The Spatial effects for the Eastern and Western regions of Russia: the comparative analysis

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ABSTRACT

The purpose of this study is to identify the spatial effects of the main macroeconomic indicators of the eastern and western regions of Russia. These regions differ significantly in population density and the distances between cities. The main research question we are interested in is the following: how are events occurring in one of the western (or eastern) region, such as economic growth or a decrease in the unemployment rate, effecting similar indicators in other western and eastern regions. The spatial effects of the western and eastern regions, when considered separately, may differ both qualitatively and with of the 'flow on effect'. The determinants of the same macro-economic indicators in the eastern and western regions may also differ. In order to test the hypothesis of a possible difference in the spatial effects and determinants for these regions, we have developed a special class of model with four spatial matrices (west-west, east- east, west-east, and east-west) and a double set of control variables (one for each type of region). As the macroeconomic indicators monitor the rate of unemployment in the region, the real regional wage and GRP growth for the year were chosen for our models. We controlled the variables describing the socio-demographic situation in the region, migration processes, economic development, and export-import activity in the region. The models were estimated by the Arellano-Bond method on panel data for Russian regions over 2000-2010. Our analysis revealed, 1) a positive spatial correlation of the main macroeconomic indicators for the western regions, 2) both positive and negative externalities for the eastern regions and 3) the asymmetric influence of eastern and western regions on each other. Usually "impulses" from the western regions have a positive effect on the eastern regions, but the "impulses" from the eastern regions usually do not affect the western regions.

1. INTRODUCTION

Spatial econometrics began with the pioneering articles of Anselin (1980, 2006). The idea underlying spatial econometric models is quite simple; in modelling the macroeconomic indicators of a region, it is necessary to take macroeconomic indicators of this region into account and also to account for the values of these indicators in other regions, especially outlying regions. However, we cannot simply add the additional parameter for each region; in this case, the number of degrees of freedom would decrease dramatically. Therefore, we attempt to reduce the number of estimated parameters. In spatial econometric models, this is achieved by introducing a weighting matrix W (such as a boundary or a distance matrix, but possibly a matrix of trade flows). Thus, the number of parameters that reflect the influence of other regions is reduced to one – the spatial autocorrelation coefficient (which is similar to the autocorrelation coefficients in the time series). If this coefficient is significant and positive (negative), then positive (negative) externalities may exist, i.e., any change that has occurred in one region will lead to a similar (opposite) change in neighbouring regions (if you use the boundary matrix).

For thirty years, spatial econometrics has been a dynamically developing field. With the appearance of special modules in modern statistical software packages the number of empirical studies in this area has sharply increased.

However, this has created some problems. Gibbons and Overman (2012) criticized the common practice in the assessment models SAR, SEM, SLX etc. for excessive technicality and the strong assumption that «… spatial econometrics assumes that W is known and represents real-world linkages. Neighborhood effects researchers argue that the true W is almost never known". Corrado and Fingleton (2012) agree with them: "…so-called W matrix, which is integral to the structure of endogenous and exogenous spatial lags, and to spatial error processes, and which are almost the sine qua non of spatial econometrics. Moreover, it has been suggested that the significance of a spatially lagged dependent variable involving W may be misleading, since it may be simply picking up the effects of omitted spatially dependent variables, incorrectly suggesting the existence of a spillover mechanism". A more detailed description of these and other problems related to spatial models given in (Partridge, 2012).

(Vega and Elhorst, 2013) partially agree with this criticism: "Although some of the critiques raised are valid, they are issues that can be overcome by improving applied spatial econometric work. There has been excessive use of so-called global spillover models and too much emphasis on statistical testing procedures". They propose adding extra parameter as a possible solution to this problem (and weighted matrix W depends on this parameter): "The commonly adopted procedure is to test the OLS model against the SAR and SEM models for an exogenously specified spatial weights matrix W. Instead, we propose that taking the SLX model using a W that is parameterized represents a better point of departure." This proposal has led to remarkable results in one empirical case, however it is hardly possible to argue that the introduction of distance decay parameter solves the problem of choosing the specification in all cases.

Another possible way to solve the problems raised is the use of Bayesian methods of estimation. This is done, for example, in LeSage et al. (2007, 2008), Fisher (2013). However, the Bayesian approach has both advantages and disadvantages. As noted by Corrado and Fingleton (2012) "While parameter uncertainty is well known, model uncertainty involving the unknown true structure of the W matrix is less well explored. However, finding the true W may involve searching through a very large number of competing specifications, which may include the true specification, rather than being decided on theoretical grounds."

One more way to relax the strong conditions of SAR, SEM etc. models is a preliminary decomposition of spatial objects into several parts for which there may be a different spatial dependence. For example, Europe is often divided into east and west (see, for example, Basile, 2010), core and periphery (Basile, 2012). Regions of the same country are often also divided into parts, in particular, Germany into the eastern and western parts (Fuchs-Schundeln and Izem , 2012; Lottmann, 2012), Italy into the northern and southern parts (Basile, 2012). Here are just a few examples.

For example, Basile R. (2010) found that "The regional distribution of labour productivity in Western Europe is characterized by a Core-Periphery spatial pattern: high (low) productivity regions are in a proximate relationship with other high (low) productivity regions. Over the period 1980-2003, intra-distribution dynamics has generated long-run multiple equilibria with the formation of two clubs of convergence."

A spatial model of commuting is used by Fuchs-Schundeln and Izem (2012) to analyze the behavior of the unemployment rate across the former East–West border in Germany. The authors found that the comparatively low labor productivity in East Germany after reunification is not caused by the depreciation of human capital at reunification, but rather by unfavourable job characteristics. Schioppa and Basile (2002) compare the unemployment situation of Italy's Mezzogiorno (regions located in the south of the country and in the islands) with that of other "Mezzogiornos" of Europe. They concluded: "The results of the analysis show that, in the nineties, regional unemployment rate differentials within the EU have widened. The growing disparities have not been determined, however, by a larger Core/Periphery gap, but by an increased variability within both areas". "The South of Italy is the most dramatic case16: over the period 1993-2000, the ratio between the unemployment rate of the Mezzogiorno and that of the European Union has increased from 1.7 to 2.5, which means that the chance to be unemployed in the South today is twice and a half that of the Union average, while it was less than twice eight years ago".

The present study attempts to identify the spatial effects for Russia, the largest and also heterogenous country. It should be noted that there are only scarce numbers of empirical studies that have used Russian data in a spatial context. For example Lugovoy, (2007) noted "Even during a relatively short period under consideration (1998–2004) one can talk about significant spatial heterogeneity in economic development of Russian regions, which obviously should be taken into account in empirical studies of regional growth". According Kholodilin et al, (2009) "… the overall speed of regional convergence in Russia, being low by international standards, becomes even lower after controlling for spatial effects. However, when accounting for the spatial regimes, we find a strong regional convergence among high-income regions located near other high-income regions". Demidova et al, (2012) revealed the spatial effects for youth unemployment in the Russian regions. Kolomak (2010) empirically demonstrated the heterogeneity of the Russian regions, and positive externalities were observed in the western regions, whereas negative externalities were observed in the eastern regions.

The present study continues the spatial econometrics work using Russian regional data. Following Kolomak, all regions are split into eastern and western. This paper develops the research in this area by using 1) Both annual and average (for 11 years) spatial effects are calculated, 2) Special class of model with four spatial matrices (west-west, east- east, west-east, and east-west) and 3) a double set of control variables (one for each type of region). Such models allow us to indentify the possible differences between eastern and western Russian regions and their asymmetric impact on each other.

The structure of the paper is as follows. The second section describes the Russian regional data used in the study and the macroeconomic variables that were analysed to determine whether they were exerting spatial effects. The third section contains the models for revealing the annual spatial effects, and the fourth section includes the models for the estimation of the average spatial effects. The final section concludes.

2. DATA AND DEPENDENT VARIABLES

In this study, three macroeconomic indicators were selected to identify possible spatial effects: the unemployment rate in the region (as a percentage), real wages (the ratio of wages in the region and in Russia, on average, divided by the ratio of the minimum basket of goods and services price in the region and in Russia, on average, * 100), and gross regional product

(GRP) growth in the region for the year (as a percentage). Thus, the identification of a positive spatial effect for GRP growth means that economically growing regions "drag" other regions. Simultaneously, the impact of negative spatial effects for GRP growth corresponds to the growing region taking resources, which does not give rise to other regions doing the same. Obviously, the spatial effects can experience dynamic changes over time. It makes sense to separate short-term (in this study, annual) and long-term (in this study 11 years) spatial effects. All calculations were performed on the data for the 2000 - 2010 period for 75 Russian regions. The data for the other 8 regions were not included in the study for the following reasons: 1) there were changes in the administrative-territorial structure of Russia, 2) for some regions, such as Chechnya, official data for some years are absent. There were 52 western regions and the 23 eastern regions (a list of all regions is given in Table A1 in Appendix).

These two groups of regions are substantially different. Western regions are smaller and more densily populated. Therefore, we can expect different spatial effects for these two groups of regions.

Traditionally, the identification of spatial effects begins with the calculation of the Moran indices (an analogue of the correlation coefficient in the spatial case).

Moran's index for variable X is defined as:

$$I(X) = \frac{N}{\sum_{i,j} w_{ij}} \frac{\sum_{i,j} w_{ij}(X_i - \overline{X})(X_j - \overline{X})}{\sum_i (X_i - \overline{X})^2}$$

where N is the number of spatial units indexed by i and j, $\overline{X}$ is the mean of X, and w_{ij} are elements of the weighted spatial matrix. Moran's I index values range from −1 (indicating perfect dispersion) to 1 (indicating perfect correlation). A zero value indicates an absence of spatial correlation. For significance testing, Moran's I values can be transformed to Z-scores in which values greater than 1.96 or smaller than −1.96 indicate spatial autocorrelation that is significant at the 5% level. A positive index indicates that any change in the other regions is given to the same (opposite) changes in considered region.

In the current study, two weighting matrices are used, boundary and inverse distance. Moran’s I with the boundary weighting matrix reveals the influence of only the boundary regions, as in the case of Moran’s I with inverted distance spatial matrix - the impact of all the regions.

Tables 1-3 contain the Moran index for each indicator and for each year for each region and separately for the group of 52 western regions and the group of 23 eastern regions.

Table1: Moran's spatial correlation indexes for the variable "Unemployment"

Years	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Boundary weighted matrix											
All Russia	0.387***	0.339***	0.334***	0.42***	0.345***	0.257***	0.346***	0.367***	0.343***	0.27***	0.248***
West of Russia	0.393***	0.382***	0.352***	0.405***	0.355***	0.252***	0.355***	0.411***	0.357***	0.233***	0.235***
East of Russia	0.132	0.068	0.14	0.367***	0.183*	0.163*	0.162	0.136	0.14	0.195*	0.12
Inverted distance weighted matrix											
All Russia	0.182***	0.159***	0.156***	0.19***	0.178***	0.132***	0.152***	0.17***	0.146***	0.103***	0.115***
West of Russia	0.209***	0.223***	0.198***	0.217***	0.212****	0.162***	0.194***	0.221***	0.182****	0.132***	0.168***
East of Russia	-0.021	-0.057	-0.035	0.147***	0.01	0.005	-0.025	-0.02	-0.022	-0.033	-0.062

Table2: Moran's spatial correlation indexes for the variable "Real Wage"

Years	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Boundary weighted matrix											
All Russia	0.347***	0.369***	0.412***	0.419***	0.448***	0.441***	0.445***	0.402***	0.396***	0.384***	0.396***
West of Russia	0.397***	0.467***	0.484***	0.485***	0.489***	0.514***	0.479***	0.461***	0.461***	0.414***	0.386***
East of Russia	0.016	0.031	0.022	0.046	0.076	0.055	0.131	0.049	0.026	0.024	0.035
Inverted distance weighted matrix											
All Russia	0.05***	0.053***	0.075***	0.086***	0.095***	0.103***	0.094***	0.109***	0.133***	0.123***	0.134***
West of Russia	0.086***	0.113***	0.146***	0.165***	0.157****	0.183***	0.184***	0.203***	0.228****	0.203***	0.206***
East of Russia	-0.102	-0.104	-0.103	-0.092	-0.078	-0.072	-0.055	-0.064	-0.058	-0.073	-0.074

Table3: Moran's spatial correlation indexes for the variable "GRP Growth"

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Boundary weighted matrix											
All Russia	0.064	0.057	0.229***	0.141**	0.052	0.109	0.179**	0.076	0.293***	0.186**	0.179**
West of Russia	0.047	-0.007	0.297***	0.127*	0.051	0.168**	0.034	0.116***	0.363***	0.154*	0.04
East of Russia	-0.075	0.036	0.107	0.18	0.061	0.047	0.261**	-0.022	-0.09	0.281**	0.26**
Inverted distance weighted matrix											
All Russia	0.029**	0.009***	0.102***	0.042**	-0.019	0.058***	0.026	-0.011	0.068***	0.084***	0.059***
West of Russia	0.004	0.001	0.15***	0.048***	0.002	0.101***	-0.022	-0.002	0.056**	0.065***	-0.036
East of Russia	0.073**	-0.079	-0.08	0.021	-0.087	0.072*	0.036	-0.045	-0.063	0.19***	0.15***

A persistently positive and significant Moran index for the level of unemployment and real wages in the western regions indicates that similar processes are exerting effects in this part of Russia. For the eastern regions, the values and significance of the Moran index for the same indicators are unstable over time. Thus, we can assume that there are annual spatial effects only for the western Russian regions and only for the first two macroeconomic indicators.

3. MODELS FOR THE DETECTION OF ANNUAL SPATIAL EFFECTS

The correlation matrix is just the first step in the regression analysis, and the Moran indices only permit the initial assumption about the existence of spatial effects. For example, a positive Moran's index for the unemployment rate suggests that the level of unemployment in one Russian region might affect the unemployment rates in other Russian regions. However, this is not sufficient; we must take into account the effects of other explanatory variables, such as GRP per capita.

Spatial annual effects are usually estimated with spatial autoregressive (SAR) models

$Y = X\beta + \rho WY + \varepsilon$, (1) where X is a matrix of explanatory variables, β is a vector of the estimated coefficients, W is a weighted matrix, ε is a vector of disturbances, and ρ is a spatial correlation coefficient (the sign and significance of ρ precisely characterise the presence or absence of spatial effects).

The parameters of equation (1) cannot be assessed by a test such as the least squares method, as a necessary condition of uncorrelated factors and disturbances disrupted. For this purpose, the method of maximum likelihood is used. The following calculations were performed using the module in the STATA[1] statistical software package.

The following factors were selected for their explanatory power:

1) The share of the urban population in the region. (It is assumed that it is easier to find a job in the cities and, therefore, that the unemployment rate there must be lower in the cities and real wages higher. It is natural to assume that cities are locomotives of economic growth. However, in "monocities", the situation may be reversed when the core enterprise closes. To account for this ambiguity, the quadratic dependence was chosen.)

2) The population density. (The explanation of this variable's inclusion is similar to the share of urban population variable; it is assumed that it is easier to find a job and higher salary in a densely populated area.)

3) Net migration rate. (On the one hand, migrants tend to move to economically favourable areas with low unemployment, high wages, etc., and we can face the problem of endogeneity. On the other hand, if the flow of migrants is significant, it might change the economic situation in the region).

4) Real GRP per capita, which is calculated as the ratio of GRP per capita and in Russia, on average, and the cost of the minimum basket of goods and services in the region and in Russia, on average, * 100%[2.] (It is assumed that the higher the GRP per capita, the better the economic situation, i.e., the lower the unemployment rate, the higher that real wages are and the higher the level of economic growth.)

5) The variables of the export-import activity in the region, which is calculated as the ratio of exports and imports in the region in rubles to GRP * 100%. (It is assumed that sufficient export and import activity in the region can stimulate economic growth. Simultaneously, the export activity in the region might encourage the creation of new jobs,

[1] The command spatreg.
[2] To avoid the problem of endogeneity, this variable is included in the model with an annual lag.

reduce the unemployment rate and increase real wages. Intense flows of imports may have the opposite effect on these last indicators)[3].

The results of the spatial lags coefficients of the models (1) with the dependent variables, Y_1 (the unemployment rate in the region), Y_2 (the real wage), and Y_3 (the GRP growth in the region) are presented in Tables 4-6.

Table 4: Annual spatial effects for the variable "Unemployment"

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Boundary weighted matrix											
All Russia	0.383***	0.378***	0.352***	0.376***	0.296***	0.169	0.311***	0.417***	0.284**	0.257**	0.168
West of Russia	0.331**	0.290*	0.351**	0.254**	0.207	0.075	0.211	0.386***	0.256*	0.022	-0.094
East of Russia	-0.001	0.122	0.464**	0.503**	0.384*	0.242	0.137	0.221	0.05	0.1	0.148
Inverted distance weighted matrix											
All Russia	0.814***	0.715***	0.716***	0.770***	0.731***	0.524**	0.619***	0.691***	0.529**	0.38	0.426
West of Russia	0.723***	0.659***	0.713***	0.510**	0.545**	0.404	0.406	0.560**	0.363	0.016	0.291
East of Russia	-0.938*	-0.452	0.201	0.699***	0.435	0.374	0.266	-0.264	-0.348	-0.446	-0.405

Table 5: Annual spatial effects for the variable "Real Wage"

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Boundary weighted matrix											
All Russia	0.189***	0.327***	0.290***	0.335***	0.308***	0.282***	0.263***	0.224***	0.269***	0.269***	0.284***
West of Russia	0.244**	0.429***	0.349***	0.297***	0.368***	0.157*	0.067	0.058	0.038	0.143	0.034
East of Russia	-0.287	0.083	-0.02	0.059	0.087	0.043	0.183	0.069	0.019	-0.041	-0.072
Inverted distance weighted matrix											

[3] The effect of export and import to CIS and non-CIS countries may differ.

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
All Russia	0.568***	0.612***	0.653***	0.727***	0.712***	0.690***	0.442**	0.476***	0.705***	0.595***	0.596***
West of Russia	0.688***	0.769***	0.596***	0.492**	0.505**	0.476**	0.127	0.204	0.390**	0.247	0.255
East of Russia	-0.176	-0.143	-0.004	-0.08	0.145	0.106	0.101	0.181	0.167	-0.155	-0.217

Table 6: Annual spatial effects for the variable "GRP Growth"

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Boundary weighted matrix											
All Russia	-0.011	0.15	0.391***	0.025	0.109	0.078	0.166	-0.025	0.303**	0.18	0.456***
West of Russia	-0.036	0.066	0.27	0.059	0.06	0.047	-0.161	0.04	0.203	0.21	0.299*
East of Russia	-0.806***	0.246	0.022	-0.118	0.041	-0.206	0.257	-0.352	-0.048	-0.178	0.372
Inverted distance weighted matrix											
All Russia	0.362	0.019	0.676***	0.262	-0.44	0.428	-0.007	-0.625	0.203	0.553**	0.692***
West of Russia	0.045	0.000	0.700***	0.081	0.198	0.511	-0.916	-0.095	0.123	0.345	-0.213
East of Russia	-0.726	-1.211**	-1.081*	-0.481	-1.487**	0.053	0.021	-1.198***	-0.473	0.214	0.071

Because the study of Moran's indices revealed fundamental differences between the western and eastern regions, the estimation of the models (1) was conducted for all observations and separately for the western and eastern regions. Unfortunately, the separation of the sample reduces the efficiency of the estimates of the coefficients.

According to the obtained results (tables 4-6), we observe the following:

1) Spatial correlation coefficients estimates for the unemployment rate are significant and positive for Russia as a whole (with the exception of 2009 and 2010, which may indicate the influence of the global financial crisis) and for more than a half year in the western regions.

2) The estimates of the spatial lags for real wages are also significant and positive for Russia as a whole and for the western regions in most years.

3) The estimates of the spatial lags for GRP growth are mostly insignificant (even for the total sample) and positive only in some cases.

4) For almost all the eastern regions, the spatial lags are insignificant (this may be a consequence of the small sample size).[4]

In interpreting the obtained results, it should be noted that it was possible to identify the annual spatial effects for the real wages and the unemployment rate, i.e., if the level of real wages increased in certain regions (or decreased the unemployment rate), this "impulse" will be transferred to other Russian regions.

Interpretations of the other results are deliberately omitted because I do not want to obscure the main research question about spatial effects.

The obtained results (i.e., the insignificance of many estimated coefficients) suggest that the identification of annual spatial effects on cross-sectional data for Russian regions is not a prospective approach. It is difficult to "catch" any spatial effects on small samples. Much more promising is to search for average (during long time period) spatial effects in the panel data.

Selection of a suitable model for this case is discussed in the next section.

4. MODELS FOR THE DETECTION OF AVERAGE SPATIAL EFFECTS

To identify the possible differences in the spatial effects for the eastern and western regions and to identify the mutual influence of the two groups of regions on one another, all the explanatory variables were divided into two parts that correspond to the observations for the western and eastern regions, and the weight matrices were divided into four parts (with an explanation provided below) and the following dynamic model is proposed:

$$\begin{pmatrix} YW_{i_w t} \\ YE_{i_e t} \end{pmatrix} = \sigma \begin{pmatrix} YW_{i_w t-1} \\ YE_{i_e t-1} \end{pmatrix} + \begin{pmatrix} \rho_{bww} W_{bww} & \rho_{bwe} W_{bwe} \\ \rho_{bew} W_{bew} & \rho_{bee} W_{bee} \end{pmatrix} \begin{pmatrix} YW_{i_w t} \\ YE_{i_e t} \end{pmatrix} + \begin{pmatrix} X_w \beta_w \\ X_e \beta_e \end{pmatrix} + \sum_{k=1}^{10} \gamma_k d_{200k} + \alpha_i + \varepsilon_{it}, \quad (2)$$

$$\begin{pmatrix} YW_{i_w t} \\ YE_{i_e t} \end{pmatrix} = \sigma \begin{pmatrix} YW_{i_w t-1} \\ YE_{i_e t-1} \end{pmatrix} + \begin{pmatrix} \rho_{idww} W_{idww} & \rho_{idwe} W_{idwe} \\ \rho_{idew} W_{idew} & \rho_{idee} W_{idee} \end{pmatrix} \begin{pmatrix} YW_{i_w t} \\ YE_{i_e t} \end{pmatrix} + \begin{pmatrix} X_w \beta_w \\ X_e \beta_e \end{pmatrix} + \sum_{k=1}^{10} \gamma_k d_{200k} + \alpha_i + \varepsilon_{it}, \quad (3)$$

[4] In this section, I discuss only short-term (annual) spatial effects.

where YW and YE are the «western» and «eastern» parts of the corresponding dependent variable (level of unemployment or real wage or GRP growth), respectively, $i_w = 1,...,52, i_e = 53,...,75, i = 1,...,75, t = 2000,...,2010$, and $d_{2001} - d_{2010}$ are dummy variables for the corresponding year, α_i, $i = 1,...,75$ are individual regional effects, and $\varepsilon_{it} \sim iid(0, \sigma_\varepsilon^2)$ are disturbances. Matrices X_w and X_e consist of the same variables, but with «western» and «eastern» sets of observations.

The weighted matrices (normalised by rows) are divided into four parts; for example, the boundary matrix is decomposed in the following manner

$$\underbrace{W_b}_{(75\times75)} = \begin{pmatrix} \underbrace{W_{bww}}_{(52\times52)} & 0 \\ 0 & 0 \end{pmatrix} + \begin{pmatrix} 0 & W_{bwe} \\ 0 & 0 \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ W_{bew} & 0 \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ 0 & \underbrace{W_{bee}}_{(23\times23)} \end{pmatrix}$$

The inverse distance matrix W_{id} may be decomposed in a similar manner.

The matrices W_{bww} and W_{idww} reflect the influence of the western regions on one another, the matrices W_{bee} and W_{idee} reflect the impact of the eastern regions on one another, W_{bwe} and W_{idwe} reflect the impact of the eastern regions on the western regions, and W_{bew} and W_{idew} reflect the influence of neighbouring western regions on the eastern regions.

In models (2) and (3), we estimated the following four coefficients characterising the spatial effects: $\rho_{bww}, \rho_{bwe}, \rho_{bew}, \rho_{bee}$ and $\rho_{idww}, \rho_{idwe}, \rho_{idew}, \rho_{idee}$.

The dynamic form of models (2) and (3) is not accidental because the usual method of estimating such models – Arellano – Bond – provides estimates for the required parameters "with good properties" because of the use of instrumental variables.

The set of independent variables in models (2) and (3) is the same as in model (1), but each variable is doubled; thus, for example

$$shurbanw = \begin{cases} shurban, if\ i = 1,\ldots,52\,(west\,regions) \\ 0, if\ i = 53,\ldots,75\,(east\,regions) \end{cases}$$

$$shurbane = \begin{cases} 0, if\ i = 1,\ldots,52\,(west\,regions) \\ shurban, if\ i = 53,\ldots,75\,(east\,regions) \end{cases}$$

Each pair of variables is included in the model, and the hypothesis of equality of the corresponding coefficients is tested for each pair. If this hypothesis is rejected, then we conclude that there is a difference in the effect of the same factor for the eastern and western Russian regions.

Table 7 shows the results of the estimation of models (2) and (3) for each selected dependent variable with for a boundary or an inverse distance weighted matrices.

Table 7. The results of estimation of dynamic models using the Arellano-Bond method

Variable		**Unemployment rate**		**Real wage**		**GRP growth**	
Spatial lag		0.413***	*0.377****	0.631***	*0.689****	0.07***	*0.072****
ρbww	*ρidww*	0.360***	*0.677****	0.425***	*1.022****	0.419***	*1.147****
ρbee	*ρidee*	0.252***	*0.652****	-0.067***	*-1.366****	0.082	*0.51***
ρbwe	*ρidwe*	-0.053	*-1.472*	0.303***	*-2.536****	0.000	*0.231*
ρbew	*ρidew*	0.542**	*-0.254*	1.425**	*2.558****	1.551***	*1.195****
shurbanw		2.916***	*3.43****	1.571	*2.769****	2.916***	*2.916****
shurbansqw		-0.02***	*-0.025****	-0.01	*-0.021***	-0.005	*-0.005*
shurbane		0.083	*-0.036*	-0.75	*-1.386*	-3.96***	*-2.16****
shurbansqe		-0.001	*0.000*	-0.000	*0.007*	0.018***	*0.029****
densityw		0.001	*0.001*	0.031***	*0.033****	0.011**	*0.010***
densitye		-0.467	*-0.897**	-0.172	*2.715**	0.984	*0.845*
migrateposw		0.009***	*0.008****	-0.045***	*-0.037****	-0.017	*-0.026**
migratepose		-0.008	*-0.004*	-0.006	*-0.011*	-0.089**	*-0.027*
migratenegw		-0.007**	*-0.01****	0.053***	*0.053****	0.046***	*0.044****
migratenege		0.009**	*0.004*	-0.006	*-0.009*	0.004	*-0.021*
gdpw		-2.428***	*-2.87****	12.974***	*14.964****	16.35***	*18.46****
gdpe		-0.535	*-0.646*	14.599***	*14.611****	9.089***	*11.49****
openexpcisw		-4.721	*-4.668*	69.094*	*39.174*	1.66	*-1.686*
openexpcise		51.697***	*42.002**	-47.023	*-8.1*	-9.538	*-28.941*
openimpcisw		12.193	*13.93****	-4.66	*8.013*	-2.365	*-2.41*

openimpcise	-15.662	*-7.927*	-59.471	*-52.658*	20.223	*71.062*
openexpotherw	-0.188	*-0.06*	2.047	*5.328***	-1.091	*-0.125*
openexpothere	0.011	*0.141*	14.703***	*12.145****	-7.98***	*-6.93****
openimpotherw	-0.156***	*-0.193****	-0.98***	*-1.02****	-0.63***	*-0.77****
openimpothere	1.03**	*0.742*	-20.84***	*-21.758****	3.47***	*3.567****
Time effects	Yes	Yes	Yes	Yes	Yes	Yes

As in the fourth section, we offer our interpretation only for spatial effects. Each respective hypothesis of the equality of the coefficients for the same "western" and "eastern" factors was tested and, if accepted, was incorporated into the model (thus, if the hypothesis $\beta_{grpw} = \beta_{grpe}$ is not rejected, only one factor, GRP, is included in the model instead of both grpw and grpe factors).

In the qualitative results, signs and the significance of spatial effects do not change after incorporating the restriction; therefore, we omit the corresponding tables.

The results (presented in table 7) indicate the following:

1) Estimates of average west-west spatial coefficients were positive and significant in all models, i.e., positive changes in one western region (GRP growth, lower unemployment, and higher wages) led to similar changes in other western regions.

2) Estimates of average east-east spatial coefficients were positive for the level of unemployment and negative for the level of real wages. Thus, if one eastern region reduces the unemployment rate, similar changes occur in other eastern regions. However, if real wages increase in one eastern region, similar increases do not occur in the other regions and the resources will move only to the first region.

3) Estimates of the average spatial coefficient that characterises the influence of the eastern regions on the western regions were insignificant for unemployment rate and GRP growth. So, unemployment rate and GRP growth in eastern regions do not affect the same indicators in western regions. The real wage spatial coefficient was positive for boundary matrix and negative for inverted distance matrix. So, if real wages increase in one eastern region, similar increases occur only in the boundary western regions.

4) The estimates of the average spatial coefficient that characterise the influence of the western regions on the eastern regions were positive (for the unemployment rate only for the

boundary weighted matrix, for real wages and GRP growth in both cases). Thus, the western regions "pull up" the eastern regions with respect to the selected indicators.

5) The negative consequences of 2008-2009 financial crisis on the unemployment rate and real wages were revealed.

5. CONCLUSION

The results obtained are briefly summarised below.

When using the two types of spatial econometric models estimated, correspondingly, on the cross-sectional and panel data, we obtained the following main results:

- Annual positive spatial effects for unemployment and real wages were revealed.
- Estimating the cross-sectional models separately for the eastern and western regions in Russia was problematic.
- In the western regions, the average positive spatial effects were identified for the unemployment rate, the real wage, and the GRP growth rate.
- In the eastern regions, the average positive spatial effects for the unemployment rate and the average negative spatial effects for real wage were revealed.
- There is an asymmetric average influence of eastern and western regions on one another (the effects from the western regions extend to the eastern regions over the long term, but not vice versa).
- A statistically significant difference in the determinants of the unemployment rate, real wages and GRP growth for both the western and eastern regions was found.

Estimated models revealed differences in economic development and the mutual influence of eastern and western Russian regions.

These results can be used for regional policies. Changes in its western part of Russia have more significant impact on the entire country.

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Appendix

Table A1. List of Russian regions

Number	Name	Number	Name
	WEST REGIONS	39	Republic of Bashkortostan
1	Belgorod region	40	Republic of Marii El
2	Bryansk region	41	Republic of Mordovia
3	Vladimir region	42	Republic of Tatarstan
4	Voronezh region	43	Republic of Udmurtia
5	Ivanovo region	44	Republic of Chuvashia
6	Kaluga region	45	Perm territory
7	Kostroma region	46	Kirov region
8	Kursk region	47	Nizhny Novgorod region
9	Lipetsk region	48	Orenburg region
10	Moscow region	49	Penza region
11	Orel region	50	Samara region
12	Ryazan region	51	Saratov region
13	Smolensk region	52	Ulyanovsk region
14	Tambov region		**EAST REGIONS**
15	Tver region	53	Kurgan region
16	Tula region	54	Sverdlovsk region

17	Yaroslavl region	55	Tumen region
18	Moscow	56	Chelyabinsk region
19	Republic of Karelia	57	Republic of Altay
20	Republic of Komi	58	Republic of Buryatia
21	Arkhangelsk region	59	Republic of Tyva
22	Vologda region	60	Republic of Khakassia
23	Kaliningrad region	61	Altay Territory
24	Leningrad region	62	Krasnoyarsk Territory
25	Murmansk region	63	Irkutsk region
26	Novgorod region	64	Kemerovo region
27	Pskov region	65	Novosibirsk region
28	Saint-Petersburg	66	Omsk region
29	Republic of Adygea	67	Tomsk region
30	Republic of Kabardino-Balkaria	68	Republic of Sakha (Yakutia)
31	Republic of Kalmykia	69	Kamchatka territory
32	Republic of Karachaevo-Cherkessia	70	Primorsky Territory
33	Republic of Northen Osetia – Alania	71	Khabarovsk Territory
34	Krasnodar Territory	72	Amur region
35	Stavropol Territory	73	Magadan region
36	Astrakhan region	74	Sakhalin region
37	Volgograd region	75	Jewish autonomous area
38	Rostov region		