Testing for Foreign Direct Investment Gravity Model for Russian Regions

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Testing for Foreign Direct Investment
Gravity Model for Russian Regions

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Abstract

Gravity model of inward Foreign Direct Investment (FDI) is specified to determine the sources of uneven distribution of FDI across Russian regions in recent years. FDI gravity model specification includes several additional variables, namely, agglomeration effect, natural resources abundance, skilled labor abundance, capital city advantages, dummy variable for cultural closeness and common language. Our data set consists of FDI inflows from six source countries (UK, Germany, Finland, Byelorussia, Ukraine and Kazakhstan) into 76 Russian regions in year 2002. FDI inflow is measured with the number of foreign firms of a particular source country in a particular Russian region. Two estimation techniques have been applied. In OLS estimation we exclude all zero observations, thus the dependent variable reflects the magnitude of foreign firm's presence. All explanatory variables, except natural resources abundance, have an expected influence on the dependent variable. ML estimation of binary choice models included also all zero observations. Thus the 1/0-valued dependent variable reflects the willingness of foreign direct investors to invest into a particular Russian region. Results imply that only the factors of the crude form of gravity model, namely, gross products of host regions and source countries and distance between them, and agglomeration effect are important for FDI entrant probability in different regions.

Key words: Foreign Direct Investment (FDI), Russian regions, foreign firms, gravity model
JEL Classification: E22, F21, P27

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1. Introduction

During the last 15 years – the period while Russian economy have been transferring from command to market economy and as a consequence liberalizing its international economic relationship including foreign direct investments (FDI) movement – Russia` s achievements in attracting FDI have been quite modest. According to Russian Statistical Agency (Goskomstat, 2004), the Russian FDI stock in the end of 2003 was roughly $ 26 billion. The share of Russia in the world FDI stock in 2002 was 0.3 %, while, for example China got 6.3 % of the world` s total. If we look at per capita FDI stock in Russia, the picture is even worse. Russia received 24 times less per capita FDI than Czech Republic and 12 times less than such countries as Estonia, Slovenia and Hungary (UNCTAD, 2003). In a survey among foreign investors in Russia, most of the problems mentioned as barriers to investment were of an institutional and legislative nature (Pan-European Institute Report, 2004).

Besides the small amounts of inward FDI into Russia, the industrial and regional structure of attracted FDI seems to be inconsistent and ineffective in the context of industrialization and post-industrial development of economy. This concerns also the more or less unequal regional development in Russia. The uneven distribution of FDI can partly be explained with Russia's large territory but this does not alone explain the distribution problem and the low scale of FDI' s in Russia in general. Our research aims to determine the main factors determining the inward FDI in Russia's regions. The empirical analysis is based on the popular gravity model approach. We estimate a specification of gravity model in order to analyze the main determinants of FDI in Russia's regions in year 2002.

The structure of paper is the following. Section 2 describes the regional and industrial composition of FDI' s in Russia. In the last decades a large amount of literature has been developed on the theory of FDI flows. Since the empirical part of this paper will be based on the gravity model of FDI, we briefly review the framework and theoretical foundations of this model in section 3. Section 4 describes the methodology and data of the study. Section 5 summarizes the results of empirical estimations, and section 6 concludes the paper.

2. Regional and industrial composition of FDI' s in Russia

Russia` s achievements in attracting Foreign Direct Investment (FDI) during its transition period have been rather modest. Another important but less discussed problem of Russia` s performance as a host country for FDI is uneven distribution of FDI within country` s territory. The Pan-European Institute (2004) estimates that the total accumulated FDI inflow to Russia in 1995-2002 was nearly 30 billion USD and over half of this went to the Central federal district (mostly to Moscow city).

One way to analyze the unequal distribution of FDI across Russian regions is to use the Index of Herfindal – Hirshman (Valiullin and Shakirova, 2004):

(1) $$I_{HH} = \sum_{j=1}^{k} \left(\frac{FDI_j}{FDI} \cdot 100\right)^2,$$

where FDI_j is FDI in a region j, and FDI is the total FDI into all regions and k is the number of regions. We calculated the Index for FDI distribution across Russian regions for the period of 1996-2003. The time path of Index is represented in Appendix 1. During the period the Index was rather high and exceeded its minimum value of perfectly even distribution ($I_{HH} \min = 100^2 / 89 = 112.4$) from 8 to 16 times. Even for the 20 Russian regions - top receivers of FDI in Russia (Pan-European Institute Report, 2004) - the Index is more than 4 times higher than its minimum level for accumulated FDI during the period of 1995-2002. Table 1 illustrates the division of inward FDI accumulated in 1995-2002 over Russian Federal Districts.

The table indicates that the sparsely inhabited but rich in natural resources Far Eastern federal district has received the highest FDI per capita. First of all it concerns Sakhalin Oblast, with its rich oil and natural gas resources. There are several large oil and gas projects operated by a unique international consortium. Sakhalin received 9% of total Russian accumulated FDI. Inward FDI accumulated in 1995-2002 per capita in Sakhalin oblast was accounted to 4472 dollars. The second region in the Far East, which is very attractive for resource-seeking FDI, is

Magadan oblast with rich stock of non-ferrous metals, such as gold, tin, uranium and silver. During the discussed period it has accumulated 1124 FDI per capita US dollars.

TABLE 1. Inward FDI accumulated in 1995-2002 over Russian federal districts

Indicators/ Districts	Share of Russian total (%)	Population, % of Russian total	Per capita (US dollars)
Central FD	53	26	427
North-Western FD	10	10	207
Southern FD	11	11	152
Volga FD	6	6	56
Ural FD	5	5	119
Siberian FD	4	4	58
Far Eastern FD	11	5	459

Source: Goskomstat, 2004; Pan-European Institute Report, 2004.

Central district also has a rather high value of accumulated FDI per capita in comparison with others. The city of Moscow has an evident dominating role in attracting FDI in the district. It accumulated almost 40 % of total accumulated FDI in Russia and FDI per capita is also very high, 1146 USD. Moscow is not only the official capital and the biggest city in Russia but also the business center and the center of foreign trade in Russian Federation. However, since almost all major companies have their headquarters in Moscow, investments finally targeted to other Russian regions may be registered as investments to Moscow (Pan - European Institute Report, 2004). Note also as Pan-European Institute indicates that among 20 Russian regions, top-receivers of FDI, 11 of them have million cities. It indicates that big city advantages like high level of business infrastructure and large market size are important factors of inward FDI inflows.

Besides the unequal regional distribution, inward FDI into Russian economy have very uneven industrial structure. In average in the period of 1998-2003 fuel industry has been receiving 17.2 % of annual FDI inflow, food, beverages and tobacco - 17.7 %, and trade and catering - 19.2 %. In total they have been receiving more than a half of total FDI inflow (54%).

Thus there are at least four evident factors that have great influence on foreign investor's decision to invest or not into a particular Russian region. First factor is the availability of natural resources. Second is the level of agglomeration in a region or, more precisely, the number of big cities. The third is the market potential of a region (as FDI into food, beverages and tobacco and trade and catering industries are considered to be market-seeking investment) and the fourth is the capital city's advantages. The relative importance of these factors must be confirmed by an empirical study. The novelty of our approach is to apply the gravity model framework to the analysis of regional factors of FDI inflows into Russia.

3. Gravity model: theoretical framework and empirical evidence

The first version of the model was suggested by Tinbergen (1962) and Pöyhönen (1963). They concluded that exports are positively affected by income of the trading countries and that the distance between the countries is likely to affect exports negatively (Kristjansdottir, 2004). Lately there have been made a number of contributions to this early version. Linnemann (1966) suggested the model, which describes the flow of goods from one country to another in terms of supply and demand factors (income and population). Anderson (1979) assumed product differentiation and Cobb-Douglas preferences. Bergstrand (1985) concluded that price and exchange rate variation have significant affects on aggregate trade flows. Deardorff (1995) derived a gravity model in the framework of the Heckscher-Ohlin model.

In recent times gravity model has been intensively used for the analysis of FDI flows` determinants. In a very simple form gravity approach to FDI suggests that FDI is positively related to GDP levels both in host and source countries and negatively related to the distance between them. The use of gravity model in explaining FDI flows is supported theoretically. The most well known theoretical framework is Dunning` s (1958) eclectic OLI (Ownership, Location, Internalization) paradigm. In this framework the market size and the proximity of markets are rather influential factors for FDI decision. Casson (1987), Ethier (1986), Ethier and Markusen (1991, 1996), Rugman (1986), and Williamson (1981) have focused on OLI. In these studies, the important determinant of location choice is the destination consumption market. Woodward (1992), Barrel and Pain (1999), Haufler and Wooton (1999), Yeaple (2001) agreed that market size is one of the most important factors of FDI inflows (Chakrabarti, 2003).

There are few empirical studies based on the regional data. The paper by Broadman and Recanatini (2005) can be mentioned here. Broadman and Recanatini use as a dependent variable different variants of net FDI inflow into Russian regions. For explanatory variables they use different indicators of regional development (mostly taken from Goskomstat) that characterize economic development, physical infrastructure, policy framework, civic society and institutional development, geography, and social stability. They use panel data for the period of 1995-2000. Broadman and Recanatini found with different panel data models that market size, infrastructure development, policy environment and agglomeration effects appear to explain much of the observed variation of FDI flows across Russia's regions.

A number of empirical studies, which analyze bilateral FDI flows through the framework of gravity model, have appeared also. Frenkel, Funke, Stadtmann (2004) examined the determinants of FDI flows to emerging economies. They used OLS estimators for panel data of bilateral FDI flows from the selected developed countries to emerging economies to test the crude form of gravity model and its several specifications. In order to capture the home and the host countries effects and the time effects they used two-component model with dummy variables. They found that while market size and distance play an important role for FDI flows, other economic characteristics like risk and economic growth in host countries are also crucial for attracting international investment projects.

Buch, Kokta, Piazolo (2003) investigated FDI redirection from Sourthen Europe to the Central and Eastern European countries, using also gravity model equation. They used a two-step panel vector autoregression (VAR) estimation suggested by Breitung (2002) for panel data set of bilateral outward stocks of FDI of seven OECD countries to 31 recipient countries. As the cointegration techniques restrict the number of explanatory variables, Buch et al. used only two variables in their specification of the gravity model. The first one is the volume of bilateral trade as a proxy for the degree of integration between two countries. The second variable is GDP per capita. They found no clear evidence that trade and FDI are substitutes or complements, and that there is a significant and positive impact of GDP per capita. However estimating a specification for the stock of German FDI abroad using cross-section regressions over 5 years, they found that market size (measured as GDP of a host country) and economic distance are important factors for FDI decision, but GDP per capita was typically insignificant. Bevan and Estrin (2004) used gravity approach for studying the determinants of FDI from western countries to Central and Eastern European. They used also panel dataset of bilateral flows and found that the most important factors are unit labor costs, market size and distance.

4. Models and Data description

4.1. The dependent variable

Our empirical study is based on cross-sectional dataset. As proxy for FDI flows we use a number of foreign firms from six source countries, namely Byelorussia, Kazakhstan, Ukraine, Germany, Great Britain and Finland to 76 Russian regions. Thus the dependent variable Y_{ji} is the number of foreign firms in region j (j=1,…,76)[1)] from country i (i = 1,…,6) at year-end for the year 2002. The source of data is Russia's Regions Yearbook issued on the yearly basis by Russian State Statistical Agency (Goskomstat, 2004). The introduced dependent variable measures the magnitude of foreign firms' presence in a particular Russian region but not the amount of FDI. This can be considered as a disadvantage of analysis. However the amount of FDI may just reflect the availability of big natural resources in some regions that might interfere to estimate the contribution of other important factors.

4.2. Explanatory variables and specification of gravity model

The first equation to be estimated is the crude form of gravity model:

$$(2) \qquad Y_{ij} = b_1 + b_2 \cdot GRP_j + b_3 \cdot GDP_i + b_4 \cdot DIST_{ij} + u_{ij} \, ,$$

where b's are the parameters to be estimated and u_{ij} are model errors. GRP_j is a gross regional product in each region at year-end as average for the years 1998 to 2002, as calculated by Goskomstat (2004). GDP_i is the gross domestic product in each source country at year-end as average for the years 1998 to 2002 (IMF, 2005). Both indicators have been transformed into

[1)] Actually there are 89 regions in Russia. We exclude from the analysis the autonomous territories which are included in other regions. These are Neneckij, Komi-Permyatckij, Hanty-Mansijskij, Yamalo-Neneckij, Dolgano-Neneckij, Evenkijskij, Ust-Ordynskij and Aginskij Buryatskij, and Koryakskij. Regions for which some data is missing, namely Ingushetiya, Chechnya, Kalmykiya, and unique territory Chukotka, are excluded also.

millions of euros in the prices of 2000. $DIST_{ij}$ is a distance in kilometers between a source country's and a region's capital cities.

Next we add several variables to the model, which are expected to have an important influence on the dependent variable. The choice of variables is based on the theories of FDI and the analysis of the current tendencies of FDI movements into Russian economy.

$$
\begin{aligned}
Y_{ij} &= b_1 + b_2 \cdot GRP_j + b_3 \cdot GDP_i + b_4 \cdot DIST_{ij} \\
&+ b_5 AGGL_j + b_6 \cdot NR_j + b_7 \cdot DV_j \\
&+ b_8 \cdot MOSCOW + b_9 \cdot SKA_j + u_{ij}
\end{aligned}
\qquad (3)
$$

The additional variables help us to test several hypotheses. We argue that agglomeration affect plays an important role in FDI decision between Russian regions. $AGGL_j$ is defined as the ratio of GRP_j to the square of region j's territory (measured in square kilometers). We consider this indicator to be better than the dummy variable for the presence of a million city in a region. $AGGL_j$ measures the average concentration of business activities in a region's territory. The dummy variable does not take into account other big cities (mainly with population from 0.5 to 1 million inhabitants). Actually agglomeration effect also can serve as a proxy of general level of regional infrastructure's development as big cities usually have relatively good business infrastructure (car roads, financial institutions, trade network, etc).

To test the hypothesis that availability natural resources is a crucial factor for foreign firms presence in a particular region, we use NR_j. It equals the ratio of extractive industries' production to the total industrial production in each region as average at year-end for the period of 1998-2002, as calculated by Goskomstat (2004). The include industries are fuel, electricity, black and color metallurgy, chemical and oil-chemical industries.

It is suggested that capital city's advantages plays important role in FDI decision into Russia. We use Moscow dummy variable (Moscow), which equals to one for Moscow and Moscow region (as they are taken together in calculations) and to zero for all other regions.

The dummy variable DV_j equals to one for Byelorussia, Kazakhstan and Ukraine and to zero for Germany, Great Britain and Finland. DV_j measures the level of uncertainty faced by foreign investor, i.e. the easier for foreign direct investor to get information about a target host country's environment, the easier to make FDI decision (Hosseni, 2005). We expect that the dummy variable is positively related to FDI decision indicating that Byelorussia, Kazakhstan and Ukraine, which have close cultural relationship and common language with Russia as former Soviet republics. Typically they will get information about Russia` s economic, political, etc environment and therefore will make decisions about FDI into Russian region quicker and easier than Western European countries.

Finally we test if the efficiency-seeking motive and level of human capital are important for FDI decision into Russian regions. This factor is included into the specification in accordance with a common notion that important advantage of Russia as a host country for FDI is not only its resource abundance, but also its skilled labor abundance. Here we use SKA_j - the ratio of people with University and College degrees in total population for the year 2002, as calculated by Goskomstat (2004). It is used as a proxy for skilled labor abundance in a region j. We expect it to be positively related to the dependent variable.

Note also that we use dummy variables for source countries (benchmark is Great Britain) and for seven Russian districts (benchmark is Central district) for controlling additional source country and host region heterogeneity. Unfortunately we cannot use the dummies for all Russian regions as the problem of the loss of degrees of freedom arises. Thus we use dummies for seven Russian federal districts, which are formed on the basis of territorial proximity of Russian regions. Regions which are included into the same federal district have common climate, common infrastructure` s and production projects, etc. The choice of using different sets of dummies is finally based on economic sense and statistical results.

It is obvious that there are a number of other factors that may influence FDI decision into Russian regions. Especially it concerns regional investment legislation. But as this factor is also very important for domestic investment and therefore GRP level in regions, its inclusion may create estimation problems (e.g., multi-collinearity, simultaneity).

4.3. Estimation methods

Our econometric analysis consists of two parts. First we use OLS estimation with parameter standard errors corrected for heteroskedasticity with White's heteroskedasticity consistent covariance estimate. For OLS estimation we exclude from the analysis all zero dependent observations. Thus our dataset consists only of regions that have at least one firm with FDI from the mentioned six countries. All the variables in the empirical study (except dummy variables) appear in natural logarithm form.

Secondly we use Binary Dependent Variable Models for the same specifications. In the model the dependent variable takes only two values: $Y_{ij} = 1$ if there is at least one foreign firm of a source country i in a region j, and $Y_{ij} = 0$ if there are no firms in the region with FDI of the source country. Thus here all the observations of the sample are present. A simple linear multiple regression is not now appropriate, since the implied model of the conditional mean places inappropriate restrictions on the residuals of the model. Furthermore, the fitted value of Y from OLS regression is not restricted to lie between zero and one. Thus we adopt an estimation strategy that is designed to handle the specific requirements of binary dependent variables. We model the probability of observing a value of one as:

$$\text{(4)} \qquad \Pr(Y = 1 | x) = F(x, \beta),$$

where x is a vector of explanatory variables, the set of parameters β reflects the impact of changes in x on the probability to investment. It follows naturally that for $Y = 0$ we have:

$$\text{(5)} \qquad \Pr(Y = 0 | x) = 1 - F(x, \beta).$$

F is a continuous, strictly increasing function that takes a real value and returns a value ranging from zero to one. As Gujarati (2003) notes, the binary choice process has two basic features: (1) As x_i increases, $P_i = E(Y=1|x)$ increases (decreases) but never steps outside the 0-1 interval, and (2) the relationship between P_i and x_i is nonlinear. The choice of the function F determines the type of binary model. In principle, any proper, continuous probability distribution defined over the real line will suffice. The most commonly used distributions are the normal cumulative distribution function and the cumulative logistic function. These give a rise to probit and logit models, correspondingly (for more technical details see Appendix 2).

5. Results

5.1. Results of OLS estimation

Results of OLS cross-sectional regressions are presented in Table 2. Correlation matrix of the dependent and explanatory variables is presented in Appendix 3. As GDP_j and $AGGL_j$ are highly correlated we use them separately in regression models (3a) and (3b). In regression (3c) we use dummy variables for Russian districts in order to improve the statistical results of the model (3b).

All the variables except $\ln NR_j$ confirm their expected influence on the dependent variable with statistical significance. However we cannot say much of the unexpected influence of the resource variable. We note only that resource industries are highly monopolized in Russia and run by one or few big companies. Thus the total number of foreign firms in such regions depends on some specific factors.

Results highly support the hypothesis that most FDI into Russian economy at region level are market seeking as the proxy for market size in a region – $\ln GRP_j$ – have positive and significant effect on the dependent variable in all regressions. Secondly, the predictions of gravity model are supported: gross domestic products of both source countries ($\ln GDP_i$) and host regions ($\ln GRP_i$) and have positive effect on FDI and distance ($\ln DIST_{ij}$) has negative effect. All coefficients are statistically significant. From the results we also conclude that agglomeration effect has positive effect on inward FDI into Russia.

TABLE 2. OLS cross-sectional regressions results of gravity model of FDI's in Russian regions.

Variables	Model (2)	Model (3a)	Model (3b)	Model (3c)
C	-2.22* (-3.04)	-9.31* (-4.52)	-10.91* (-3.70)	-4.72* (-1.82)
$\ln GRP_j$	0.74* (10.04)	0.70* (8.31)		
$\ln GDP_i$	0.33* (10.98)	0.39* (10.70)	0.31* (8.21)	0.38* (10.31)
$\ln DIST_{ji}$	-0.82* (-8.28)	-0.72* (-7.11)	-0.53* (-4.62)	-0.76* (-5.22)
$\ln AGGL_j$			0.24* (3.40)	0.47* (5.42)
$\ln NR_j$		-0.35* (-2.72)	0.28* (2.61)	0.11 (0.99)
DV		0.44* (2.91)	0.31* (2.01)	0.41* (2.92)
Moscow		0.79* (1.82)	2.31* (4.81)	2.23* (5.08)
$\ln SKA_j$		1.81* (3.41)	2.70* (3.74)	1.14* (1.82)
D Ural				1.03* (4.41)
D Siberia				1.42* (5.82)
D Volga				0.003 (0.22)
D South				0.61* (2.82)
D North-West				0.98* (4.14)
D Far-East				1.51* (4.04)
Number of observations	282	282	282	282
Adjusted R^2	0.51	0.57	0.43	0.54
Jarque-Bera test for residual normality $\chi^2(2)$	1.39	3.86	13.4*	0.44
White's Hetero-skedasticity F-Test	75.8*	61.6*	75.6*	79.8*

Dependent variable is a natural logarithm of a number of foreign firms in a region j (j = 1,…,76) from country i (i = 1,…,6) at year-end for the year of 2002.
t-values in parenthesis (SE's corrected for heteroskedasticity). *) significant at 5% level.

DV_j is also significant and with expected sign. It confirms that common language and culture ties are positively related to inward FDI. Moscow variable is positive and significant, which means that the capital city advantage is a rather influential factor of FDI inflows into Russian economy. Skilled labor abundance variable $\ln SKA_j$ is also positive and significant and indicates that FDI into Russian regions are skilled-labor (or human capital) seeking. However according to the theory of FDI (see, e.g. Markusen, 2002), skilled labor abundant countries tend to have more outward and less inward FDI in comparison with skilled-labor scarce countries. There are at least two reasons that help to explain this contradiction. First, it is a well-known fact that labor force in Russia, including skilled labor, is rather cheap but the theory is based on the fact that skilled labor is costly and therefore FDI is seeking for cheap unskilled labor. Second, in recent years there is a FDI tendency in world economy seeking for, instead of cheap resources (including labor resources), the strategic assets (including human capital). Generally if we look at the magnitude of coefficients the most important factors are capital city` s advantages, skilled labor abundance, and the distance between source country and host region.

Almost all regional dummy variables for federal districts are statistically significant. Their coefficients are called differential intercept coefficients. The coefficients show how the intercepts differ between federal districts. In equation (3c) the coefficient b_1 = *-4.7* is the intercept of the regression for foreign firms in Central district. The intercept of the regression for foreign firms in the Far Eastern district, for example, equals to *(-4.7+1.5)*, for foreign firms in the North-Western district – *(-4.7+0.98)* and so on. If the differential intercept coefficient is statistically insignificant (like for Volga district in (3c)), than we may accept the hypothesis that the two regressions (here for foreign firms in Central district and for foreign firms in Volga district) have the same intercept, that is, the two regressions are concurrent and regional differences are not present.

4.2. Results of Binary Dependent Variable Models estimation

First, in order to make preliminary conclusions we conduct the dummy variable model for every explanatory variable. The model is the following:

(5) $$EV_i = b_0 + b_1 \cdot Dummy + u_i ,$$

where EV_i is one of the explanatory variables (not ion logarithms), namely, GRP_j, GDP_i, $DIST_{ij}$, $AGGL_j$, NR_j, DV_i, and SKA_j. Dummy is equivalent to the binary dependent variable (Y_{ij}). The model allows us to calculate the mean values of each explanatory variable for both sub-samples of our dataset and to see if they are significantly different from each other. First sub-sample includes observations when Y_{ij}=0 (150 observations) and second sub-sample includes observations when Y_{ij}=1 (282 observations). b_0 is the mean value for the first sample and $b_0 + b_1$ - for the second sub-sample. Table 4 displays the results of OLS estimation.

TABLE 4. Mean values for the explanatory variables of sub-samples of Y=0 and Y=1 classification

Variable	Mean by Y_{ij}		
	$Y_{ij} = 0\,(b_0)$	b_1	$Y_{ij} = 1\ (b_0 + b_1)$
GRP_j	1067* (12.35)	2783* (5.90)	3850
GDP_i	305202* (6.12)	533076* (7.11)	838278
$DIST_{ij}$	4360* (14.71)	-1380* (-4.25)	2980
$AGGL_j$	20* (14.11)	36* (4.12)	56
NR_j	46* (25.23))	1.9 (0.84)	---
DV_i	0.62* (15.50)	-0.18* (-3.61)	0.44
DV_i with control variable GDP_i	0.75* (22.01)	0.05 (1.31)	---
SKA_j	51* (98.12)	0.90 (1.41)	---

*) significant at 5% level.

The analysis suggests that the binary dependent variable do not seem to vary with natural resources (NR_j) and skilled labor abundance (SKA_j) variables as Y_{ij}'s coefficients are not significant in these cases. This means we cannot reject the hypothesis that $b_0 = b_0 + b_1$ (mean values for the both sub-samples equal to each other). For the DV_i we use also the dummy variable model with control variable GDP_i:

(6) $$DV_i = b_0 + b_1 \cdot Dummy + b_2 \cdot GDP_i + u_i \,.$$

Without this control variable the DV_i just captures the effect of Gross Domestic Product` s differences between two groups of source countries, namely Post Soviet and West European countries. Thus the results indicate the preliminary conclusions that all the other factors, namely, GRP_j, GDP_i, $DIST_{ij}$, $AGGL_j$ are important for FDI decision in binary dependent variable model.

Next we use logit and probit models introduced in Section 4.2 to determine the relative importance of the factors. We use the same specification of gravity model as for OLS estimation earlier. However now we use the whole sample. Note that we cannot use Moscow-dummy variable, as it is always equal to one for all $Y_{ij} = 1$ observations. All the explanatory variables except dummies have been standardized by the following way:

(7) $$x_{st} = \frac{x_i - \overline{x}}{SD(x_i)} \,.$$

The descriptive summary statistics of the variables used in estimation is presented in Appendix 4. The results of logit and probit modeling are represented in Table 5.

The results show that the crude form of gravity model's factors and agglomeration effect play an important role in FDI decision to invest or not into a particular Russian region as their coefficients are with expected signs and statistically significant. The coefficients of all the other factors, namely the stock of natural resources, dummy variable for cultural closeness and skilled labor abundance, were not statistically significant in most cases as expected from dummy variable analysis above. Thus we can proceed only with the crude form of gravity model.

TABLE 5. Binary Dependent Variable Models for FDI in Russian regions.

	Logit			Probit		
Explanatory variables	(2)	(3a)	(3b)	(2)	(3a)	(3b)
C	2.09* (4.71)	2.10* (3.61)	1.10* (4.62)	0.99* (4.25)	0.91* (3.42)	0.61* (4.71)
GRP_j	6.55* (4.12)	7.42* (3.43)		2.94* (3.24)	3.12 (3.21)	
GDP_i	1.01* (6.74)	1.21* (6.11)	1* (5.4)	0.58* (7.14)	0.67* (6.22)	0.60* (5.62)
$DIST_{ij}$	-0.41* (-3.23)	-0.35* (-2.71)	-0.14 (-1)	-0.21* (-3.12)	-0.21* (-2.60)	-0.11 (-0.96)
$AGGL_j$			4.11* (4.20)			2.41* (4.42)
NR_j		-0.30 (-1.63)	0.20* (1.93)		-0.10 (-1.1)	0.12* (1.92)
DV		0.05 (0.42)	0.42 (1.41)		0.24 (1.23)	0.25 (1.34)
SKA_j		0.53 (1.42)	0.22 (1.62)		0.02 (0.27)	0.12 (1.51)
Number of obs.	432	432	432	432	432	432
McFadden R-squared	0.27	0.28	0.16	0.25	0.26	0.16
Akaike IC	0.96	0.96	1.11	0.98	0.99	1.11
LM χ^2 -test for Heteroskedasticity	3.14	8.57*	8.55*	7.82*	11.3*	10.8*
Count R-squared [1)]	0.18	0.16	0.17	0.19	0.19	0.17

Dependent variable is $Y_{ij} = 0$ (no FDI firms) and $Y_{ij} = 1$ (at least one FDI firm) in region j (j = 1,…,76) from country i (i = 1,…,6) at year-end for the year 2002.
t-values in parenthesis (Huber/White SE). *) significant at 5% level.

[1)] Count R^2 is a measure of goodness of fit in binary regression model which is equal to number of correct predictions / total number of observations (Gujarati, 2003)

LM test for heteroskedasticity shows that for both cases (logit and probit models) we cannot reject the hypothesis of heteroskedasticity. Thus we use dummy variables in order to control for heterogeneity of the source countries. Because the country dummies are highly correlated with the gross domestic product` s variable of the source countries we exclude the latter from the equation. We estimate also an Extreme value distribution model as it is a robust alternative that partly solves heteroskedasticity problem (for details, see Appendix 2). The results are represented in Table 6.

In all model alternatives all coefficients are statistically significant except the dummy variable for Germany. LM test rejects the heteroskedasticity alternative. McFadden and Count R-squared statistics measure the goodness of fit of the model.

TABLE 6. Binary Dependent Variable Models for FDI in Russian regions with source countries dummies.

Explanatory variables	(2a) Logit	(2a) Probit	(2a) Extreme value
C	3.51* (5.61)	1.75* (5.31)	3.11* (7.34)
GRP_j	7.34* (3.92)	3.32* (3.07)	5.54* (4.81)
$DIST_{ij}$	-0.42* (-3.22)	-0.21* (-3.12)	-0.31* (-3.32)
D Germany	0.27 (0.54)	0.16 (0.59)	0.24 (0.57)
D Byelorussia	-1.51* (-3.22)	-0.91* (-3.61)	-1.10* (-3.01)
D Ukraine	-1.33* (-3.23)	-0.74* (-2.94)	-1.12* (-3.21)
D Kazakstan	-3.32* (-6.22)	-1.68* (-6.22)	-2.23* (-6.12)
D Finland	-2.25* (-4.81)	-1.28* (-4.91)	-1.63* (-4.62)
Number of observations	432	432	432
McFadden R-squared	0.31	0.29	0.32
Akaike IC	0.93	0.96	0.92
LM test for Heteroskedasticity	4.78	0.03	2.25
Count R-squared	0.20	0.19	0.19

Dependent variable is $Y_{ij} = 0$ (no FDI firms) $Y_{ij} = 1$ (at least one FDI firm) in region j (j = 1,…89) from country i (i = 1,…,6) at year-end for the year 2002.
t-values in parenthesis (Huber/White SE). *) significant at 5% level.

We also conclude here (holding other things constant) that Great Britain and Germany tend to have more firms in Russia than Finland. The Post-Soviet countries Byelorussia and Ukraine tend to also have more firms in Russia than Kazakhstan. Partly it can be explained by the differences in gross domestic product of the source countries: large economies tend to make more outward FDI than small. However Finland, being much larger than Byelorussia and Ukraine, tends to invest less into Russian economy than Byelorussia and Ukraine. One reason for it is the cultural closeness of the former Soviet Union republics to Russia. Unfortunately the two variables employed in the model, gross regional product and distance between host region and source country, are not directly comparable as they are measured differently.

In order to get a better overview of the marginal effects of independent variables, conditional predicted probabilities (for more details, see Appendix 4) have been computed using the model specification 2a-Probit. The results are presented in Table 7. The predicted probabilities tell us how many regions (in %) may have foreign firms from a particular source country. For instance, about 99 per cent of those Russian regions, which gross product is about 4500 million euros, will have German and British firms. Similarly 90% of them will have Finnish firms, 95 % -

Byelorussian firms, 96 % - Ukrainian firms, and 81 % - Kazakhstan` s firms. Table 7 also shows that assuming that, for example, distance variable is held at its median value, an increase of the gross product in a particular region by 1000 million euros, from 500 million euros to 1500 million euros, produces 12% increase of the predicted probability of having British or German firms in the region, 8% increase of the predicted probability of having Finnish firms and so on. The same conclusions can be made for distance variable.

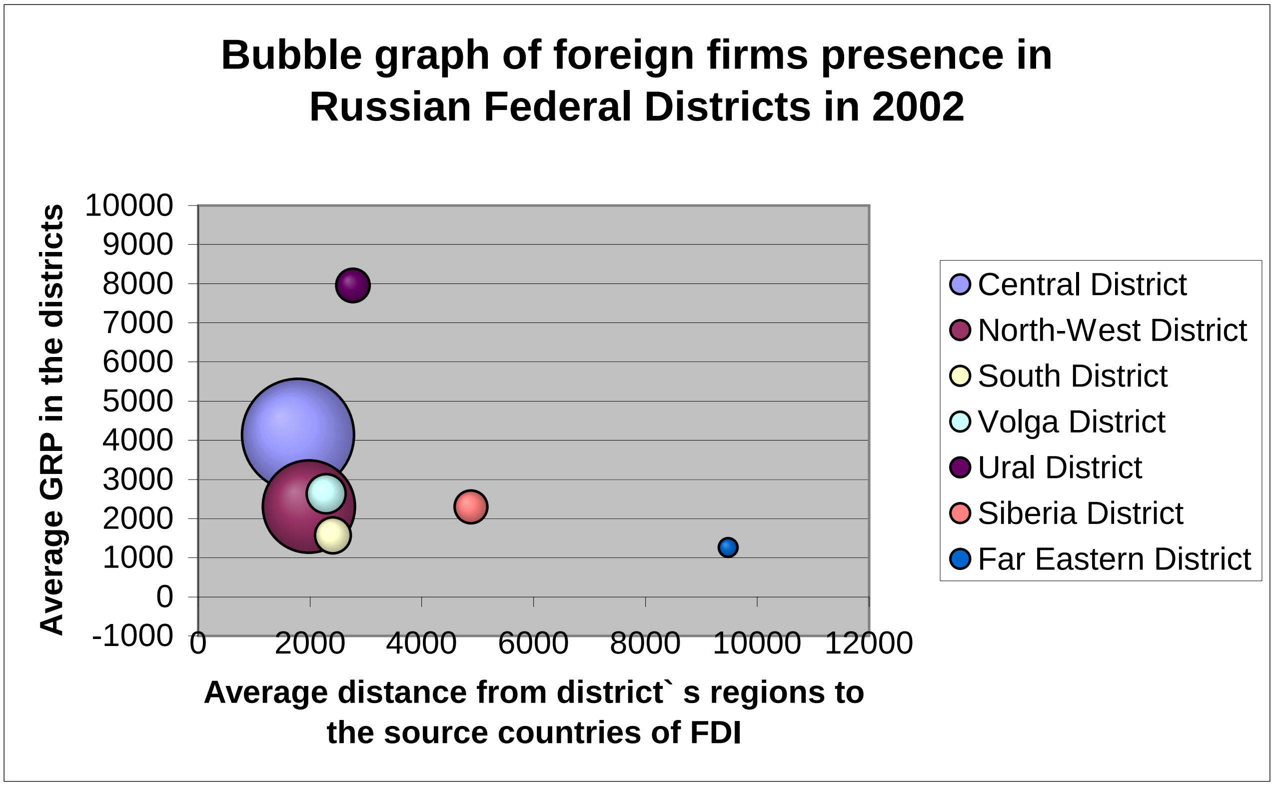
TABLE 7. Illustration with predicted probabilities, *Prob(Y=1)*

Predicted probabilities conditional on other variable is held at median value			
GRP_j -Gross Regional Product			
Great Britain and Germany			
500 million euro	1500 million euro	4500 million euro	13500 million euro
0.76	0.88	0.99	1
Finland			
0.28	0.46	0.90	1
Byelorussia			
0.42	0.61	0.95	1
Ukraine			
0.48	0.67	0.96	1
Kazakhstan			
0.16	0.31	0.81	1
$DIST_{ij}$ - Distance between source country and host region			
Great Britain and Germany			
500 km	1500 km	4500 km	13500 km
0.90	0.89	0.83	0.61
Finland			
0.5	0.47	0.38	0.16
Byelorussia			
0.64	0.62	0.53	0.27
Ukraine			
0.71	0.68	0.59	0.33
Kazakhstan			
0.34	0.32	0.24	0.08

To sum up our results in both OLS and Binary choice models we illustrate the application of gravity model approach to regional distribution of inward FDI (measured by a number of foreign firms) in Russia using a bubble graph. In the graph all Russian regions are grouped into seven

Russian federal districts. The bubbles size reflects the number of foreign firms in each federal district of the 6 source countries involved in the empirical study.

FIGURE 1. Number of FDI firms, source country distance and level of host region economy activity



In general the graph supports the results of our empirical study. Districts with larger average gross regional product and smaller average distance from FDI source country tend to have more foreign firms. The only one evident exception is Ural district where the most FDI is concentrated in resource industries (Pan-European Institute Report, 2004) that typically have few foreign firms. Central and North-Western districts have considerably more foreign firms than the other districts although the differences in the average gross regional product and distance are not so evident. Agglomeration effects in these districts are evident since the two biggest cities in Russia – Moscow and Saint Petersburg are located in these district. The relatively large amount of foreign firms in the Central district can be also explained by the capital city's advantages.

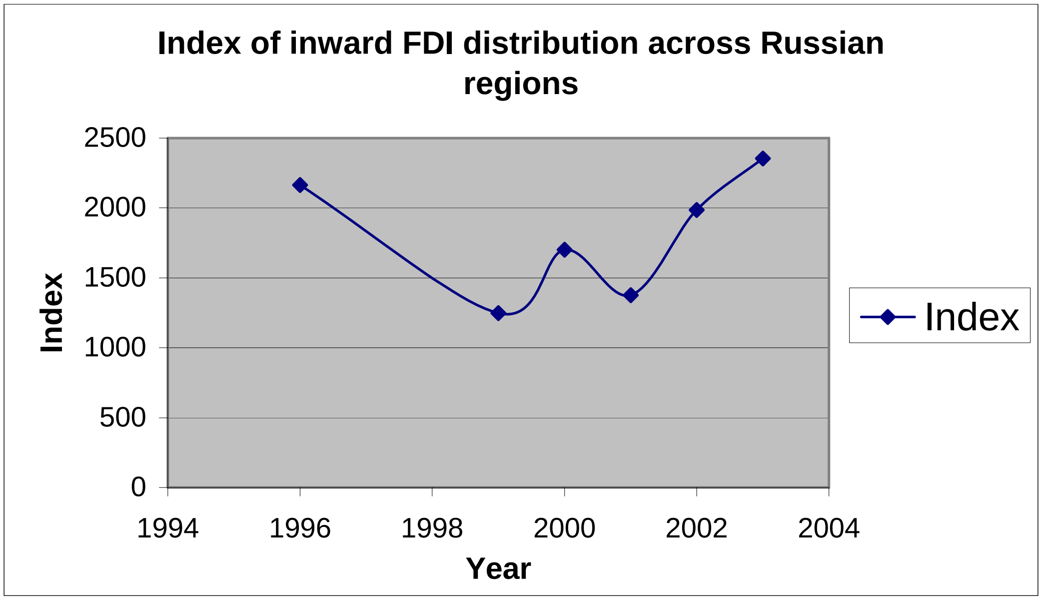
5. Conclusions

The paper analyzed the factors affecting the foreign firms presence of six source countries (namely Great Britain, Finland, Germany, Byelorussia, Ukraine and Kazakhstan) in 76 Russian regions. The analysis was conducted with a recently compiled cross-sectional data set from the period of 1998 - 2002 and with different specifications of a gravity model. Two econometric methods were used: OLS estimation and ML-estimation of Binary Dependent Variable Models. For OLS estimation we excluded all zero observations. The results suggest that gross products of host regions and source countries, agglomeration effect, capital city advantages, cultural closeness and skilled labor abundance are positively related to the number of foreign firms in a particular Russian region. The distance between host regions and source countries is negatively related to the dependent variable. As for the resource abundance there is no evidence of an expected positive influence on the dependent variable. The first possible explanation is the fact that the resource sector in Russia is highly monopolized. Although it attracts high amounts of foreign direct investments the number of foreign firms is rather low still in this sector.

In binary choice analysis we include also all zero observations. Thus the dependent variable equals to one if there is at least one foreign firm in a region of a particular source country and zero otherwise. The results show that only four factors can be considered to be important in determining the probability of a foreign firm entering in a particular Russian region. These factors are gross products of host regions and source countries, distance between them and agglomeration effect. According to the results the larger is the GDP of a host region and a source country and the larger is the agglomeration effect of a host region, the higher is the probability of the region to have foreign firms of this source country. Contrary to this, the larger is the distance between the host region and the source country the less is this probability.

Thus the major result of the study is that the necessary condition for FDI presence in a particular Russian region is its economic performance measured by gross regional product. The general level of regional infrastructure's development can also be viewed as an important factor of FDI presence in a region. Regarding the general conclusions we argue that the gravity model approach can be successfully applied to regional distribution of inward FDI in Russia irrespectively of the use of a number of foreign firms as a proxy for FDI.

Appendix 1. Herfindal-Hirshman Index of inward FDI distribution across Russian regions



Source: calculated on the basis of Goskomstat (2004)

Appendix 2. Theory on Binary Choice Models

2.1. Logit model

The logit binary choice model is based on the logistic cumulative distribution function:

$$\Pr(Y=1|x)=\frac{e^z}{1+e^z}, \qquad (1)$$

$$\Pr(Y=0|x)=1-\frac{e^z}{1+e^z}, \qquad (2),$$

where $z=b_1+b_2\cdot x_1+...+b_k\cdot x_k$. It is easy to verify that as z ranges from $-\infty$ to $+\infty$, Pr ranges between 0 and 1 and is related nonlinearly to z (i.e., x), thus satisfying elementary assumptions of probability modeling. But as Pr is nonlinear not only in x but also in the b` s we cannot use the familiar OLS procedure to estimate the parameters. However (1) and (2) can be linearized. If Pr, the probability of 1 is given by (1), then (1 - Pr), the probability of zero is:

$$1-\Pr=\frac{1}{1+e^z}, \qquad (3)$$

Therefore we can write:

$$\frac{\Pr}{1-\Pr}=\frac{1+e^z}{1+e^{-z}}=e^z, \qquad (4)$$

where $\frac{\Pr}{1-\Pr}$ is simply the odds ration in favor of 1. Now a linear model is obtained since

$$L = \ln(\frac{\Pr}{1-\Pr}) = z = b_1 + b_2 \cdot x_2 + ... + b_n \cdot x_n \, , \qquad (5)$$

where L is the log of the odds ratio.

2.2. Probit model

The estimating model that emerges from the normal CDF is known as the probit model. Briefly if a variable x follows the normal distribution with mean μ and variance σ^2, its CDF is:

$$F(X) = \int_{-\infty}^{x_0} \frac{1}{\sqrt{2\sigma^2 \pi}} e^{-(x-\mu)^2/2\sigma^2} \qquad (6)$$

where x_0 is some specified value of x. In fact one could substitute the normal CDF in place of the logistic CDE in (9) and (10) and proceed as in section 4.3.1. Also McFadden (1973) developed the probit model based on utility theory. Accordingly to McFadden if an event happens (1) (or not (0)) depends on an unobservable utility index I (also known as a latent variable), that is determined by one or more explanatory variables:

$$I = b_0 + b_1 \cdot x_1 + ... + b_n \cdot x_n \qquad (7)$$

It is assumed that there is a critical or threshold level of the Index, I*, such that if I exceeds I*, an event happens, otherwise it will not. If we assume that the threshold is normally distributed with the same mean and variance, it is possible not only to estimate the parameters of the Index given in (15) but also to get some information about the unobservable index itself.

Given the assumption of normality, the probability that I* is less than or equal to I can be computed from the standardized normal CDF as:

$$\Pr = \Pr(Y = 1 | x) = \Pr(I^* \le I) = \Pr(Z \le b_0 + b_1 \cdot x_1 + ... + b_n \cdot x_n) = F(b_0 + b_1 \cdot x_1 + ... + b_n \cdot x_n) \, , \qquad (8)$$

where z is the standard normal variable. F is the standard normal CDF, which can be written in the present context as:

$$F(I) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{I} e^{-z^2/2} dz = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{b_0 + b_1 \cdot x_1 + ... + b_n \cdot x_n} e^{-z^2/2} dz \qquad (9)$$

Thus, to get information on I, as well as on b` s, we take the inverse of (9) to obtain:

$$I = F^{-1}(I) = F^{-1}(\Pr) = b_0 + b_1 \cdot x_1 + ... + b_n \cdot x_n \, , \qquad (10)$$

where F^{-1} is the inverse of the normal FDI.

2.3. Extreme value model

The Extreme value model is based upon the CDF for the Type-I extreme value distribution:

$$\Pr(y_i = 1 | x_i, \beta) = 1 - (1 - \exp(-e^{-x_i'\beta})) = \exp(-e^{-x_i`\beta}). \qquad (11)$$

The distribution is skewed.

2.4. Estimating the binary choice models: method of maximum likelihood
In all cases for individual data we will have to use a nonlinear estimating procedure based on the method of maximum likelihood. Each observation is treated as a single draw from a Bernoulli distribution (binominal with one draw). The model with success probability F (x` β) and independent observations leads to the joint probability, or likelihood function:

$$\Pr ob(Y_1 = y_1, Y_2 = y_2, ..., Y_n = y_n | X) = \prod_{y_i=0} [1 - F(x`\beta)] \prod_{y_i=1} F(x`\beta), \qquad (12)$$

where X denotes $[x_i]_{i=1,...,n.}$ The likelihood function for a sample of n observations can be written as:

$$L(\beta | data) = \prod_{i=1}^{n} [F(x`\beta)]^{y_i} [1 - F(x`\beta)]^{1-y_i} . \qquad (13)$$

Taking logs we obtain:

$$\ln L = \sum_{i=1}^{n} \{ y_i \ln F(x`\beta) + (1 - y_i) \ln [1 - F(x`\beta)] \}. \qquad (14)$$

The likelihood equation is the following:

$$\frac{\partial \ln L}{\partial \beta} = \sum_{i=1}^{n} \left[\frac{y_i f_i}{F_i} + (1 - y_i) \cdot \frac{-f_i}{(1 - F_i)} \right] \cdot x_i = 0, \qquad (15)$$

where f_i is the density, $dF_i / d(x`\beta)$. The choice of a particular form for F_i leads to the empirical model (Gujarati, 2003; Greene, 2003).

2.5. Interpretations of coefficients in logit and probit models
In the logit (and in extreme value) model the slope coefficient of a variable gives a change in the log of the odds associated with a unit change in that variable, holding all other variables constant. The slope coefficient for dummy variables indicates a change in the log of the odds associated with the change from 0 to 1 of a variable.

In the probit model the slope coefficient of a variable gives a standard deviation change in the predicted probit index associated with a unit change in that variable, holding all other variables constant. For dummy variable, the slope coefficient gives a standard deviation change in the predicted probit index associated with the change from 0 to 1 of a variable.

There are several ways of interpreting parameter estimates in probability models (Liao, 1994). In our study we use two of them. First concerns the sign of parameter estimate and its statistical significance. Given a significant statistical test, a positive sign of a parameter estimate suggests the likelihood of the response (event) increases with the level or presence of explanatory variable x, with the other x` s held constant, depending on whether the variable is continuous or dichotomous. Conversely, a negative sign of the estimate suggests that the likelihood of the response decreases with the level or presence of x.

Second concerns the predicted probabilities given a set of values in the explanatory variables. Predicted probabilities are intuitively appealing because these give an idea of how likely certain types of events are to affect certain outcomes. Using certain values of the x variables, predicted probabilities are derived by calculating the values of μ :

$$\mu = \sum_{k=1}^{k} \beta_k x_k . \quad (16)$$

Than we specify η as a linear predictor produced by $x_1, x_2, ..., x_k$. Regardless of the type of model, the set of explanatory variables always linearly produce η, which is a predictor of Y. The relation between η and the x variable is given by:

$$\eta = \sum_{k=1}^{k} \beta_k \cdot x_k . \quad (17)$$

Applying this link function to Equation (16), we specify a logit and probit models:

$$\eta = \log\left[\mu/(1-\mu)\right] \quad (18) \qquad \eta = \Phi^{-1}(\mu), \quad (19)$$

where Φ^{-1} is the inverse of the standard normal cumulative distribution function.

Thus we calculate the predicted probabilities e.g. for logit and probit models in the following way:

$$Prob(Y=1) = \frac{e^{b_0 + b_1 \cdot x_1 + ... b_n \cdot x_n}}{1 + e^{b_0 + b_1 \cdot x_1 + ... b_n \cdot x_n}}, \quad (20) \qquad \Pr ob(Y=1) = \Phi(b_0 + b_1 \cdot x_1 + ... b_n \cdot x_n). \quad (21)$$

If we have many explanatory variables, some of which are categorical, some continuous, it is better to focus on one or two variables of interest and set the values in other variables at their sample means. If one of the two variables that have been selected is discrete and the other is continuous, it is advisable to plot the predicted probability values against the continuous x variable within each category of the discrete variable (Liao, 1994).

Appendix 3. Correlation matrix of the dependent and explanatory variables used in OLS estimation

	Y	GRP_j	GDP_i	$DIST_{ij}$	$AGGL_j$	NR_j	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	SKAj	DVj	MOS
Y	1.0	0.6	0.1	-0.1	0.7	-0.2	0.1	0.0	0.0	0.0	-0.1	0.1	0.0	-0.1	-0.1	0.0	0.1	-0.1	0.4	-0.1	0.6
GRPj	0.6	1.0	-0.1	-0.1	0.9	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.5	0.0	0.9
GDPi	0.1	-0.1	1.0	0.3	0.0	0.0	0.7	-0.4	-0.4	-0.3	-0.3	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.0	-0.6	0.0
DISTji	-0.1	-0.1	0.3	1.0	-0.1	0.2	0.1	-0.2	-0.2	0.0	-0.1	-0.3	0.0	0.3	-0.1	-0.1	-0.2	0.8	0.2	-0.3	-0.1
AGGLj	0.7	0.9	0.0	-0.1	1.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	-0.1	0.0	0.0	-0.1	-0.1	0.4	0.0	1.0
NRj	-0.2	0.1	0.0	0.2	-0.2	1.0	0.0	0.0	0.0	0.0	0.1	-0.3	0.4	0.2	-0.1	0.0	0.0	0.0	0.0	0.0	-0.2
D1 Germany	0.1	0.0	0.7	0.1	0.0	0.0	1.0	-0.2	-0.2	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0
D2 Byelorussia	0.0	0.0	-0.4	-0.2	0.0	0.0	-0.2	1.0	-0.2	-0.2	-0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
D3 Ukraine	0.0	0.0	-0.4	-0.2	0.0	0.0	-0.2	-0.2	1.0	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
D4 Finland	0.0	0.0	-0.3	0.0	0.0	0.0	-0.2	-0.2	-0.2	1.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	-0.3	0.0
D5 Kazakhstan	-0.1	0.1	-0.3	-0.1	0.0	0.1	-0.2	-0.1	-0.2	-0.1	1.0	-0.1	0.1	0.1	0.0	0.0	0.0	-0.1	0.0	-0.2	0.0
D6 Central	0.1	0.1	0.0	-0.3	0.3	-0.3	0.0	0.1	0.0	-0.1	-0.1	1.0	-0.2	-0.2	-0.3	-0.2	-0.3	-0.2	-0.1	0.1	0.3
D7 Ural	0.0	0.2	-0.1	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	-0.2	1.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.1	0.0	0.0
D8 Siberia	-0.1	-0.1	0.0	0.3	-0.1	0.2	0.0	0.0	0.0	0.0	0.1	-0.2	-0.1	1.0	-0.2	-0.1	-0.2	-0.1	0.0	0.0	-0.1
D9 Volga	-0.1	-0.1	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.3	-0.1	-0.2	1.0	-0.2	-0.2	-0.1	-0.3	0.0	-0.1
D10 South	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1	-0.1	-0.2	1.0	-0.1	-0.1	0.1	0.0	0.0
D11 North West	0.1	-0.1	0.0	-0.2	-0.1	0.0	0.0	0.0	0.0	0.1	0.0	-0.3	-0.1	-0.2	-0.2	-0.1	1.0	-0.1	0.1	0.0	-0.1
D12 Far East	-0.1	-0.1	0.1	0.8	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	1.0	0.2	-0.1	0.0
SKAj	0.4	0.5	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	0.1	0.0	-0.3	0.1	0.1	0.2	1.0	0.0	0.4
DVj	-0.1	0.0	-0.6	-0.3	0.0	0.0	-0.4	0.6	0.6	-0.3	-0.2	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	1.0	0.0
MOSCOW	0.6	0.9	0.0	-0.1	1.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	-0.1	-0.1	0.0	-0.1	0.0	0.4	0.0	1.0

Appendix 4. Descriptive statistics of the dependent and explanatory variables used in Binary Choice Models

	Y	$DISTji$	GRP_j	GDP_i	SKA_j	$AGGL_j$	NR_j
Mean	0.7	3386.4	2887.1	654416.1	51.9	43.4	46.8
Median	1.0	2553.0	1390.2	89638.2	51.5	23.4	40.0
Maximum	1.0	12736.0	51307.9	2110400.0	67.6	1117.1	94.1
Minimum	0.0	323.0	128.8	12965.4	40.4	0.8	9.1
Std. Dev.	0.5	2742.6	6450.8	864068.3	5.8	129.9	21.5
Skewness	-0.7	1.5	6.2	0.8	0.2	7.9	0.5
Kurtosis	1.4	4.6	45.4	1.8	2.7	65.2	2.1
Jarque-Bera test	75.3	200.3	35042.6	73.0	4.2	74058.8	28.6

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