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THE GRAVITY MODEL OF INTERREGIONAL TRADE: CASE OF EASTERN SIBERIA

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Abstract

This paper analysis the gravity model of interregional trade of Irkutsk region the base of statistical data on gross regional products and trade flows between Russian regions. We find that the market size significantly impacts the trade volumes. The elasticity of export on importer region size is approximately equal to one. Moreover, it appears that the distance significantly negatively impacts the trade volumes. The elasticity of export on distance to the importer region is approximately equal to -1,5. We also find that Irkutsk region trade with Eastern regions is significantly (about 11 times) greater. Furthermore, we arrive at the conclusions that the absence of railroad significantly negatively (about 4 times) impacts the trade flows.

Keywords: gravity model, interregional trade, regression analysis, spatial economics, Russian Federation

JEL Classification: F12, F14, R11

Introduction

In spite of business cycles and world crisis the last two centuries yielded extremely high growth of the world economy. The main reason of the growth is technical progress (the fifty times increase in labor productivity in the developed countries with no doubt impacts the social welfare). But there is one more very significant factor: international and interregional trade, globalization, and the formation integrated world economic space.

The reality of modern economy is connected with fifty times per 200 years decrease in transportation costs and the time of transportation, seven times (from 32% in 1930 to 4,6% in 2000) decrease in average tariffs (Combes, et al, 2008), and almost elimination of the communication costs due to Internet and mobile phones.

At the first sight it looks like an argument for the depreciation of the spatial factor in economics. In reality there is the opposite situation: there is a trade now in industries where before it was impossible, but at the same time the long distance between producer and retailer means considerable increase in price. It's also approved with the empirical data: during one and a half centuries the average share of export in GDP increased approximately by 17 times along with 10 times growth of real GDP. We consolidate data for several countries and present them in Table 1.

The new reality of the world globalized economy needs new theory of industrial organization, and new models of interregional and international trade. Earlier economists thought that the engine of international trade is the comparative advantages of the countries in production connected with heterogeneity in labor productivity (Ricardo, 1817) and production factors supply (Ohlin, 1968). The obvious conclusion from this assumption is the following hypothesis: the main trade flow should be between various countries, for example, developed European countries should trade with banana republics. At the same time the statistics (especially in last decades – in globalization era) shows the opposite results: the considerable share of trade is occurred between countries of Europe and North America quite similar among themselves. Moreover it's possible to observe bilateral streams of very close substitute goods, and it can't be explained with market inefficiency.

Table 1: the share of export in GDP for several countries, 1870–2011, %

Country	1870	1913	1950	1973	1987	2000	2011
Belgium	7,0	17,5	13,4	40,3	52,5	86,3	84,4
Great Britain	10,3	14,7	9,5	11,5	15,3	28,1	32,5
Germany	7,4	12,2	4,4	17,2	23,7	33,7	50,2
Italy	3,3	3,6	2,6	9,0	11,5	28,4	28,8
China	–	–	–	4,3	14,2	23,5	30,6
Netherlands	14,6	14,5	10,2	34,1	40,9	67,2	83,0
Russia	–	–	–	–	19,3	44,5	31,1
USA	2,8	4,1	3,3	5,8	6,3	11,2	14,0
France	3,4	6,0	5,6	11,2	14,3	28,5	26,9
Japan	0,2	2,1	2,0	6,8	10,6	10,8	15,2

Source: Combes et al. (2008)

The solution was proposed by Avinash Dixit and Joseph Stiglitz in (Dixit and Stiglitz, 1977). As a starting point they took the basic ideas of the monopolistic competition (Chamberlin, 1933) – product differentiation and consumers' love for diversity, and also the increasing returns to scale connected with significant fixed costs, which make the most profitable the mass production and the widest sale all over the world. Paul Krugman (Krugman, 1979, 1980) applied these models to the theory of international trade.

Moreover, for such a large country as Russia, the interregional trade along with international one gains special importance as one of the most significant factors of economic growth, political stability and territorial integrity. Strengthening of regions integration and interregional trade increase is especially important in situation of the world economic crisis and the international sanctions.

We investigate the spatial factor of interregional trade on the case of Eastern Siberia, the Russian region situated rather far from the economic center of the country. Particularly we will estimate the negative influence of long distances which can be aggravated with imperfect transport connection and inefficient regional policy. Let us apply the gravity model for the quantitative estimation of trade flows.

The Gravity Trade Model

The gravity equation is one of the greater success stories in empirical economics (Feenstra, et al., 2001) and one of the most interesting interdisciplinary analogies. Economists thought for a long time how to model trade between two countries or regions. The new era in the international trade theory started in 1962 when Jan Tinbergen proposed the economic analogue of Newton's Law of universal gravitation (1) states that any two bodies in the Universe attract each other with a force F_{ij} that is directly

proportional to the product of their masses M_i and M_j and inversely proportional to the square of the distance D_{ij} between them:

$$F_{ij} = G\frac{M_i M_j}{D_{ij}^2}, \qquad (1)$$

Due to the gravity model export of each country should correlate positively with its own GDP because supply is defined by production, GDP of the importing country though it determines the market capacity and demand for imported goods, and correlate negatively with transportation costs connected with a distance between the countries. If actual amount of export is more than the obtained by this model, then there is most likely the export subsidizing, if actual export is less than the estimated one – there could be high tariffs, or discrimination restrictions of any kind.

The idea of Jan Tinbergen didn't have any microeconomic substantiation (the first explaining microeconomic model was proposed 17 years later by James Anderson (Anderson, 1979), but gave excellent results. Particularly, it became possible to construct precise forecasts, to estimate distance elasticity of export for different groups of countries and goods. The gravity model is started to be used for migration estimation (with population of both countries as the masses) and also for capital flows (with money supply as the masses).

By the present moment the gravity models of international trade became mainstream, there are hundreds theoretical and empirical papers on this topic. They are based on the modern approaches to spatial economics include firms heterogeneity (Melitz, 2003). They explain zero trade flow between several countries (the fixed costs of the entrance on the foreign market are greater than the possible trade profits) and asymmetry of trade flows. They also take into account the other factors such as common language, common border, and membership in the common trade and military blocks (Helpman, et al, 2008).

At the same time there are no many intra-country empirical investigations of the interregional trade, in spite of the fact that it could be very interesting due to the absence of tariffs, language problems, problems with legal system, etc.

Basic gravity model

The basic gravity model looks as follows:

$$F_{ij} = G\frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\theta}}, \qquad (2)$$

or, in log-linear form,

$$\ln F_{ij} = \ln G + \alpha \ln M_i + \beta \ln M_j - \theta \ln D_{ij}. \qquad (3)$$

Here, in (2), (3) F_{ij} – export from the *i*-region to the *j*-region, M_i and M_j – gross regional products determining the economic masses of regions, D_{ij} – distance between regions, α, β, θ – estimating elasticities of demand on the corresponding variables.

We will carry out the empiric analysis of the interregional trade in Russia on the base of Rosstat data for Irkutsk region in 2012. Though one of the regions is fixed the first regressor M_i is eliminated from the model. Let us identify the regression equation using OLS:

$$\ln F_{ij} = \underset{(0,98)}{2,14} + \underset{(0,15)}{1,00} \ln M_j - \underset{(0,34)}{2,05} \ln D_{ij}. \qquad (4)$$

The obtained model (4) shows high significance of both factors (t-statistics are equal to 6,61 and 5,96 respectively). The importing region size and distance elasticities of export are equal to 1 and –2 respectively which perfectly corresponds to the original Newton gravity equation. It means particularly that distance matters and even more than the investigations based on the European Union data show. It can be connected with not so good infrastructure and high tariffs on railroad transportation in Russia.

But the model shows one more interesting detail: in spite of high accuracy of the forecast for some regions actual export is greater or less than the model one. Moreover this deviation is systematic and significant (see Table 2).

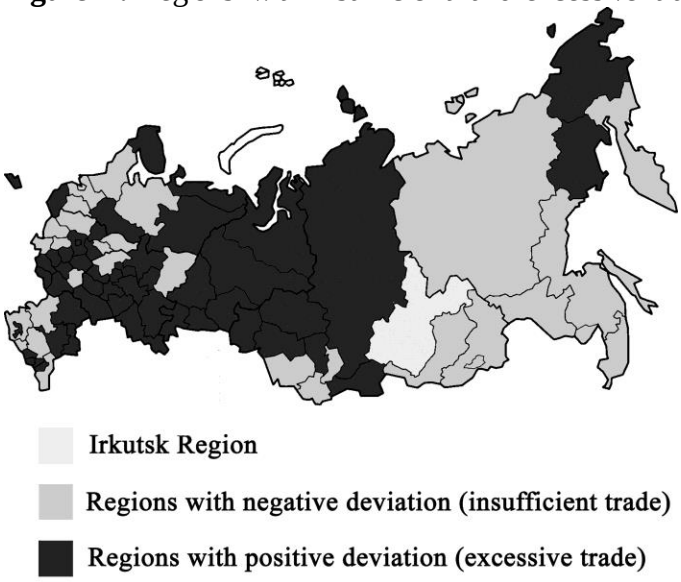
Table 2: the outlier regions in the basic model

Region	Export, forecast	Export, fact	Deviation
Republic of Karelia	41	1219	1178
Perm region	506	1783	1277
Nizhny Novgorod region	305	1749	1444
Khanty-Mansi region	2381	218	–2163
Krasnoyarsk region	8560	6316	–2244
Kamchatsky region	62	2581	2519
Republic of Buryatiya	7090	10783	3693
Khabarovsk region	317	6820	6503
Amur region	243	9078	8835
Zabaikalsky region	1908	12489	10581
Republic of Yakutiya	715	13248	12533
Primorsky region	266	23993	23727

Source: calculated by the authors.

Table 2 shows that most regions with excessive export are located on the East from the Irkutsk region (the eastern regions are noted grey). Even more brightly this regular deviation of «eastern vector of trade» we can see on Figure 1. Here with lighter shade we will represent regions with excessive trade, and dark regions – regions with insufficient trade.

Figure 1: Regions with insufficient and excessive trade



Source: Own results

The model modifications

To estimate quantitatively «the eastern vector of trade» it's possible to use dummy variable v_i equal to one for regions located to the east from Baikal. The modified model looks like the following:

$$\ln F_{ij} = \underset{(0,92)}{0,25} + \underset{(0,13)}{1,13} \ln M_i - \underset{(0,32)}{1,44} \ln D_{ij} + \underset{(0,45)}{2,40} v_i . \qquad (5)$$

The model (5) became more significant – the determination coefficient increases from 49% to 63%. It's also possible to mention that in spite of certain decrease of distance elasticity of export, all regressors are still significant, including at significance level α = 0,001. The «eastern vector» in trade is also very significant (the empirical value of *t*-statistics is equal to 5,29).

Although the original model is reduced from the log-linear form by using exponent, the trade of Irkutsk region with eastern regions for which dummy v_i is equal to one, is greater in exp(2,40) = 11 times, that is very significant. But probably it isn't a feature of the Irkutsk region, there at just two affected factors. European regions are even further from the Far East, and transportation costs don't allow to trade effectively with them. Besides certain share of the exported to Far East production is possibly re-exported to the countries of Southeast Asia. Most regions being outliers in the basic model left this list. Among remained regions it's possible to mention the Republic of Karelia, Perm region and Nizhny Novgorod region where trade considerably exceeds the expected level, and also Khanty-Mansi region with insufficient trade quantities. Let's try to partly explain the remained outliers.

One can see that among the Eastern regions there are only two with significantly insufficient trade with Irkutsk region – Magadan region and Chukotka, the regions where it's very hard to deliver goods. As a proxy of transport connection inconvenience we will use the absence of the railroad connection. Let's include into the model the dummy w_i equal to one for appropriate regions. The obtained regression looks like as follows:

$$\ln F_{ij} = \underset{(0,91)}{0,82} + \underset{(0,13)}{1,07} \ln M_i - \underset{(0,31)}{1,35} \ln D_{ij} + \underset{(0,45)}{2,64} v_i - \underset{(0,56)}{1,48} w_i . \qquad (6)$$

In the modification (6) the determination coefficient became 0,66 (it means that the model explains two third of the trade variation). All the regressors, include absence of the railroad, are significant at significance level α = 0,01. Taking into account log-linearity of the model (6) we can interpret the last term as following: export to the regions without railroad is less in exp(1,48) = 4,4 times. Size elasticity of export is insignificantly greater than one, and distance elasticity of export is equal to –1,35. The differences of the eastern regions from the western ones became even more amplified, than in the previous model.

Conclusions

The main result of the carried out research is the constructed and estimated set of the gravity models for the interregional trade of Irkutsk region, one of the Siberia regions of Russia being at considerable distance both from the European capitals, and from the South-West Asia countries. Our regression analysis shows the following main implications:

- The importer region size significantly positively impacts the trade quantity. The size elasticity of export is close to one. It means that export increases proportionally to the importer region size.
- The distance to the importer region significantly negatively impacts the trade quantity. The distance elasticity of export is close to –1,5.
- Irkutsk region trade with eastern regions is significantly (about 11 times) greater than with western ones ceteris paribus.
- The absence of railroad impacts trade significantly negatively (decreases quantities about 4 times).
- The possible prospects of the research are connected with the analysis of interregional trade of all regions of the Russian Federation, and also with taking into account the export flows to the other countries.

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