_1 \ln y_{it} + \gamma_2 \ln I_{it} + \gamma_3 \ln I_{it-1} + \gamma_4 \ln E_{it} + \gamma_5 \ln W_{it-1} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext-exp}} \gamma_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}} \gamma_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}} \gamma_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}} \gamma_{\boldsymbol{cont}} + \gamma_6 d8d9_t + \gamma_7 d1998_t + \mu_{Wi} + \psi_{it},$$

$$i = 1, 2, \ldots, n, \; t = 1, 2, \ldots T\text{-}1,$$

where:

$$\alpha_0, \alpha_1, \alpha_2, \alpha_4, \alpha_6, \alpha_7, \beta_0, \beta_1, \beta_3, \beta_6, \beta_7, \delta_0, \delta_3, \delta_6, \delta_7, \gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6, \gamma_7$$

are the unknown parameters;

$$\alpha_{\boldsymbol{ext-exp}}, \alpha_{\boldsymbol{ext}}, \alpha_{\boldsymbol{int}}, \alpha_{\boldsymbol{cont}}, \beta_{\boldsymbol{ext-exp}}, \beta_{\boldsymbol{ext}}, \beta_{\boldsymbol{int}}, \beta_{\boldsymbol{cont}}, \delta_{\boldsymbol{ext-exp}}, \delta_{\boldsymbol{ext}}, \delta_{\boldsymbol{int}}, \delta_{\boldsymbol{cont}}, \gamma_{\boldsymbol{ext-exp}}, \gamma_{\boldsymbol{ext}}, \gamma_{\boldsymbol{int}}, \gamma_{\boldsymbol{cont}}$$

are the vectors of the unknown parameters;
$\mu_{yi}, \mu_{Ei}, \mu_{Ii}, \mu_{Wi}$ are the regional specific effects;
ε_{it} , ν_{it}, w_{it}, ψ_{it} are the random disturbances. Distributions of disturbances have the following form:

$$\varepsilon_{it} \sim IID(0,\sigma_\varepsilon^2); \; \nu_{it} \sim IID(0,\sigma_\nu^2); \; w_{it} \sim IID(0,\sigma_w^2); \; \psi_{it}. \sim IID(0,\sigma_\psi^2).$$

Besides, it is logically to assume that there is the possibility of correlation between disturbances of the simultaneous equations of system:

$$\mathrm{cov}(\varepsilon_{it}, \nu_{it}) = \sigma_{\varepsilon\nu}; \; \mathrm{cov}(\nu_{it}, w_{it}) = \sigma_{\nu w}; \; \mathrm{cov}(\varepsilon_{it}, w_{it}) = \sigma_{\varepsilon w};$$

$$\mathrm{cov}(\varepsilon_{it}, \psi_{it}) = \sigma_{\varepsilon w}; \; \mathrm{cov}(\nu_{it}, \psi_{it}) = \sigma_{\nu w}; \; \mathrm{cov}(\psi_{it}, w_{it}) = \sigma_{\varepsilon w}, \; t = 1,2, \ldots,T;$$

as the disturbances can simultaneously influence the different areas of regional development.

The similar econometric models for the testing of processes of the spatial concentration in Russia under the presence of expectations have been developed by the author and presented in (Лапо, 2004, 2010, 2012), and also in (Lapo V., 2002; Lapo V.F., 2007). Similar models for the analysis of the world economy poles influence on the spatial structure of the Russian economy have not previously been considered.

The expected variables included in the model are not observable values, therefore they are immeasurable. Proposing that the investor's expectations are rational, we can approximate the expected values by the actual data from appropriate years. The observable values for the expected external variables in period $T + 1$ will be the following:

$$\boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext}} = \boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext-exp}} + \boldsymbol{e}_{\boldsymbol{t+1}}^{\boldsymbol{ext}}, \qquad (2)$$

where $\boldsymbol{X}_{\boldsymbol{t+1}}^{\boldsymbol{ext}}$ is the row-vector of observable actual values of external variables in $T + 1$ year;
$\boldsymbol{e}_{\boldsymbol{t+1}}^{\boldsymbol{ext}}$ is a row-vector of prediction errors of external variables. Under rational expectations conditioned by information $\Im_t$ at the moment t the errors of prediction of external variables have the

conditional mean equal to 0:

$$E(\boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}}|\Im_t) = \mathbf{0},$$

where $\mathbf{0}$ is the zero vector of size K, K is the number of expected external variables in vector $\boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext-exp}}$; and constant dispersion: $\boldsymbol{\sigma}_{ext-k}^2$, where k is the index of expected external variable in vector $\boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext-exp}}$**.** It is logical to propose the existence of prediction errors correlation of different expected variables. Then the correlation matrix of prediction errors at any moment t, $t = 1, 2, \ldots T$, have the form: Σ_{ext}, the size of covariance matrix $\sum_{ext}$ is $K \times K$.

It is necessary to note that the expected values of external variables $\boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext-exp}}$ do not depend on the prediction errors $\boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}}$ at the moment t. The prediction errors of external variables are not correlated with the disturbances of the model equations: ε_{it}, ν_{it}, w_{it}, ψ_{it} at the moment t. Autocorrelation in the prediction errors $\boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}}$ is absent.

Taking into account the equation (2) we will find the expression for approximation of the expected values of external variables:

$$\boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext-exp}} = \boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext}} - \boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}}. \tag{3}$$

Substituting (3) in the system of equations (1) we will get the following system:

$$\ln y_{it} = \alpha_0 + \alpha_1 \ln y_{it-1} + \alpha_2 \ln I_{it} + \alpha_4 \ln E_{it} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext}}\alpha_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}}\alpha_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}}\,\alpha_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}}\alpha_{\boldsymbol{cont}} + \alpha_6\, d8d9_t + \alpha_7\, d1998_t + \mu_{yi} + \varepsilon_{it}^*;$$

$$\ln E_{it} = \beta_0 + \beta_1 \ln E_{it-1} + \beta_3 \ln I_{it-1} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext}}\beta_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}}\beta_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}}\,\beta_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}}\beta_{\boldsymbol{cont}} + \beta_6 d8d9_t + \beta_7\, d1998_t + \mu_{Ei} + w_{it}^*;$$

$$\ln I_{it} = \delta_0 + \delta_3 \ln I_{it-1} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext}}\delta_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}}\delta_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}}\,\delta_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}}\delta_{\boldsymbol{cont}} + \delta_6\, d8d9_t + \delta_7\, d1998_t + \mu_{Ii} + \nu_{it}^*;$$

$$\ln W_{it} = \gamma_0 + \gamma_1 \ln y_{it} + \gamma_2 \ln I_{it} + \gamma_3 \ln I_{it-1} + \gamma_4 \ln E_{it} + \gamma_5 \ln W_{it-1} + \boldsymbol{X}_{\boldsymbol{t+1}}^{\mathbf{ext}}\gamma_{\boldsymbol{ext-exp}} + \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{ext}}\gamma_{\boldsymbol{ext}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{int}}\,\gamma_{\boldsymbol{int}} + \boldsymbol{X}_{\boldsymbol{it}}^{\boldsymbol{cont}}\gamma_{\boldsymbol{cont}} + \gamma_6\, d8d9_t + \gamma_7\, d1998_t + \mu_{Wi} + \psi_{it}^*, \tag{4}$$

where

$$\varepsilon_{it}^* = \varepsilon_{it} - \boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}} \cdot \alpha_{\boldsymbol{ext-exp}} \tag{5}$$

$$w_{it}^* = w_{it} - \boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}} \cdot \beta_{\boldsymbol{ext-exp}} \tag{6}$$

$$\nu_{it}^* = \nu_{it} - \boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}} \cdot \delta_{\boldsymbol{ext-exp}} \tag{7}$$

$$\psi_{it}^* = \psi_{it} - \boldsymbol{e}_{\boldsymbol{t+1}}^{\mathbf{ext}} \cdot \gamma_{\boldsymbol{ext-exp}} \tag{8}$$

Therefore the explanatory variables $\boldsymbol{X_{t+1}^{ext}}$ correlate with the distributions of equations.

Under information known at the moment *t*, the *v*ectors of stochastic variables marked by asterisk: ε_{it}^*, w_{it}^*, ν_{it}^*, ψ_{it}^* have the zero means:

$$E(\varepsilon_{it}^*|\Im_t) = \mathbf{0},$$

and analogically for w_{it}^*, ν_{it}^* and ψ_{it}^*. The covariance of ε_{it}^* has the form:

$$ov\left(\varepsilon_{it}^*\varepsilon_{js}^*|\Im_t\right) = \begin{cases} \sigma_\varepsilon^2 + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\alpha_{\boldsymbol{ext-exp}} = h_\varepsilon, t = s, i = j; \\ \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\alpha_{\boldsymbol{ext-exp}} = h_\alpha, t = s, i \neq j; \\ 0, t \neq s, \forall i \neq j. \end{cases}$$

We get the similar result for w_{it}^*, ν_{it}^*, ψ_{it}^* (see Appendix). Then for the equation disturbances of the dependent variables $\ln y_{it}$, $\ln E_{it}$, $\ln I_{it}$, and $\ln W_{it}$ the covariance matrixes have the block diagonal form:

$$cov(\varepsilon^*|\Im_t) = \left(h_\varepsilon I_n + h_\alpha(J_n - I_n)\right)I_{T-1} = H^\varepsilon;$$

where I_n is the identity matrix of dimension *n*, J_n is the matrix of units with dimension *n*. The $cov(w^*|\Im_t)$, $cov(\nu^*|\Im_t)$, and $cov(\psi^*|\Im_t)$ have similar structure, see Appendix.

The correlation of disturbances of different equations is determined both by the mutual dependence of economic processes and by the correlation of prediction errors, and has the following form:

$$cov\left(\varepsilon_{it}^* w_{js}^*|\Im_t\right) = \begin{cases} \sigma_{\varepsilon w}^2 + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}} = h_{\varepsilon w}, t = s, i = j; \\ \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}} = h_{\alpha\beta}, t = s, i \neq j; \\ 0, t \neq s, \forall i \neq j. \end{cases}$$

The formulas for other pairs of disturbances are presented in Appendix.

Covariance matrix of disturbances of two equations has the block diagonal form, for example, for the dependable variables $\ln y_{it}$ and $\ln E_{it}$:

$$cov(\varepsilon^* w^*|\Im_t) = \left(h_{\varepsilon w} I_n + h_{\alpha\beta}(J_n - I_n)\right) I_{T-1} = H^{\varepsilon w}.$$

The formulas for other pairs of variables are presented in Appendix. These matrixes are symmetric about main diagonal. Therefore the full matrix for all equations is too symmetrical relative to the main diagonal. We will mark through E the vector combining disturbances of the all equations:

$$\mathrm{E} = (\varepsilon^{*\mathrm{T}}, w^{*\mathrm{T}}, \nu^{*\mathrm{T}}, \psi^{*\mathrm{T}})^{\mathrm{T}}.$$

Then the covariance matrix of the system of equations will have the following block diagonal form:

$$cov(\mathrm{E}) = \begin{bmatrix} H^{\varepsilon} & H^{\varepsilon w} & H^{\varepsilon \nu} & H^{\varepsilon \psi} \\ H^{w\varepsilon} & H^{w} & H^{w\nu} & \mathrm{H}^{w\psi} \\ H^{\nu\varepsilon} & H^{\nu w} & H^{\nu} & \mathrm{H}^{w\psi} \\ H^{\psi\varepsilon} & H^{\psi w} & H^{\psi\nu} & \mathrm{H}^{\psi} \end{bmatrix}.$$

Conducting research we pay attention on specific features of the world economy influencing, on multipolar structure of world economy, and on impact of world financial crisis.

Discussion problem of estimation and expected results

Sample for model includes panel data from 1994 to 2010. During the estimation process there are problems with endogenous explanatory variables. The reasons of endogeneity are the following:

1) lagged dependent variables in dynamic panel regression;

2) expected variables;

3) potential endogeneity of industrial output, investment, and others explanatory variables.

As the consequence of endogenous correlations, there is the spatial correlation of disturbances of equations that should be accounted under estimation. Discussion of model estimation problems with expected variables is given in the works of Maddala G.S. (1992). The estimation of models with panel data is given in the works of Baltagi B.H. (2003). Under the rational expectations the expectation errors in the model (1) are correlated with explanatory variables. In addition there is the possibility to have the autocorrelation between values of variables ln$gdpc_{t+1}$, ln$gdpu_{t+1}$, ln$gdpg_{t+1}$ and ln$gdpc_t$, ln$gdpg_t$, ln$gdpu_t$. The model (1) is the system of simultaneous equations with the correlated errors, therefore it is necessary to jointly estimation of equations.

Taking into account that the equations of system are determined as a dynamic panel regression under covariated disturbances, the generalized least squares method for system of equations will not be suitable for estimation (Verbeek, 2000; Baltagi, 2003). The generalized method of the moments (GMM) is more appropriated for estimation; the discussion of GMM can be found in (Baltagi, 2003; Arrelano, Bond, 1991; Blundell, Bond, Windmeijer, 2000).

Sample covers the large number of observational periods *T*. The usage of the full number of the GMM instruments for the large *T* gives very rare matrix of the big size, as a consequence there will be problems of matrix operations calculation. In such situations it is recommended to cut the number of instruments, therefore we used the maximum number of lags equal to 10 to construct the instruments for the lagged dependent variable, and the maximum number of lags equal to 6 to construct the instruments for other explanatory variables.

The usage of first differences eliminates the regional fixed effects, and removes the general economical trend in data.

For the first differences the covariance matrix of disturbances has the following form.

The covariance matrix of the first differences ε_{it}^{*} has the following form:

$$cov\left(\Delta\varepsilon_{it}^{*}\Delta\varepsilon_{js}^{*}|\Im_t\right) = \begin{cases} 2\left(\sigma_{\varepsilon}^{2} + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\alpha_{\boldsymbol{ext-exp}}\right) = 2h_{\varepsilon}, t = s, i = j; \\ -\left(\sigma_{\varepsilon}^{2} + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\alpha_{\boldsymbol{ext-exp}}\right) = -h_{\varepsilon}, s = t-1, i = j; \\ 2\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\alpha_{\boldsymbol{ext-exp}} = 2h_{\alpha}, t = s, i \neq j; \\ -\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\alpha_{\boldsymbol{ext-exp}} = -h_{\alpha}, s = t-1, i \neq j; \\ 0, s \neq t, s \neq t-1, \forall i \neq j\,. \end{cases}$$

We have the similar results for the first differences Δw_{it}^{*}, $\Delta\nu_{it}^{*}$, $\Delta\psi_{it}^{*}$(see Appendix). The correlation of disturbances of different equations in first differences will be equal to the following expression:

$$cov\left(\varepsilon_{it}^{*} w_{js}^{*} | \Im_t\right) = \begin{cases} 2\left(\sigma_{\varepsilon w}^2 + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \beta_{\boldsymbol{ext-exp}}\right) = 2h_{\varepsilon w}, t = s, i = j; \\ -\left(\sigma_{\varepsilon w}^2 + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \beta_{\boldsymbol{ext-exp}}\right) = -h_{\varepsilon w}, s = t-1, i = j; \\ 2\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \beta_{\boldsymbol{ext-exp}} = 2h_{\alpha\beta}, t = s, i \neq j; \\ -\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \beta_{\boldsymbol{ext-exp}} = -h_{\alpha\beta}, s = t-1, i \neq j; \\ 0, \quad s \neq t, s \neq t-1, \forall i \neq j\,. \end{cases}$$

And it is similar for other pairs of disturbances (see Appendix 1).

Information

The analysis has been conducted on the basis of sample covering all regions of Russia, cities Moscow and St.-Petersburg (in total 79 regions). The Chechen Republic has been considered together with Ingushetia. The observation period has covered 1994 – 2010 years. The main source of information is the statistical collections «Regions of Russia» (1994-2011) and the collections including the statistics about foreign countries, published by the Russian Statistics Committee (Россия и страны мира, 2010; Россия и страны – члены Европейского союза, 2009; «Группа восьми»в цифрах, 2009). In the model we have used internal and external variables therefore there have been some problems of comparability of: (1) internal variables (2) external variables and (3) internal and external variables. Any correction of variables leads to disturbance in data. In order to use the real values of variables it is necessary to correct for the inflation both the internal and external data using indexes of the appropriate counties. There is the methodological problem – how to conduct this correction. We can use different methods: a) the inflation rate; b) price indexes: consumer price index, industry price index, transport price index – all of them differ, but are aggregates by themselves; or c) to compare countries on the purchasing-power parity. With the huge amount of sample the indexing errors would accumulate under any method of correction. The corrected data would be poorly comparable. Therefore we have used nominal values of variables in calculations.

The model estimation in the first differences eliminates the trend in data. Additionally the problem of inflation has been solved by inclusion of the control variables: the exchange rate of currency and mid-annual oil price into the model. Variables of price indexes and exchange rate of currency demonstrate strong correlation, see table 5. The variables take up the influence of inflation, guaranteeing the comparability of internal and external data.

Estimation results

Some explanatory variables that have been considered in the preliminary list have not been included into the final variant of model because of the high multicollinearity and instability of the estimation results. For example, it is the variable of the mid-annual population that is strongly correlated with employment values.

There have been attempts to include the dummy variables connected with geography into the in model. But dummy variables for Moscow, St.-Petersburg, and Sverdlovsk were insignificant. Inclusion of the dummy variables for federal districts was also unsuitable, because almost all of they were insignificant. More effective way to take into account the geographical position of regions was the usage of gravity variables determined the distance up to the eastern and western borders of the country. We have defined the distance to borders from the largest city of the region and multiplied it by the transport tariff growth index for corresponding year. Therefore, two variables have been

defined: *distance-w* is the variable of remoteness from the western borders and *distance-o* is the variable of remoteness from the eastern border.

Variables for which there are no data. We have not found data on GRP for the regions of the Russian Federation for 2010. They will be calculated only in 2013; therefore we have not used GRP for the regions of the Russian Federation. There are no data on industrial production of China approximately for the last ten years, therefore we did not use the indicators of industrial production in foreign countries, but there are data of gross domestic product that is also appropriate for the purposes of our research.

Thus, we have estimated four equations of industrial output, employment, investment in fixed capital and mid-annual monetary income of population in the Russian Federation according to the set of explanatory variables. Among explanatory variables there are: gross domestic product of countries, being the gravity poles of the world economy: the USA, China and Germany. (Germany represents the influence of European Union economy). The results of model estimation are presented in Table 6.

Table 6 – Regression equations of macro parameters in the Russian Federation[1)]

Explanatory variable	Dependent variables (in logarithm)			
	Industrial output	Employment	Investment in fixed capital	Mid-annual monetary income of population
	1	2	3	4
LD.ln y	**0,2264602***	**–**	**–**	**–**
LD.lninc	–	–	–	0,3578845*
D1.ln y	–	–	–	0,0390451*
D1.ln I	0,063671*	–	–	0,0228263*
LD.ln I	–	0,0359652*	0,5400632*	–0,0065821
LD.ln E	–	0,5736019*	–	–
D1.ln E	0,2538513*	–	–	0,0676677*
FD.lngdpg12345	–1,240649*	0,3595318*	–10,15337*	–1,040522*
FD.lngdpc12345	1,370768*	–0,8032607*	–0,1763527	0,7381277*
FD.lngdpu12345	–2,292726*	–0,7742179*	13,2379*	–1,868196*
FD.lngdpg678	–0,2104479	–0,0504281	–8,089926*	–1,979363*
FD.lngdpc678	0,9509487**	–0,0883497**	0,0946328	1,742209*
FD.lngdpu678	–4,817955*	–0,7122276*	11,5594*	–0,9454027*
D1.lngdpg12345	–0,6132005***	–1,006594*	–6,777738*	–1,759675*
D1.lngdpc12345	0,9402184*	1,571535*	–5,926747*	4,148657*
D1.lngdpu12345	2,761994*	0,5363002*	14,50514*	0,90949*
D1.lngdpg678	–4,183736*	–1,40448*	–8,168115*	–2,013803*
D1.lngdpc678	2,757506*	1,846365*	–3,832133**	4,317871*
D1.lngdpu678	4,153395*	0,7466206*	13,74282*	1,07215*
D1.dol	0,0132471*	0,0023517*	0,0473188*	0,0082945*
LD.dol	–	–	,0146199*	–
D1.oil	0,0021382*	0,0007696*	0,0288704*	0,0000223
LD.oil	–	–	0,0350616*	–
D1.oildob	0,0085893*	–0,0013396*	–0,003301*	–0,004836*
D1. ln distance-w	–0,0034762*	–0,0035758*	–0,0146138*	–0,0024374**
D1. ln distance-o	0,0026081*	0,00168*	0,0035666*	0,0010982***

Table 6 continued

	1	2	3	4
D1.d8d9	–0,0833673*	0,0222538*	–0,921247*	0,0557701*
D1.d1998	–0,138571*	–0,0226501*	0,0395227***	–0,1676542*
D1.kep	0,0126067*	–0,0097192*	–0,0068179**	–0,0066145*
D1.kmigr	0,0003385*	–0,0000811*	–0,0001323*	–0,0000715*

[1)] Denotes of variables: the symbol *D* means that variable is in the first differences, *L* is lag to one period into the past, *F* is lag to one period into the future for the expected values.

* is the significance is at level 1%, ** the significance is at level 5%, *** the significance is at level 10%

Variables with the index 12345 corresponds to the western group of regions of the Russian Federation, variables with the index 678 corresponds to the eastern group.

We have to note that estimates of parameters of contemporary, past and expected explanatory variables are rather stable to the changes of explanatory variables composition. The received results allow marking out the following regularities.

1. Coefficients of autoregression are significant for all dependent variables: industrial output, employment, investment in fixed capital and mid-annual monetary income of population in the Russian Federation. All coefficients have the positive sign that shows the growth of indicators in the regions and strengthening of territorial concentration of industrial output, employment, and investment. The positive coefficient of autoregression testifies to growth of mid-annual nominal monetary incomes of population. The estimation of the equations in logarithms allows to interpret the coefficients of autoregression as indicators of elasticity of variables.

Coefficient of elasticity of industrial output in the Russian regions is equal to 0.23. Thus, the growth of industrial output by 1% provides the further growth in the next year by 0.23%. It can be concluded that the increase of industrial output in the regions is significantly determined by the strengthening of spatial concentration of output. The growth rate of employment in the regions conditioned by the spatial concentration of employment is the highest and equal to 0.57% to one per cent growth rate of employment in the previous year. The moving investment into the regions is determined by the historical tendencies of growth of spatial concentration by 0.54% to 1% of investment growth in the previous year. The elasticity coefficient of the population income reaches 0.36 per cent to 1 per cent of growth in the previous year.

2. The influence of gravity variables *distance-w* and *distance-o* in the all equations is significant and demonstrates the similar picture.

The coefficients under the variable *distance-w* demonstrating the remoteness from the western borders of the country everywhere have the negative sign and are all significant. The coefficients under the variable *distance-o* (remoteness from the eastern borders) are also all significant and have the positive sign. The received results allow formulating the following conclusion: with the moving away from the western borders of the Russian Federation there is decrease of the growth rates of all regional macro parameters: industrial output, employment, investment in fixed capital, mid-annual monetary income of population. Thus, the extension of distance from the region to the western border by one unity decreases the macro parameters of the region:

–industrial output by 0.0034%;

– employment by 0.0035%;

–investment in fixed capital by 0.0146%;

–mid-annual monetary income of population by 0.1124%.

And on the contrary, the extension of distance from the eastern borders by one unity increases as followed:

–industrial output by 0.0026%;

– employment by 0.0017%;

–investment in fixed capital by 0.0036%;

–mid-annual monetary income of population by 0.0011%.

Of course, the obtained result does not allow to make conclusion about the reasons of such regularities. Evidently the nearness of the European market and concentration of Russian production in the European part of the country have the influence. Nevertheless, the received results give the proof both to gravity and to spatial concentration theories and point out the problem of the eastern regions development.

3. The influence of crisis processes is taken into account by variables *d8d9* for the world financial crisis in 2008 – 2009 and *d1998* for the crisis in 1998. Despite the significance of all parameters estimates, the influence of crises on macro parameters of the regions is not the same.

The world financial crisis in 2008 – 2009 decreases the level of industrial output, and really cuts down the amount of investment in fixed capital. The parameter estimates for the crises years are –0.083 and –0.92 accordingly. The parameter estimates in the equation of employment regression and mid-annual monetary income of population are positive: 0.022 and 0.056 accordingly. In general, they confirm the fact that the economic policy of the Russian government has smoothed the crisis processes and lowered the social and economic tension in the regions.

The negative result of the crisis in 2008 – 2009 has been the sharp decrease of investment in the regions. This result strongly contrasts with the crisis in 1998, when, on the contrary, the investment in fixed capital have grown that has been a push for overcoming the crisis, and in the long term for growth of the economy. The influence of crisis on all other macro parameters of the regions is negative: estimates of parameters have reflected the decrease of industrial output (–0.138) in 1998, employment (–0.023) and sharp decrease in income (–0.168).

4. Demographic and migratory processes. The demographic and migratory factors in equations of regression are presented by variable of birth rate (*kep*) and variable of migratory population increase (*kmigr*). Estimates of parameters of the birth rate and migratory population increase are rather stable and significant in all equations. But influence on macro parameters of regions are differs. As a whole the influence of the indicators of natural population growth is much more than impact of indicators of migration growth.

Both parameters of birth rate and migratory rate are positive in the equation of industrial output. The force of correlation between the infant natality and the growth of industrial production in the regions is stronger (0.0126) than dependence between migration growth and growth of industrial output (0.0003). It is more complicated to interpret the received results and define the causes and effects of the processes interrelation.

On the one hand, the birth rate is related to the family members' growth, as result, to the increase in necessities and demand on goods including the demand on production of the regional industries. In this sense the infant natality facilitates the increase in industrial production. On the other hand, the growth of regional economy raises welfare of population and stimulates the natality. In other words the birth rate is the consequence of the growth of industrial production. In any case the correlation is positive and is proved by calculations. The increase in coefficient of infant natality by 1 percentage point is accompanied by the industrial production growth by 1.26%. And the corresponding decrease in birth rate leads to the reduction in industrial production by 1.26%.

The migration growth can also be seen as the endogenous variable. The population migration in the region promotes the production growth, and on the other hand, the growth of the economy in the region attracts migrants. Nevertheless, the influence of migration growth on the economy of the regions is not so strong. The reason, evidently, is in the fact that the migrants are mostly employed in the nonindustrial sectors of the economy, and, probably, in shadow sectors of industrial production. The increase in the migration growth coefficient by 1 percentage point is accompanied by the industrial production growth in the regions only by 0.03 %.

Both for the natural and migration population growth there is the negative correlation with all

other macro parameters: employment, investment and incomes.

It is quite possible that the indicators of employment and income were influenced by the factor of high unemployment in densely populated republics of Northern Caucasus with high birth rate and decreasing in infant natality in other regions of the Russian Federation. The migration population growth raises the offer on a labour market and also reduces the indicators of employment. The cheap labour of migrants puts the pressure upon a labour market and reduces an average level of wages in the region.

In our opinion, the result of correlation between indicators and investment is important. The migration growth in Russia connected with the migration of low qualified labourforce does not create stimulus for the development and modernization of industry, increase of labour productivity, and, consequently, the investment into the economy of the regions. Therefore it is possible to conclude on negative influence from the migration of low qualified labour on economy of the regions of the Russian Federation.

The variable shares of urban population and share of students including in the equation of employment and income are significant and have the positive sign. Therefore, we can conclude that concentration of population in cities, agglomeration processes and growth of the intraregional market stimulate the formation of new workplaces and growth of employment. So the growth of the urban population unit weight in the region by 1 percentage item promotes the increase of the level of employment by 0.538 %. Simultaneously we see the increase of mid-annual monetary income of population. Therefore the formation of cities and city agglomerations can be considered as the positive process facilitating the growth of employment and incomes.

The confirmation of the positive impact of agglomeration processes on employment can be found in the variable population. The increase in population of the region by 1% increases the employment by 0.25 %. The unit weight of students in population characterizes the quality of the labour resources in the region and the level of qualification. With the increase of the unit weight of students in the region by 1 percentage item the employment increases by 0.3 %, and income increases by 0.18 %.

6. Influence of the world economy poles. The testing of the influence of countries economies forming the modern multipolar economic system on spatial development of economy of the Russian Federation has shown the following.

The influence of all contemporary variables of all poles of the world economy on macro parameters of the regions of the Russian Federation is significant in all equations. The estimates of parameters for expected values are mainly significant.

Results of estimation allow to analyse the impact of world economic poles in several aspects. At the beginning we will discuss, in which direction the world economic poles influence the regions of the Russian Federation not mentioning the issues about the power of influence.

The testing results have determined the negative influence of the EU countries on development of the Russian regions. There is the discussion about both expected and contemporary effects. Among the expected effects the EU economy negatively influences the industrial output of the western regions of Russia. The Russian manufacturers lose in the competition with the states of Europe. In parallel with production, there is the negative influence on investment into fixed capital and mid-annual monetary income of population. All contemporary effects are negative. The expectations connected with the development of the European economy greatly influence the European regions of the Russian Federation rather than the eastern regions. It is confirmed by the fact that for the eastern group of regions the estimates of parameters of industrial output and employment are insignificant.

The influence of the Chinese economy more likely has a positive character despite on competition of the cheap Chinese goods. The significant positive estimates for industrial output and

incomes are received both for expected, and for contemporary effects. This result is fount both for eastern, and for the western group of regions of the country. Change of a sign in the expected and contemporary effects on employment, most likely, reflects the process of adaptation of the economy. Impact of expectations concerning development of the Chinese economy on the investment is insignificant; the contemporary effects are negative. All the other contemporary effects: on the industrial output, employment and income– are positive. Preferences concerning east regions it is not revealed. Thus, the conclusion is the following. The growth of the Chinese economy positively affects on economy of the Russian regions. It facilitates the growth of mutual trade and, as consequence, the growth of industrial output in the Russian Federation.

The direction of the impact of the American economy also does not differ by the groups of the regions. In production, employment and income the expectations for the changes of the American economy has more likely the negative character. All contemporary effects are positive.

Both the expected and contemporary effects in the equation of investment are positive. Therefore, the result on investment probably means that all investors into the Russian economy are substantially guided by their own expectations concerning the American economy.

At the same time it should be noted that due to the significant reduction of scales during the period of reforms the economy of Russia has become less stable. According to the results of estimation we have revealed not only significant correlations between the economy of the Russian regions and the economy of the world economy poles, but also the fact that the changes of global economy cause the greater changes, even shocks, in the economy of the Russian regions.

We will consider in details the values of the parameters' estimatesw reflecting the power of influences of the world economy poles on the Russian regions.

6.1. The influence of the world economy poles on investment in fixed capital. We will mark out the following features:

1) the investment into the Russian regions in comparison with other regional macro parameters show the highest sensitivity to the changes in the world economy poles. The reaction of the Russian investors reaches 8 – 14% by 1% of changes in gross national product in poles;

2) the crucial expectations of investors are expectations concerning the developed economies of the EU and the USA;

3) the growth of Chinese economy does not influence the investment expectations of investors in the regions of the Russian Federation;

4) the reaction of investors in the western regions of Russia to the expected changes of gross domestic product in the world economy poles is stronger than reaction in the eastern regions of the country. So under the expected growth of the USA GDP by 1% the investment in the western regions of the Russian Federation increases by 13%, in the eastern regions does accordingly by 11.6 %. It is necessary to understand, that in case of the negative expectations the reaction of the Russian investors is opposite;

5) the condition of the USA economy both the expected and the modern one much more influence the decision of the Russian investors to make investment. We have found the significant, high positive values of the elasticity coefficients to the USA gross domestic product both for the expected and contemporary data.

6.2. Influence of the world economy poles on industrial production. The following regularities have been found:

1) reaction of industrial output in the regions of the Russian Federation to the changes in the USA economy is greater than to the changes in the economy of other countries;

2) the positive response is found, both to expected and modern growth of the Chinese economy;

3) expectations for the Chinese economy growth affect much more the industrial production of the western regions of the Russian Federations than on the eastern ones. For example, the expectations for the growth of the Chinese gross domestic product by 1% give the increase in industrial output in the western regions of the Russian Federation by 1.37% and in the eastern ones by 0.95 %;

4) however, as the elasticity coefficients for contemporary indicators show, the economy of the eastern regions adapts to the growth of the Chinese economy more quickly. Elasticity coefficient for the eastern regions is 2.75 % in comparison to the coefficient for the western region equal to 0.94 %;

5) expectations concerning the European and American economies influence negatively industrial production in the Russian Federation;

6) the negative sign for the expectations on gross domestic product of the USA is replaced by the positive one for contemporary data. According to the power of influence the coefficients for the expected and contemporary data are approximately equal, but they have different signs: –4,8 and 4,15 % accordingly. Therefore it is possible to conclude that the economy of the regions of the Russian Federation reacts to the changes in economy of the USA really strong. Very frequently the manufacturers overestimate negative consequences in the expectations, therefore there is a necessity of correction on the contemporary data.

6.3. Employment and mid-annual monetary income of the population. The results of estimation allow to make the following conclusions:

1) the elasticity coefficients both on employment and income take the values from –2 to 4.5;

2) the elasticity of employment and income to the expected values strongly differs by the groups of the regions. The picture of the employment and income elasticity to the contemporary changes in the world economy poles is similar in general;

3) the picture of the Chinese economy influence on employment and income as a whole coincides with the results on production;

4) all income elasticity coefficients in the regions of the Russian Federation to gross national product of China are positive. Coefficients are higher in the eastern regions of Russia. The elasticity coefficients to the Chinese contemporary data significantly exceed the elasticity to the expected data. So on the expectation for the growth of Chinese GDP the income in the western regions of the Russian Federations grows by 0.74%, and in the eastern ones - by 1.74% respectively. With the actual growth of Chinese gross domestic product by 1% the income in the western regions increases by 4.15%, in the eastern ones - by 4.32%;

5) the reaction to the expected USA GDP growth is negative both from the income, and from the employment. The percent of income decrease is bigger than percent of employment decrease. Based on estimation it is clear, that with the expected growth of GDP of the USA employment in the regions of the Russian Federations decreases: in the western regions by 0.77%, in the eastern regions by 0.7%. Income in reply to expectations also decreases by 1.87 and 0.95 % accordingly.

6) the adaptation processes to the current situation shows the positive correlation between the American economy and indicators of the Russian regions. As a reply to the USA economy growth in the Russian regions there is employment growth in the western regions by 0.54 % and by 0.7% in the eastern regions, the income growth is by 0.91% and by 1.07 % respectively.

To sum it up, it is possible to make a conclusion that expectations concerning the development of the world economy poles influence the economy of the Russian regions more negatively. Reaction to the contemporary changes is more likely positive. Probably, the strong negative expectations allow business to prepare better for forthcoming changes, therefore contemporary indicators are better than expected ones.

7. Influence of the dollar exchange rate, oil prices, and oil extraction. The variable of the dollar exchange rate is significant and positive in all equations. It is rather natural result for the export oriented raw economy of Russia. The growth of the dollar exchange rate by 1 point causes an increase of industrial output in regions by 1.32%, the growth of investment by 4.73%, the mid-annual monetary income growth by 0.83%. The positive influence of the oil prices growth is also rather expected result. The increase in the oil price by 1 point provides the industrial output growth by 0.21%, the growth of investment by 2.89%.

The oil extraction influence on development of the Russian regions has been unexpected. The oil extraction growth by 1 point provides the growth of industrial output by 0.86%.At the same time it decreases the investment by 0.33%, income – by 0.48%, and employment – more than by 0.13%.

Thus, generally the petrodollar factor is positive only at the high oil prices and high dollar exchange rate. In case of falling of any of them, or both at once, the effect for economy of the regions will be negative at any volume of extraction.

Basic conclusions

The results of estimation give proof to the proposed hypotheses.

1. There are grounds to speak about significant influence of the world economic poles on spatial development of the Russian economy. Small changes in the world economy can cause significant shock in economy of the Russian regions: in industrial production, investment, and income.

2. There has been the confirmation of the hypothesis that the eastern and western parts of the Russian Federation have the different poles of gravity and differently react to the changes of the world economy poles.

The economy of the European regions of the country is greatly influenced by the economy of the European Union. The influence of the economy of China and the USA on the eastern and western regions of Russia is similar in direction, but differs according to the power of influence. Nevertheless, the economies of China and the USA have more positive influence on the economy of the regions of the Russian Federation.

3. Influence of the geographical position on the development of the regions is reflected in the significance of the gravitational variables influence.

4. There has been the confirmation of the hypothesis about the influence of expectations concerning the development of the world economy poles on macro parameters of the Russian regions, in particularly, the negative expectations connected with the economy of the European Union and the USA.

5. There has been the confirmation of the influence of the world financial crisis on economy of Russia.

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Appendix

Correlation of disturbances $\boldsymbol{\varepsilon_{it}^*, w_{it}^*, \nu_{it}^*}$, and $\boldsymbol{\psi_{it}^*}$:

$$cov\left(w_{it}^* w_{js}^* | \Im_t\right) = \begin{cases} \sigma_w^2 + \beta_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \beta_{\boldsymbol{ext-exp}} = h_w, \text{under } t = s \text{ and } i = j; \\ \beta_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \beta_{\boldsymbol{ext-exp}} = h_\beta, \text{under } t = s \text{ and } i \neq j; \\ 0, \text{under } t \neq s \text{ and } \forall i \neq j. \end{cases}$$

$$cov\left(\nu_{it}^* \nu_{js}^* | \Im_t\right) = \begin{cases} \sigma_\nu^2 + \delta_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \delta_{\boldsymbol{ext-exp}} = h_\nu, \text{under } t = s \text{ and } i = j; \\ \delta_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \delta_{\boldsymbol{ext-exp}} = h_\delta, \text{under } t = s \text{ and } i \neq j; \\ 0, \text{under } t \neq s \text{ and } \forall i \neq j. \end{cases}$$

$$cov\left(\psi_{it}^* \psi_{js}^* | \Im_t\right) = \begin{cases} \sigma_\psi^2 + \gamma_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \gamma_{\boldsymbol{ext-exp}} = h_\psi, \text{under } t = s \text{ and } i = j; \\ \gamma_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \gamma_{\boldsymbol{ext-exp}} = h_\gamma, \text{under } t = s \text{ and } i \neq j; \\ 0, \text{under } t \neq s \text{ and } \forall i \neq j. \end{cases}$$

Correlation of disturbances in different equations:

$$cov\left(\varepsilon_{it}^* \nu_{js}^* | \Im_t\right) = \begin{cases} \sigma_{\varepsilon\nu}^2 + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \delta_{\boldsymbol{ext-exp}} = h_{\varepsilon\nu}, \text{under } t = s \text{ and } i = j; \\ \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \delta_{\boldsymbol{ext-exp}} = h_{\alpha\delta}, \text{under } t = s \text{ and } i \neq j; \\ 0, \text{under } t \neq s \text{ and } \forall i \neq j. \end{cases}$$

$$cov\left(\varepsilon_{it}^* \psi_{js}^* | \Im_t\right) = \begin{cases} \sigma_{\varepsilon\psi}^2 + \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \gamma_{\boldsymbol{ext-exp}} = h_{\varepsilon\psi}, \text{under } t = s \text{ and } i = j; \\ \alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}} \Sigma_{ext} \gamma_{\boldsymbol{ext-exp}} = h_{\alpha\gamma}, \text{under } t = s \text{ and } i \neq j; \\ 0, \text{under } t \neq s \text{ and } \forall i \neq j. \end{cases}$$

$$cov\left(\nu_{it}^{*}w_{js}^{*}|\Im_t\right)=\begin{cases}\sigma_{\nu\,w}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}=h_{\nu\,w},\text{under } t=s \text{ and } i=j;\\ \delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}=h_{\delta\beta},\text{under } t=s \text{ and } i\neq j;\\ 0,\text{under } t\neq s \text{ and } \forall i\neq j.\end{cases}$$

$$cov\left(\nu_{it}^{*}\psi_{js}^{*}|\Im_t\right)=\begin{cases}\sigma_{\nu\,\psi}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=h_{\nu\,\psi},\text{under } t=s \text{ and } i=j;\\ \delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=h_{\delta\gamma},\text{under } t=s \text{ and } i\neq j;\\ 0,\text{under } t\neq s \text{ and } \forall i\neq j.\end{cases}$$

$$cov\left(w_{it}^{*}\psi_{js}^{*}|\Im_t\right)=\begin{cases}\sigma_{w\,\psi}^{2}+\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=h_{w\,\psi},\text{under } t=s \text{ and } i=j;\\ \beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=h_{\beta\gamma},\text{under } t=s \text{ and } i\neq j;\\ 0,\text{under } t\neq s \text{ and } \forall i\neq j.\end{cases}$$

Correlation of the first differences of disturbances:

$$cov\left(\Delta w_{it}^{*}\Delta w_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{w}^{2}+\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}\right)=2h_{w},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{w}^{2}+\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}\right)=-h_{w},\text{under } s=t-1 \text{ and } i=j;\\ 2\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}=2h_{\beta},\text{under } t=s \text{ and } i\neq j;\\ -\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}=-h_{\beta},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\text{under } t\neq s \text{ and } \forall i\neq j.\end{cases}$$

$$cov\left(\Delta\nu_{it}^{*}\Delta\nu_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{\nu}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}\right)=2h_{\nu},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{\nu}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}\right)=-h_{\nu},\text{under } s=t-1 \text{ and } i=j;\\ 2\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}=2h_{\delta},\text{under } t=s \text{ and } i\neq j;\\ -\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}=-h_{\delta},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{ under } s\neq t, s\neq t-1,\text{and } \forall i\neq j.\end{cases}$$

$$cov\left(\Delta\psi_{it}^{*}\Delta\psi_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{\psi}^{2}+\gamma_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=2h_{\psi},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{\psi}^{2}+\gamma_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=-h_{\psi},\text{under } s=t-1 \text{ and } i=j;\\ 2\gamma_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=2h_{\gamma},\text{under } t=s \text{ and } i\neq j;\\ -\gamma_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=-h_{\gamma},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{ under } s\neq t, s\neq t-1,\text{and } \forall i\neq j.\end{cases}$$

Correlation of the first differences of disturbances in different equations:

$$cov\left(\varepsilon_{it}^{*}\nu_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{\varepsilon\nu}^{2}+\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}\right)=2h_{\varepsilon\nu},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{\varepsilon\nu}^{2}+\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}\right)=-h_{\varepsilon\nu},\text{under } s=t-1 \text{ and } i=j;\\ 2\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}=2h_{\alpha\delta},\text{under } t=s \text{ and } i\neq j;\\ -\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\delta_{\boldsymbol{ext-exp}}=-h_{\alpha\delta},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{ under } s\neq t, s\neq t-1,\text{and } \forall i\neq j.\end{cases}$$

$$cov\left(\varepsilon_{it}^{*}\psi_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{\varepsilon\psi}^{2}+\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=2h_{\varepsilon\psi},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{\varepsilon\psi}^{2}+\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=-h_{\varepsilon\psi},\text{under } s=t-1 \text{ and } i=j;\\ 2\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=2h_{\alpha\gamma},\text{under } t=s \text{ and } i\neq j;\\ -\alpha_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=-h_{\alpha\gamma},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{under } s\neq t, s\neq t-1, \text{and } \forall i\neq j\ .\end{cases}$$

$$cov\left(\nu_{it}^{*}w_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{\nu w}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}\right)=2h_{\nu w},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{\nu w}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}\right)=-h_{\nu w},\text{under } s=t-1 \text{ and } i=j;\\ 2\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}=2h_{\delta\beta},\text{under } t=s \text{ and } i\neq j;\\ -\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\beta_{\boldsymbol{ext-exp}}=-h_{\delta\beta},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{under } s\neq t, s\neq t-1, \text{and } \forall i\neq j\ .\end{cases}$$

$$cov\left(\nu_{it}^{*}\psi_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{\nu\psi}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=2h_{\nu\psi},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{\nu\psi}^{2}+\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=-h_{\nu\psi},\text{under } s=t-1 \text{ and } i=j;\\ 2\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=2h_{\delta\gamma},\text{under } t=s \text{ and } i\neq j;\\ -\delta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=-h_{\delta\gamma},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{under } s\neq t, s\neq t-1, \text{and } \forall i\neq j\ .\end{cases}$$

$$cov\left(w_{it}^{*}\psi_{js}^{*}|\Im_t\right)=\begin{cases}2\left(\sigma_{w\psi}^{2}+\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=2h_{w\psi},\text{under } t=s \text{ and } i=j;\\ -\left(\sigma_{w\psi}^{2}+\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}\right)=-h_{w\psi},\text{under } s=t-1 \text{ and } i=j;\\ 2\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=2h_{\beta\gamma},\text{under } t=s \text{ and } i\neq j;\\ -\beta_{\boldsymbol{ext-exp}}^{\mathrm{T}}\Sigma_{ext}\gamma_{\boldsymbol{ext-exp}}=-h_{\beta\gamma},\text{under } s=t-1 \text{ and } i\neq j;\\ 0,\ \text{under } s\neq t, s\neq t-1, \text{and } \forall i\neq j\ .\end{cases}$$