Spatial aspects of unemployment in Russia: what is more important, sectoral proximity or geographical proximity?

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Abstract *Due to labor and capital mobility, the regional labour markets of Russia are interlinked. The mutual influence of regional labour markets on each other is usually taken into account by introducing a spatial lag into the model. However, the question of which matrix to use still remains: reflecting the proximity of the sectoral structure or geographical proximity. In this paper, data for 80 Russian regions for 2005-2015 are used to estimate the model with the unemployment rate as the dependent variable. The main feature of the work is the mix of two types of weighing matrices: reflecting the geographic proximity of regions and the proximity of the sectoral structure (the Euclidean distance between 15-dimensional vectors reflecting the sectoral structure was used). A preliminary conclusion from spatial models is: it is necessary to take into account the geographical proximity and proximity of the sectoral structure approximately equally.*

1. Introduction and brief literature review

The study of regional labour markets is one of the areas of the modern economics, where spatially-econometric modeling is applied. This is not surprising, because data are becoming more accessible not only on the country level, but also on the regional level. In the era of globalization, links between regional labour markets are becoming stronger through the movement of labour and capital flows. Modeling the situation in the labour market of specific regions, it becomes necessary to take into account the situation in other regions, otherwise the omitted variable bias problem arises.

There are quite a lot studies on the data of European regions (Caroleo and Pastore (2010), Cracolici et al. (2007), Lottman (2012), Mussida and Pastore (2015), Head and Mayer (2006), Ketterer and Rodríguez-Pose (2018), Niebuhr (2003)). A review of the papers devoted to the regional labour market in transition countries can be found in Huber (2007) and Bah and Brada (2014). Russia is an example of such a country.

From a regional perspective issues related to economic growth in Russia have been studied more widely (Solanko (2008), Ledyaeva et al. (2008), Kholodilin et al. (2012), Akhmedjonov et al. (2013), Lehmann and Silvagni (2013), Dolinskaya,)2002)) than questions concerning Russian labour market. However, the Russian labour market is also being explored from the regional point of view. Oschepkov and Kapelyushnikov (2015) emphasize that there is no single labour market in Russia, but only a system of local labour markets. Gimpelson et al. (2017) shows that local labour markets in Russia are very different from each other and tend to cluster; there are groups of leaders and outsiders, in which labour markets work relatively well or badly. Most studies on regional labour markets examine unemployment rates (Demidova and Signorelli (2012), Demidova et al. (2013), Demidova et al. (2015), Blinova et al. (2015), Blinova et al. (2016), Rusanovskiy and Markov (2016)).

These studies used exogenous weighting matrices based on the geographical proximity of Russian regions. The question of the sensitivity of the estimates to the choice of the weighting matrix remains one of the most discussed questions in the literature on spatial econometrics (Anselin (2002), Corrado and Fingleton (2012), Gibbons and Overman (2012), Partridge et al. (2012)). Some researchers criticized spatial econometric models for their sensitivity to the weighting matrix specification (Bell and Bockstael (2000), Stakhovych and Bijmolt (2009), Plümper et al. (2010)), others called it "the biggest myth in spatial econometrics" (LeSage and Pace (2014)).

These studies mostly used weighting matrices based on the geographical proximity of regions. However, for Russian regions, it is desirable to take into account not only geographical, but also economic proximity of the regions, as suggested by Conley and Topa (2002). The special feature of this research is the mixing of geographic and economic weighting matrices. The idea of using convex combinations of weighting matrices is not new; it is used in Pace and LeSage (2002); Hazir et al. (2014); Debarsy and LeSage (2017), and LeSage and Fischer (2017). However, convex combinations of different types of exogenous weighting matrices are used in these articles. The novelty of this work consists in mixing an exogenous geographical weighting matrix and an endogenous economic one. In this case, maximum likelihood or Bayesian methods of estimation should not be used for estimation. This article determines what combination of geographical and economic weighting matrices is optimal.

The next section presents data sources and variables. The last section describes the models and the results of the estimation.

2. Data and Variables

2.1. Data

I use data for 80 Russian regions (a list of all regions is given in Table A1 in the Appendix) over the period of 2005-2015 provided by the Russian statistical agency Rosstat (www.gks.ru). Before this period there are no data on the sectoral structure of the regions. Data on the Republic of Chechnya were not included in the study because there are no data for some years. The Kaliningrad region was not included in the study because it has no common borders with other regions of Russia. During the reporting period, some regions underwent changes of an administrative-territorial character. This altering of boundaries was taken into consideration, mitigated by an aggregating procedure (see Table A2 in Appendix).

Table 1 indicates the wide range in the regional unemployment rate.

Table 1. Descriptive statistics for the unemployment rate

	Mean	Std. Dev.	Min	Max
2005	9.09	7.18	1.72	63.10
2006	8.56	6.92	2.14	58.65
2007	7.43	5.76	1.26	47.43
2008	8.07	6.20	1.61	54.89
2009	9.68	5.66	3.13	53.07
2010	8.66	5.37	2.37	49.70
2011	7.79	5.16	1.96	48.17
2012	6.77	5.25	1.10	47.70
2013	6.66	4.90	1.50	43.70
2014	6.25	3.69	1.40	29.80
2015	6.67	3.70	2.10	30.50

2.2. Weighting matrices

To test whether we need to take into account the spatial heterogeneity of Russian regions, we calculated Moran's indices for the weighting matrices based on the geographical proximity of the regions: the binary contiguity W_b, and matrix of inverse distance between the capitals of the regions by road W_{id}.

Table 2. Moran's spatial correlation index for the variable unemployment

	Binary contiguity weighting matrix	**Inverted distance weighting matrix**
2005	0.076	0.096**
2006	0.119**	0.109**
2007	0.19***	0.152***
2008	0.145***	0.114**
2009	0.101**	0.055
2010	0.096**	0.06
2011	0.085*	0.053
2012	0.119**	0.068

2013	0.146***	0.088*
2014	0.259***	0.143***
2015	0.258***	0.148***

* p-value < 0,1 ** p-value < 0,05 *** p-value < 0,001

Moran's indices (see Table 2) are significant for most years, which allow us to conclude that it is necessary to include spatial lags in the models under consideration.

I also created an endogenous matrix based on the economic distance between regions, W_{end} for each year 2005-2015. These matrices reflect the proximity of the industry structure of the regions. There are 15 types of economic activity; details are given in Table A3 in Appendix.

From a mathematical point of view, each region corresponds to a 15-dimensional vector. The economic distance between these vectors was measured as Euclidean.

All the weighting matrices were normalized in rows.

2.3 Variables

Let us briefly explain the choice of explanatory variables (share of urban population *urbanshare*, share of employed with a higher education *highed*, gross regional product per capita *grp*, ratio of investments and grp *invgrp*, the density of highways *road*, index of investment risk, provided by rating agency Expert *risk*, the level of federal subsidies *dot*, the Herfindahl-Hirschman diversification index *hh*, openness of the regional economy to exports and imports *impexp*).

Usually there are more employment opportunities in urban areas, so I expect a lower level of unemployment in regions with high share of urban population. However, Russia is a country of single-industry towns: according to Maslova (2011), there are more than 500 of them, that is, about 46% of the total number. If a city-forming enterprise closes, then it is not easy for residents to find a new job, so an opposite dependence is possible.

An important indicator determining unemployment in the region is the level of education of its population. The more educated and skilled the worker, the higher the demand for him and the sooner his potential reemployment in the case of job loss. In addition, highly educated workers are more prone to interregional migration if other regions that can offer better economic opportunities (Aragon, 2003). I expect the higher the share of people with high education in employed population, the lower level of unemployment.

It is expected that the better the economic situation in the region, the lower its unemployment rate. As variables characterizing the economic situation in the region, gross regional product per capita, ratio of investments and gross regional product, the density of highways, index of investment risk, and the level of federal subsidies to the region as a share of gratuitous receipts from the federal government were chosen. It is assumed that with an increase in the first three indicators, the unemployment rate decreases, and with the increase in the last two indicators it increases.

As an indicator of the diversification of the region's economy, the Hirfindahl-Hirschman diversification index was used. In accordance with Jacobs (1969) it is assumed that the more diversified the economy of the region, the lower the unemployment rate. I also expect that the openness of the regional economy to exports and imports contribute to the creation of new jobs, and thereby reduces unemployment.

Since unemployment is determined by long term factors, there is a certain stability in its development. This relation on the Russian labour market has been repeatedly observed in many empirical studies. Oschepkov and Kapelyushnikov (2015) note that the correlation between the level of unemployment in 2000 and its level in 2014 is 0.79. That confirms the strong dependence of the unemployment rate on its past values. To take into account this dependence, the lag of the dependent variable is included in the model.

A complete list of explanatory variables and their descriptive statistics are given in Table A4 in Appendix.

3. Model and Results of estimation

In the present study I used the dynamic SAR model (1) in which convex combinations of geographical and economic weighting matrices are used as weighing matrices:

$$UNEM_{it} = \sigma UNEM_{it-1} + \rho_{W_j}(W_{jt}UNEM)_{it} + \sum_{k=7}^{15}\gamma_k d_{200k} + (X\beta)_{it} + \alpha_i + \varepsilon_{it}, \quad (1)$$

$$i = 1,...,80,\ t = 2005,...,2015,\ j = b\_end, id\_end$$

where $UNEM$ is the unemployment rate,

$$W_{b\_endt}(a) = aW_b + (1-a)W_{endt} \quad (2)$$

is a convex combination of exogenous matrix W_b and endogenous matrix W_{endt} for each $a = 0, 0.1,...,1,$

$$W_{id\_endt}(a) = aW_{id} + (1-a)W_{endt} \quad (3)$$

is a convex combination of exogenous matrix W_{id} and endogenous matrix W_{endt} for each

$a = 0, 0.1,...,1,$

$d_{2007} - d_{2015}$ are indicators of the corresponding years; X is a matrix of the explanatory variables (choice of these variables is discussed in the previous section); $\alpha_i, i = 1,...,80$ are individual effects for the regions; and $\varepsilon_{it} \sim iid(0, \sigma_\varepsilon^2)$.

In total I estimated 22 models (since $j = b\_end, id\_end$ and $a = 0, 0.1, ..., 1$).

Since $W_{b\_endt}(a)$ and $W_{b=id\_endt}(a)$ are endogenous matrices, I used the algorithm proposed by Kelejian and Piras (2014). First I instrumented all nonzero elements of weighting matrix $w_{ij}, i, j = 1, \ldots, 80, i \neq j$ (for each year). As instruments I used distances between capitals of regions i and j, ratio of populations in regions i and j and their second and third powers. Second, I used the Arellano-Bond (1991) approach and GMM as an estimation method.

As a criterion for choosing the optimal parameter a, maximum correlation coefficient between the estimated and real values of the dependent variable was used.

3.2 The results of estimation

Tables A5 and A6 in Appendix contain the results of the estimation. According to the estimates, there are positive spatial effects for the Russian labour market, but only for the boundary weighting matrix. This is consistent with Oschepkov and Kapelyushnikov (2015) on the weak connection of regional markets in Russia.

At the same time, negative effects for economic weighted matrix were identified, which may indicate competition for labour resources.

According to the chosen criterion, for models with convex combination of matrices W_b and W_{endt} (2) model with $a = 0.4$ was the best; and for models with convex combination of matrices W_{id} and W_{endt} (3) model with $a = 0.5$ was the best.

This allows us to make a preliminary conclusion that for the Russian regions, it is necessary to take into account the geographical proximity and proximity of the sectoral structure equally.

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Appendix

Table A1. List of Russian regions

1	Belgorod region	41	Republic of Marii El
2	Bryansk region	42	Republic of Mordovia
3	Vladimir region	43	Republic of Tatarstan
4	Voronezh region	44	Republic of Udmurtia
5	Ivanovo region	45	Republic of Chuvashia
6	Kaluga region	46	Perm territory
7	Kostroma region	47	Kirov region
8	Kursk region	48	Nizhny Novgorod region
9	Lipetsk region	49	Orenburg region
10	Orel region	50	Penza region
11	Ryazan region	51	Samara region
12	Smolensk region	52	Saratov region
13	Tambov region	53	Ulyanovsk region
14	Tver region	54	Kurgan region
15	Tula region	55	Sverdlovsk region
16	Yaroslavl region	56	Tumen region
17	Moscow	57	Khanty-Mansi Autonomous Area - Yugra
18	Republic of Karelia	58	Yamal-Nenets autonomous region
19	Republic of Komi	59	Chelyabinsk region
20	Arkhangelsk region	60	Republic of Altay
21	Nenets Autonomous Okrug	61	Republic of Buryatia
22	Vologda region	62	Republic of Tyva
23	Leningrad region	63	Republic of Khakassia
24	Murmansk region	64	Altay Territory
25	Novgorod region	65	Zabaykalsky Territory
26	Pskov region	66	Krasnoyarsk Territory

27	Saint-Petersburg	67	Irkutsk region
28	Republic of Adygea	68	Kemerovo region
29	Republic of Kalmykia	69	Novosibirsk region
30	Krasnodar Territory	70	Omsk region
31	Astrakhan region	71	Tomsk region
32	Volgograd region	72	Republic of Sakha (Yakutia)
33	Rostov region	73	Kamchatka territory
34	Republic of Dagestan	74	Primorsky Territory
35	Republic of Ingushetia	75	Khabarovsk Territory
36	Republic of Kabardino-Balkaria	76	Amur region
37	Republic of Karachaevo-Cherkessia	77	Magadan region
38	Republic of Northen Osetia – Alania	78	Sakhalin region
39	Stavropol Territory	79	Jewish autonomous area
40	Republic of Bashkortostan	80	Chukotka Autonomous Okrug

Table A2. United subjects of the Russian Federation

Data	Merging regions	Incorporated as
01.01.2007	Taymyr Autonomous Okrug	Krasnoyarsk Territory
	Evenk Autonomous Okrug	
	Krasnoyarsk territory	
01.07.2007	Kamchatka oblast	Kamchatka territory
	Koryak Autonomous Okrug	
01.01.2008	Ust-Orda Buryat Autonomous Okrug	Irkutsk region
	Irkutsk region	
01.03.2008	Chita region	Zabaykalsky Territory
	Aginsky Buryatsky Autonomous Okrug	
01.07.2012	Moscow	Moscow
	Moscow region	

Table A3. Gross value added by economic activity

agriculture, forestry
fishing
mining and quarrying
manufacturing
production and distribution of electricity, gas and water
construction
wholesale and retail trade; repair of motor vehicles and motorcycles
accommodation and food service activities
information and communication
financial and insurance activities
real estate, rent and services activities
public administration and defense; compulsory social security
education
human health and social work activities
provision of other communal, social and personal services

Table A4. Explanatory variables and their descriptive statistics

Acronym	**Definition**
unempl	*Unemployment rate, in %*
lngdp	Log of GRP per capita in 2005 prices
urbanshare	Share of urban population, in %
invgdp	ratio of investments and grp
highed	Share of employed with a higher education, in %
impexp	*Ratio of export and import and grp*
road	the density of highways
risk	index of investment risk
hh	Herfindahl-Hirschman diversification index
dot	the level of federal subsidies in the regional budget

Variable		Mean	Std. Dev.	Min	Max	Observations
unempl	overall	7.786231	5.610855	1.1	63.1	N = 880
	between		5.28935	2.080334	47.88273	n = 80
	within		1.955186	-10.2965	23.0035	T = 11
lngdp1	overall	11.08711	.9077051	7.665537	13.85074	N = 880
	between		.7925842	9.021398	13.21906	n = 80
	within		.4504281	9.156248	13.07584	T = 11
urbans~1	overall	.6924251	.1261701	.259	1	N = 880
	between		.1264254	.2733636	1	n = 80
	within		.0108331	.6483341	.7408796	T = 11
invgrp1	overall	.2767627	.1064828	.10068	1.07994	N = 880
	between		.0756008	.1332181	.5020501	n = 80
	within		.0754197	.0382025	.9406442	T = 11
highed1	overall	.2547008	.0562318	.125	.5	N = 880
	between		.04486	.1787273	.475	n = 80
	within		.0342416	.1113371	.3800644	T = 11
impexp1	overall	.3028016	.3061319	0	3.653477	N = 880
	between		.2428705	.0147744	1.338308	n = 80
	within		.1881535	-.8797143	3.334111	T = 11
road1	overall	172.6168	259.3399	.8	2199.773	N = 880
	between		254.0271	.8454545	2127.524	n = 80
	within		58.83462	-57.20142	494.8895	T = 11
risk1	overall	.272044	.1917987	0	1	N = 880
	between		.1635325	.0152307	.8948132	n = 80
	within		.1017258	-.3277442	.8393332	T = 11
hh1	overall	.2932806	.0604559	.203716	.63496	N = 880
	between		.0560723	.2153307	.5616731	n = 80
	within		.0233791	.1887804	.5521494	T = 11
dot1	overall	30.94777	19.30705	-42.80133	91.44629	N = 880
	between		18.30181	-3.429642	88.26651	n = 80
	within		6.451101	-8.423924	62.26104	T = 11

Table A5. Results of estimation with convex combination of boundary and economic weighting matrices

Variable	modb00	modb01	modb02	modb03	modb04	modb05
unempl						
L1.	0.767***	0.758***	0.749***	0.745***	0.745***	0.746***
wy00	-0.212**					
lngdp1	-0.047	0.022	0.026	-0.013	-0.043	-0.059
urbanshare1	-16.198**	-14.810**	-12.655*	-9.383	-8.516	-9.002
invgrp1	0.165	0.071	0.004	-0.034	-0.018	-0.004
highed1	1.354	2.048	2.776*	3.263**	3.468**	3.466**
impexp1	-0.368**	-0.275	-0.225	-0.247	-0.275	-0.301*
road1	-0.002**	-0.003***	-0.004***	-0.003***	-0.003***	-0.003***
risk1	-0.162	-0.164	-0.228	-0.236	-0.243	-0.237
hh1	0.475	0.834	0.188	-0.410	-0.449	-0.407
dot1	-0.013	-0.013	-0.014	-0.014	-0.015*	-0.016*
d2007	-0.904***	-1.175***	-1.102***	-0.750***	-0.465*	-0.354
d2008	0.770***	0.617***	0.626***	0.733***	0.826***	0.869***
d2009	2.494***	2.805***	2.816***	2.420***	2.061***	1.920***
d2010	-0.045	-0.008	0.043	0.012	-0.042	-0.062
d2011	-0.242	-0.443	-0.386	-0.205	-0.064	-0.004
d2012	-0.821**	-1.306***	-1.257***	-0.776**	-0.369	-0.200
d2013	-0.126	-0.602	-0.548	-0.065	0.344	0.507
d2014	-0.433	-1.041**	-0.977*	-0.362	0.155	0.357
d2015	0.319	-0.171	-0.120	0.334	0.706	0.850*
wy01		-0.465***				
wy02			-0.433***			
wy03				-0.123		
wy04					0.137	
wy05						0.237*
wy06						
wy07						
wy08						
wy09						
wy1						

legend: * p<.1; ** p<.05; *** p<.01

Variable	modb06	modb07	modb08	modb09	modb1
unempl					
L1.	0.748***	0.749***	0.750***	0.751***	0.751***
wy00					
lngdp1	-0.067	-0.073	-0.076	-0.079	-0.081
urbanshare1	-9.593	-10.044	-10.362	-10.589	-10.760*
invgrp1	-0.003	-0.007	-0.012	-0.018	-0.023
highed1	3.425**	3.381**	3.343**	3.311**	3.283**
impexp1	-0.323*	-0.340**	-0.353**	-0.363**	-0.371**
road1	-0.003***	-0.003***	-0.002***	-0.002***	-0.002***
risk1	-0.220	-0.201	-0.185	-0.173	-0.164
hh1	-0.378	-0.361	-0.351	-0.347	-0.346
dot1	-0.017*	-0.018*	-0.018**	-0.019**	-0.019**
d2007	-0.333	-0.342*	-0.358*	-0.374**	-0.390**
d2008	0.883***	0.888***	0.889***	0.889***	0.889***
d2009	1.894***	1.905***	1.927***	1.950***	1.971***
d2010	-0.062	-0.056	-0.049	-0.041	-0.035
d2011	0.009	0.006	-0.000	-0.007	-0.013
d2012	-0.164	-0.173	-0.194	-0.218	-0.240
d2013	0.537	0.522	0.496	0.469	0.445
d2014	0.389	0.365	0.327	0.290	0.255
d2015	0.871**	0.852**	0.823**	0.795**	0.770**
wy01					
wy02					
wy03					
wy04					
wy05					
wy06	0.255**				
wy07		0.244**			
wy08			0.227**		
wy09				0.209***	
wy1					0.193***

legend: * p<.1; ** p<.05; *** p<.01

Table A6. Results of estimation with convex combination of inverted distance and economic weighting matrices

Variable	modid00	modid01	modid02	modid03	modid04	modid05
unempl						
L1.	0.767***	0.762***	0.760***	0.759***	0.757***	0.755***
wyid00	-0.212**					
lngdp1	-0.047	-0.027	-0.017	-0.031	-0.066	-0.087
urbanshare1	-16.198**	-13.539*	-11.275	-9.224	-8.432	-9.430
invgrp1	0.165	0.094	0.004	-0.132	-0.261	-0.303
highed1	1.354	1.450	2.021	2.699	3.199**	3.493**
impexp1	-0.368**	-0.349**	-0.330*	-0.327*	-0.334*	-0.339**
road1	-0.002**	-0.003***	-0.003***	-0.004***	-0.004***	-0.003***
risk1	-0.162	-0.215	-0.307	-0.318	-0.296	-0.283
hh1	0.475	0.957	1.009	0.233	-0.523	-0.828
dot1	-0.013	-0.013	-0.013	-0.013	-0.012	-0.012
d2007	-0.904***	-1.237***	-1.534***	-1.565***	-1.292***	-1.035***
d2008	0.770***	0.615***	0.466**	0.424*	0.512**	0.612***
d2009	2.494***	2.781***	3.028***	3.016***	2.740***	2.490***
d2010	-0.045	-0.048	-0.073	-0.094	-0.124	-0.150
d2011	-0.242	-0.471*	-0.668**	-0.719***	-0.574**	-0.426*
d2012	-0.821**	-1.326***	-1.768***	-1.822***	-1.420***	-1.046***
d2013	-0.126	-0.627	-1.074**	-1.135***	-0.751**	-0.385
d2014	-0.433	-1.072**	-1.630***	-1.701***	-1.207***	-0.740**
d2015	0.319	-0.196	-0.655	-0.735*	-0.366	-0.014
wyid01		-0.473***				
wyid02			-0.694***			
wyid03				-0.693***		
wyid04					-0.454***	
wyid05						-0.243***
wyid06						
wyid07						
wyid08						
wyid09						
wyid1						

legend: * p<.1; ** p<.05; *** p<.01

Variable	modid06	modid07	modid08	modid09	modid1
unempl					
L1.	0.756***	0.757***	0.758***	0.759***	0.759***
wyid00					
lngdp1	-0.098	-0.106	-0.115	-0.123	-0.129
urbanshare1	-11.225*	-13.081**	-14.786**	-16.240***	-17.367***
invgrp1	-0.318	-0.350	-0.402	-0.461	-0.511
highed1	3.617***	3.633***	3.595***	3.538***	3.487***
impexp1	-0.346**	-0.351**	-0.355**	-0.357**	-0.358**
road1	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***
risk1	-0.262	-0.241	-0.225	-0.215	-0.209
hh1	-0.939	-0.955	-0.920	-0.869	-0.831
dot1	-0.012	-0.013	-0.014*	-0.015*	-0.016*
d2007	-0.882***	-0.796***	-0.743***	-0.708***	-0.685***
d2008	0.681***	0.730***	0.769***	0.802***	0.829***
d2009	2.349***	2.288***	2.266***	2.260***	2.256***
d2010	-0.158	-0.152	-0.138	-0.124	-0.113
d2011	-0.328	-0.260	-0.206	-0.162	-0.130
d2012	-0.815***	-0.675***	-0.580**	-0.512**	-0.464**
d2013	-0.154	-0.012	0.088	0.163	0.218
d2014	-0.453	-0.284	-0.173	-0.095	-0.041
d2015	0.210	0.354	0.458	0.538*	0.598**
wyid01					
wyid02					
wyid03					
wyid04					
wyid05					
wyid06	-0.123**				
wyid07		-0.063			
wyid08			-0.032		
wyid09				-0.016	
wyid1					-0.007

legend: * p<.1; ** p<.05; *** p<.01