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A Core-Periphery Pattern in Russia – Twin Peaks or a Rat's Tail

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Summary: Due to its transition process in the decades 1990 - 2010 Russia has experienced a change in its regional structure. Its design is characterized by a core-periphery structure, where one can see that Russia has more than one economic core. The insight gained from this study is that convergence happens in Russia but only on a minor scale. Most of this economic convergence is a convergence of different convergence clubs becoming more similar or merging in contrast to a divergence inside the clubs. Furthermore, growth spillovers are analysed and it is observed that there are almost no significant positive growth effects across the Russian regions. Therefore, no endogenous forces are dynamic sources of the present regional structure of the Russian Federation.

Zusammenfassung: Aufgrund des Transformationsprozesses von 1990 bis 2010 hat Russland einen Wandel in seiner regionalen Struktur erfahren. Diese zeichnet sich kurz eine Kern-Periphery-Struktur, wobei mehr als ein Kern vorhanden ist. Die zentrale Einsicht hierbei ist, dass zwar ein Konvergenzprozess in Russland stattfindet allerdings auf einem sehr geringen Niveau. Ein Großteil dieser wirtschaftlichen Konvergenz findet statt al seine Konvergenz unterschiedlicher Konvergenzclubs zueinander im Gegensatz zu einer Divergenz innerhalb der Clubs. Weiterhin werden Spillover Effekte untersucht und es wird herausgearbeitet, dass es nahezu keine Regionen gibt, die positive Spillover Effekte generieren. Daher liegen keine endogenen Kräfte vor, die als dynamische Quelle der vorliegenden regionalen Struktur in der Russischen Förderation angesehen werden können.

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1. Introduction

Since the break up of the Soviet Union in 1991, the gap between rich and poor or more aptly put between high and low income earners in Russia has steadily grown - partly stimulated by the Russian crisis in 1998[1]. It is an individual problem as well as a regional one. Rich regions as the two large federal cities or regions richly endowed in natural resources - mostly oil and gas - offer higher opportunities for well-paid employment and therefore a higher average income.

In the following study the economic regional structure in Russia is analyzed and future development trends as well as possible explanations are presented and discussed. The basic idea is to focus on the structure of economic welfare across Russian regions and to explain the regional wealth distribution by means of regional nearness, especially growth spillovers.

From a theoretical perspective (neighboring) regions are linked with each other through technology spillovers and economic backward and forward linkages along value-added chains; from the perspective of gravity models of trade, regional trade also has to be considered as well as infrastructure projects affecting interregional trading costs. Moreover, interregional migration could play a role that could create a negative link between regions *i* and *j* since those emigrating from region *i* will immigrate into region *j*.

Findings by BUCCELLATO (2007) show that spatial autocorrelation[2] is present in the context of a conditional regional convergence analysis of the Russian regions while the hypothesis of absolute convergence is rejected. It is implicitly indicated that convergence takes place in localized convergence clubs in contrast to an overall convergence process as predicted by pure neoclassical growth theory[3].

In this context Russia differs for example from Canada that, although being a resource based economy itself and having similar ecological conditions, shows consistent levels of absolute convergence regarding per capita GRP as well as human capital[4].

Advancing on regional conditional convergence in Russia, we are conducting tests to show that the Russian regions can be divided into significantly different subgroups concerning GRP. Furthermore, to observe the structural composition of the Russian regions tests are applied to periods of ten or fourteen years respectively of post transitional Russian development, starting in 1998 after the Russian-Asian crisis and in some cases after the first transition years in 1994.

In the following second section the data used are described and applied data-related restrictions are discussed. Moreover, the section gives a short description of the methods applied in the course of the later sections and their implementation. In the third section cluster analytic methods are applied and the results are derived from the application of a kernel density estimator. The results are graphically displayed and future development

[1] See WELFENS and WIEGERT (2002).

[2] A reference to the concept of spatial autocorrelation and related aspects of spatial econometrics can be found in ANSELIN (1988), ANSELIN et al. (1997) or SCHULZE (1993).

[3] See SOLOW (1956) and SWAN (1956). Even though, refering to GALOR (1996) and MOSSIG (2002), the construction of a neo-classical model, including convergence clubs, is rather problematic to construct and not robust.

[4] See COULOMBE and LEE (1995), COULOMBE and TREMBLEY (1998) and COULOMBE and DAY (1999).

trends analysed. The fourth section takes the results from the third section and observes for spillover effects. Finally the fifth section concludes.

2. Basics

2.1 Data

As the Russian transition process started in 1991, the available statistical data is limited. While Russian regional GRP per Capita (in rubles) is reported from 1994 onwards by GOSKOMSTAT (2009), the Russian-Asian crisis in 1998 and the problem that the Russian transition process has not nearly been finished in 1994, 1999 is a more prudent choice than 1994. Nevertheless, in some parts of the study we observe the total data set - starting in 1994 - restricting it to begin in 1998 or 1999 only if a starting point after the Russian is economically a more reasonable choice. Taking 1998 / 1999 as a starting point is supported by the findings of BERKOWITZ and DEJONG (2003a) as well as the description of the Russian crisis in WELFENS and WIEGERT (2002).
Furthermore, GRP data is only available up to 2007. While the reported data only gives nominal GRP, regional price indices are reported as well, allowing us to calculate consistent real GRP data. As prices differ across Russian regions rather strongly, the implementation of regional price levels instead of national prices has been imperative.
While analysing the regional GNP as well as the development of GRP would provide additional insights on labor mobility and regional interrelations, the lack of corresponding data prohibits this study from undertaking this kind of analysis[5].
In the course of the study the division of Russia into regions follows the given division in krais, okrugs, republics and federal cities that are independent administrative units of the Russian Federation. The only exceptions are the autonomous okrugs in the krai Krasnoyarsk as well as the Tyumen oblast that are not observed separately. This leaves 80 Russian regions across a time horizon of ten and fourteen years, respectively.
A problem given by the regional division implemented is the absolute difference in geographic size of the regions as the smallest region, the city of Moscow, only spans an area of 1,081 km^2 while the largest region, the republic of Sakha, spans an area of 3,083,523 km^2. Nonetheless, the city of Moscow is the richest of the Russian regions - this is a problem insofar as regional size thereby does not represent the region's wealth. Another problem is the distance between two regions. Not only are the economic centers as well as the population unequally distributed across the regions but also distances between the regions might be misleading; for example, the capital of the republic of Sakha is near its southern border so that distances to southern regions might appear geographically less than to north eastern or north western regions. Alleviation to this is that it is to be assumed that most economic activity is concentrated in the area around the capital city.

[5] The expectation nonetheless is that the difference between regional GNP and GRP might be much higher for smaller regions and especially for the federal cities of Moscow and St. Petersburg where most industry is located in the surrounding oblast. Whereas it has to be considered that labor mobility to these cities is still rather limited.

2.2 Methods

2.2.1 Kernel Density Estimation

As shown by CANOVA (2001) based on the works of QUAH (1995) kernel density approach is a reasonable solution for the detection of convergence clubs. For a sample $\{x_1, x_2,..., x_n\}$ of the random variable X, the kernel density estimator of the probability density function is given as follows[6]:

$$(1)\quad X_h(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{\bar{x} - x_i}{h}\right)$$

Here the overline signifies taking the mean and parameter h defines the smoothness of the estimation. h is set equal to the optimal smoothness h^*, which is defined as:

$$(2)\quad h^* = \frac{c_1^{-0.4} c_2^{0.2} c_3^{-0.2}}{n^{0.2}}$$

$$(3)\quad c_1 = \int x^2 K(x)\, dx$$

$$(4)\quad c_2 = \int K(x)^2 dx$$

$$(5)\quad c_3 = \int f''(x)^2 dx$$

Furthermore, the kernel K is taken to be the Gaussian kernel defined as follows:

$$(6)\quad K\left(\frac{\bar{x} - x_i}{h}\right) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{(\bar{x} - x_i)^2}{2h^2}\right)$$

The resulting probability density function will be similar in form to the Gaussian distribution in the case of an independent and identically distributed X.
In the case that the data used shows more than one peak[7] distinct different groups exist. Especially, if two peaks are present for the distribution of income it can be surmised that a high and a low-income cluster are present. If more than two peaks are present, there exists a high diversity in the regional income distribution. Furthermore if one peak is clearly defined and is combined with a number of smaller peaks we refer to this phenomenon as a rat's tail, signifying a rather segmented structure on one side of the income distribution.

[6] See PAZEN (1962).

[7] In the case of the Gaussian distribution it should be around the mean.

The implementation of the kernel density estimator used in this study is the RSC AMC Minitab implementation.

2.2.2 Clustering

The starting point of any clustering algorithm is a graph *G(V,E,w)*, that consists of a set of vertices *V*, a set of edges *E* and weights *w* assigned to the edges. In the case of geographically distributed data, the weights of the edges can be interpreted as distances of the vertices from one another.
In the present case the set of vertices *V* is the set of Russian regions as defined in section 2.1 and the set of edges *E* is given by the canonical product *V* x *V*. Every vertex v_i has a value g_i given by the GDP per capita of the corresponding region. The weight of the edge (v_i, v_j) is calculated as $|g_i-g_j|$. Set *E* is thus given by the resulting adjacency matrix. Clustering algorithms can be applied accordingly.

The clustering algorithm applied in this study is a k-means-type algorithm, which is implemented as a tabu search clustering algorithm in the UCINET 6.15 program package by Analytictech.
A k-means algorithm was favored over a spectral clustering algorithm[8] with a variable number of clusters as the k-means algorithm allows to test different numbers of clusters and calculate significance levels for the overall fit[9].
Nevertheless, a k-means algorithm is not prudent when testing for only a single common cluster. To observe for development concerning a single cluster we start from the absolute convergence approach motivated by neoclassical growth theory with a timeframe of one year[10]. In essence, the following equation is estimated:

(7) $$g_{GRP}^{t,\,t+1} = \alpha + \beta\ GRP_t + \mu$$

Where $g_{GRP}^{t,\,t+1}$ is the growth rate of GRP for period *t*. Equation (7) is reformulated as:

(8) $$GRP_t = \alpha' + \beta'\, g_{GRP}^{t,\,t+1} + \mu'$$

If the resulting parameter β' is insignificant while parameter α' is highly significant and the R^2 value of the estimation is high as well, the presence of a single cluster can be assumed for the Russian regions.
An alternative when checking for convergence clubs is in observing for regional spatial heterogeneity[11].

[8] HOSER and SCHRÖDER (2007) have used spectral clustering algorithms.

[9] CAPPELEN et al. (2003) use a k-means type algorithm as well to calculate convergence clubs in the European Union.

[10] Compare BARRO and SALA-I-MARTIN (1991) or TONDL (2001)

[11] See CHATTERJI and DEWHURST (1996).

2.2.3 Markov Chains

From the broad range available on the characteristics of Markov chains in the course of this study only the calculation of the steady state is of importance[12]. A Markov chain herein consists of *N* regions that can be in one of *m* possible states at any point in time. $A=(a_{i,j})_{i,j}$ then describes a *m* x *m* matrix with $a_{i,j}$ giving the possibility that a region which at time *t* was in state *i* to be in state *j* at time *t+1*.
The normalized eigenvector to the eigenvalue zero of matrix *A* gives the distribution across states in the steady state.

2.2.4 Measuring growth spillovers

Growth spillovers can be described as external effects of one region on another neighboring region. If spillovers are considered in economic research, mainly knowledge spillovers are observed.
Growth spillovers as in the economic performance of region *A*, having an influence on the economic performance of region *B*, are only the external facets of the underlying process of knowledge spillovers. Therefore, the following analysis of growth spillovers can be seen as an indirect measure of knowledge spillovers. As only the external facets of knowledge spillovers are observed it is not necessary to divide knowledge and related spillovers in categories of tacit or codified knowledge spillovers or knowledge spillovers by trade.
Even though, as argued below, it might be reasonable to take a look at the different types of knowledge spillovers as well, it is no part of the present study.
Spillovers in general are closely related to spatial autocorrelation, which is the econometricians' way of describing external effects across regions. As such, they can be measured in the same fashion. In course of this argument the global Moran's I statistic (I)[13] as well as the local Getis-Ord statistic (G_i)[14] are used to check for regional growth spillovers.
When the focus lies on the pure existence of spillovers, but not on the spillovers generated by individual regions we use the global version of the Moran's I. If instead the interest lies more in the question whether a region can be seen as growth enhancing or diminishing for other regions, the local Getis Ord statistic is better suited than the Moran's I statistic.
Central to both statistics is the matrix $W=(w_{i,j})_{i,j}$ of spatial weights. In essence, this matrix represents the distance between two regions. The most common way to model such a matrix is by setting $w_{i,j}=1$ if region *i* neighbors region *j* and vice versa. Furthermore, *W* needs to be row-normalized, so that the following restriction is kept:

$$(9)\quad \sum_{j=1}^{N} w_{i,j} = 1 \qquad \forall\ i = 1,...,N$$

Using the row-normalized matrix *W*, the Moran's *I* statistic is given as:

[12] See HÄGGSTRÖM (2002).

[13] See MORAN (1950).

[14] See GETIS and ORD (1992).

$$(10)\quad I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{i,j}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{\sum_{j=1}^{N}\left(x_j - \bar{x}\right)^2}$$

Here N gives the number of spatial units, while x_i gives the value for region i and the overline signifies taking the mean.
The mean for the I-statistic is given as:

$$(11)\quad \bar{I} = -\frac{1}{N-1}$$

Values above/below the mean[15] signify the presence of positive/negative autocorrelation and values near the mean signify the absence of autocorrelation.
When using the Getis Ord statistic the weights matrix is changed insofar as the entries of W, $w_{i,j}$ are assigned zero if the linear distance between region i and region j is more than 400km and unity if the linear distance is lesser than 400 km. DOERING (2004) shows that the half time of distance decay for the European Union is less than 30 km and BOTTAZZI and PERI (2003) show that for the European Union the expected reach of spillovers is around 300 km[16]. Therefore, a radius of 200 km or 400 km is reasonable when observing spillover and cluster formation activities.
The local Getis Ord statistic is defined as:

$$(12)\quad G_i = \frac{\sum_{j=1}^{N} w_{i,j}x_j - w_{i,i}x_i}{\sum_{j=1}^{N} -x_i}$$

and its mean is given as:

$$(13)\quad \overline{G_i} = \frac{\sum_{j=1}^{N} w_{i,j} - w_{i,i}}{n-1}$$

In contrast to the Moran's I, the Getis-Ord statistic focuses less on spillover activities and rather more on the formation of clusters or the differences in regional density. Furthermore, LE GALLO and DALL'ERBA (2006) argue that the Getis-Ord statistic is

[15] For large N the mean converges to zero.

[16] Nevertheless, it is necessary to note that VARGA (2000) and FUNKE and NIEBUHR (2000) propose a range of only 75 miles, while ANSELIN et al. (1997) show that spillovers generated by universities are bounded by a range of 50 km.

better suited to differentiate between core and periphery regions. Therefore in the following analysis the Getis-Ord statistic is chosen over the Moran's I.
There exists a range of more advanced approaches of measuring spatial autocorrelation as described by ANSELIN (1988), NIEBUHR (2001), TIEFELSDORF et al. (1999) and TIEFELSDORF (2002) or especially for the case when spatial heterogeneity is present as well by KARLSTRÖM and CECCATO (2002), which are not considered here but seem reasonable to be considered in future works.
A problem to be expected in this context is the size of the regions. Some of the Russian regions span large areas that lead the distance between regions to exceed the reach of spillovers of 300 km as shown for example for the European Union by BOTTAZZI and PERI (2003) and DÖRING (2004). Therefore it is assumed that spillovers will be much less pronounced in Russia than they are across European regions. Another aspect that strengthens this position is the relatively low level of labor mobility present in Russia, given for by governmental mobility restrictions as well as by the population being caught in a poverty gap[17]. Both aspects taken together are also the main reason why a cutoff distance of 400 km instead of 300 km is considered.
A question that arises in this context is whether regional size does have a distinct influence on the level of spillovers. Though, this question cannot be answered satisfactorily in any way, since it largely depends on the implemented neighborhood matrix. While a neighborhood constructed from neighboring regions would be beneficial especially for large regions with a large number of neighboring regions, whereas a neighborhood consisting of regions within a given radius around the center of the region would be beneficial for effects across smaller regions.

3. Cluster Analysis

3.1 Absolute convergence - A single regional cluster

As was argued in section 2.2.2 a low significance level for the β'-coefficient together with a high significance level for the α' coefficient and a high R^2 indicates a single common structure. Theoretically, the result of the following estimation can be predicted by using the findings of BARANES and TROPEANO (2003) or BERKOWITZ and DEJONG (2003b) who show that regional convergence is inversely related to the distance of regions to each other. This argument is related to the basic principle of economic geography (KRUGMAN (1991), KRUGMAN (1998a) and KRUGMAN (1998b)), according to whom, regions closer to each other tend to influence each other more strongly and therefore tend to be more similar.
While the hypothesis of a common structure can already be rejected by comparing GRP values of for example Moscow and the Republic of Ingushetia, the results of the estimations as shown in Table 1 allow for the drawing of some additional conclusions.

[17] See ANDRIENKO and GURIEV (2004) or BERKOWITZ and DEJONG (2003b).

Except for 1994, 2004, 2005 and 2006 there has always been an insignificant β'-coefficient. Furthermore, in all cases the R^2 values are very small. While this shows on the one hand the above mentioned absence of a common level of income and on the other hand that even though no common structure can be detected in 1994, 2004, 2005 and 2006, there was a slight movement towards a common structure; as the estimated model is similar to the neoclassical growth model. While in itself this is no significant insight, it does show that in the earlier transition period as well as in recent years the trend to converge to a common structure is more accentuated than during the years inbetween. Politically, this is an indication that policy measures especially by the Putin legislation show some small successes.

Even though the results should not be misread as an overall absolute convergence process, as for this, the R^2 values are still too low and the corresponding β-coefficients are very small.

As Russia has started to equilibrate the regional income differences a little over the last years; it still stays an open question if this process keeps on equating in light of the recent economic crisis. A subquestion to this would be whether clusters, founded voluntarily or not in the time of the Soviet Union, still dominate the regional structure of the Russian economy today and if so, to what extent. Even though, to answer this last question would be very hard as it still remains an open discussion how to classify the Soviet cluster and whether the Soviet clusters are comparable to a cluster in an open market economy.

Table 1: Significance levels for variables - Single common cluster

	1994	1995	1996	1997	1998	1999	2000
R^2	0.037	0.002	0.009	0.001	0.013	0.010	0.018
Sig. α	0.028	0.000	0.000	0.000	0.004	0.000	0.000
Sig. β	0.074	0.674	0.367	0.726	0.288	0.346	0.208

	2001	2002	2003	2004	2005	2006
R^2	0.004	0.020	0.000	0.064	0.068	0.031
Sig. α	0.000	0.022	0.000	0.009	0.000	0.000
Sig. β	0.574	0.187	0.922	0.018	0.014	0.013

3.2 Identifying convergence clubs

The analysis of convergence clubs - as introduced by BAUMOL (1986) - is divided in two parts. It starts with an application of the above stated k-means algorithm, thereby getting an indication of how the Russian regions are structured according to income. Building on the general findings in this aspect and to strengthen these findings, a kernel density estimation is performed to see what form the overall distribution of income in Russian regions takes and if the assumptions of the preceding section are feasible under different measures.

3.2.1 k-means clustering approach

In the preceding section the hypothesis of a single common cluster is rejected. Therefore, it is necessary to calculate the exact number of convergence clubs and observe their

development path or whether their number remains constant over time. The analysis of growth spillovers in section 4 necessitates a preceding description of the economic structure across the observed regions as the structure of the Russian regions is nothing less than the external facet of the ongoing process of regional economic change. Whereas this process is in a large part influenced by interregional interaction, which can by itself be described by interregional spillovers. Therefore, before the process of change is observed in detail its external facet over the last years is described.

For reasons mentioned in the second section this part restricts itself to the use of data starting from 1998.

The k-means algorithm offers a prudent means to sort a set of regions in a pre-specified number of groups and estimate the fit of this grouping. In detail the k-means algorithm is applied to the data for a number of two to five groups. Five groups are taken as a preliminary upper bound as CAPPELEN et al. (2003) find four to five clusters for the European Union and it seems prudent to believe that Russia as a formerly centrally planed country will show even less clusters. The corresponding R^2 value is taken as an estimate of the quality of the grouping. The following Table 2 gives an overview of the R^2 values arranged by the number of clusters[18].

Table 2: R2 values for the full data set

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
R^2 – 2 Groups	0.601	0.613	0.647	0.635	0.727	0.765	0.668	0.739	0.730	0.774
R^2 – 3 Groups	0.611	0.611	0.646	0.641	0.727	0.764	0.671	0.740	0.729	0.775
R^2 – 4 Groups	0.605	0.570	0.633	0.637	0.723	0.761	0.668	0.629	0.660	0.773
R^2 – 5 Groups	0.556	0.569	0.585	0.635	0.700	0.692	0.597	0.575	0.647	0.770

The development of these last indicators can be interpreted as an indication that the differences in Russian regions' income are constantly - with the exception of 2002 - rising. The R^2 values in later years are much higher than in earlier ones. Even though, these R^2 values themselves are not comparable to the R^2 values of the estimations in the preceding section 3.1. Here high R^2 values even for a larger number of clusters might not necessarily indicate divergence of income, but they do not rule it out either - only the groups become more clearly defined, which signifies that the groups might diverge from each other. It should be noted that this also strengthens the observation of the preceding section that for most periods the neoclassical conclusion of poor regions growing faster than rich ones and of resulting regional convergence (BARRO and SALA-I-MARTIN (1991) and TONDL (2001)) does not hold in Russia. However, some questions remain unasked for 1994 and 2004-2006.

It can be alleviated insofar as for most periods, the rise in R^2 values for two and three groups in comparison to four or five groups are an extended indicator for convergence and indicate a structure with fewer clusters. However, it is still possible that the regions in these groups by themselves diverge rather drastically.

Combined with the insights gained in section 3.1 it is reasonable to assume that in the observed time horizon in Russia there is a prevalent structure, where there are, on the one hand, few rich regions and on the other hand, many poor ones. Heedless of the fact

[18] From now on the dataset consisting of all Russian regions considered in the analysis will be called the *full* set.

whether the distinction between two or three groups has to be made it can be concluded, that the number of distinct groups has declined, which means that groups converge with themselves and therefore merge. Furthermore, only in recent years a slight overall trend for convergence is present while in the years before 2003 there was nearly no structural change meaning that the structure inside the groups remains fixed.
In addition to the aforementioned, the most important insight from Table 2 is that the best fit is achieved either with two or three groups. Even though, it is not significantly clear if either two or three yield the optimal structuring.
Though, if the group assignments are considered, the two-group solution is more reasonable. In the three-group solution in every period there is at least one group with only one region assigned to it. Therefore, a structure of two groups is assumed. The groups are termed primary core - for the group of richer regions - and periphery - for the group of poor regions.
An overview as to which regions are assigned to the primary core and in what years can be found in Table 3.

Table 3: Primary Core membership - full data set

Region	Years of primary core membership
Federal City Moscow	1998 – 2007
Oblast Tyumen	1998 – 2007
Republic of Komi	1998
Republic of Sakha	1998, 1999, 2001
Oblast Kamchatka	1998
Oblast Magadan	1998
Oblast Sakhalin	2007
Autonomous okrug Chukotka	1998, 2001 – 2004, 2007

For the exception of Moscow and the oblast Tyumen no region stays part of the primary core in all periods. It is noteworthy that the regions that make up the primary core are the city of Moscow and those regions well endowed in natural resources, especially oil, gas and precious metals as in the case of the oblast Tyumen, the autonomous okrug Chukotka, the Republic of Sakha or the oblast Sakhalin.
Furthermore, it can be seen that the primary core regions have GRP per capita levels that are well above those of the average Russian region. To check if those regions distort the results and to structure the remaining regions in more detail, we exclude the primary core from the ongoing analysis. The resulting data set will be referred to as the reduced data set.
In an analogy to the construction of Table 2, the k-means algorithm is applied to the reduced data set and the results are shown in Table 4 below.

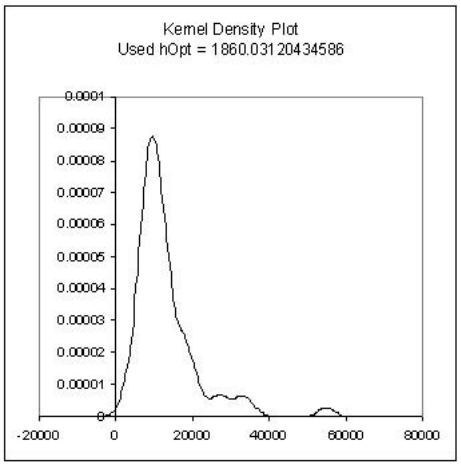
Table 4: R^2 values for the reduced data set

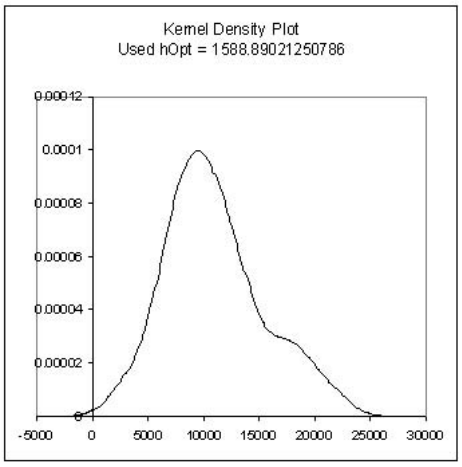
Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
R^2 – 2 Groups	0.468	0.568	0.546	0.505	0.451	0.468	0.522	0.482	0.456	0.479
R^2 – 3 Groups	0.519	0.561	0.551	0.512	0.475	0.488	0.527	0.485	0.456	0.489
R^2 – 4 Groups	0.516	0.553	0.547	0.520	0.492	0.504	0.528	0.484	0.454	0.488
R^2 – 5 Groups	0.510	0.544	0.541	0.519	0.491	0.503	0.527	0.478	0.443	0.487

As the values in Table 4 are generally lower than those in Table 2, the level of similarity among the regions from the reduced set is significantly higher than that from the full set as the fit of even two different groups is worse than that in the first table. Even though, there are some observations that favor the three-group structure over the two-group structure[19]. As the full data set proposes a two-group or a three-group structure, a two-group structure is more likely for the reduced set. Though, instead of taking the three-group structure from the first part of the analysis, the two-group structure of the second part is taken in order to divide the periphery into an inner periphery - the group of richer regions of the periphery - and an outer periphery - the group of poorer regions.
Combining the generally lower R^2 values for the reduced set and an overall declining trend of convergence at least up to 2004[20] leads to the conclusion that the Russian regions, excluding the capital and major oil and gas producing regions, are diverging and the divergence is no longer across groups but across regions. This holds even more in earlier periods as has been shown in section 3.1. Combining 3.1 with these insights it seams that the convergence observed in later years is merely an artefact generated by a *convergence* of the different clubs with each other and less so by overall regional convergence, which is also underlined by the results from Table 2.
In favor of this argument, SOLANKO (2003) shows by means of an analysis of β- and σ-convergence across Russian regions that the regions themselves are conditionally converging. This is an indicator that indeed there is less divergence across regions but rather a convergence with different clubs and an overall convergence of clubs. Even though, SOLANKO (2003) draws the conclusion that there is a convergence across the poorer regions.

3.2.2 Kernel density approach

To strengthen the conclusions of the preceding section, kernel density estimates for the full as well as the reduced data set are presented in Figures 1 through 6. They are given for the years 1998, 2004 and 2007. To predict the number of clusters, the procedure as used in CANOVA (2001), QUAH (1995) or CANTNER et al. (2004) is applied.



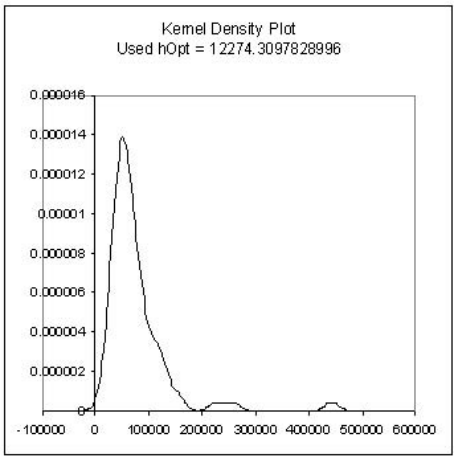


[19] This can also be explained by the results of section 3.1 that in the years between 1998 and 2004 there is a distinct level of no convergence.

[20] Even the R^2 values for 2005, 2006 and 2007 are only slightly higher for the three-group case than for the four-group case.

Fig. 1: Full data set: Kernel density estimation for 1998

Fig. 2: Reduced data set: Kernel density estimation for 1998



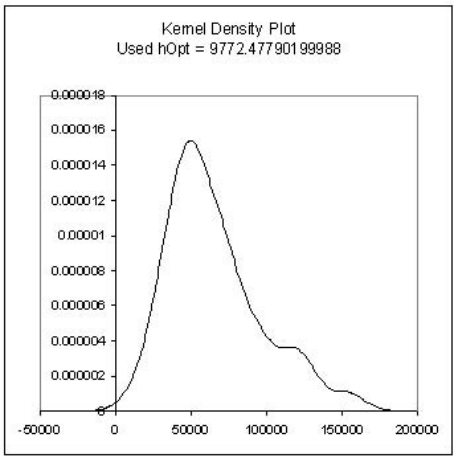
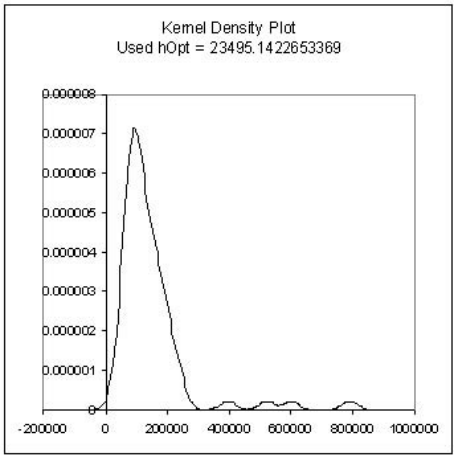


Fig. 3: Full data set: Kernel density estimation for 2004

Fig. 4: Reduced data set: Kernel density estimation for 2004



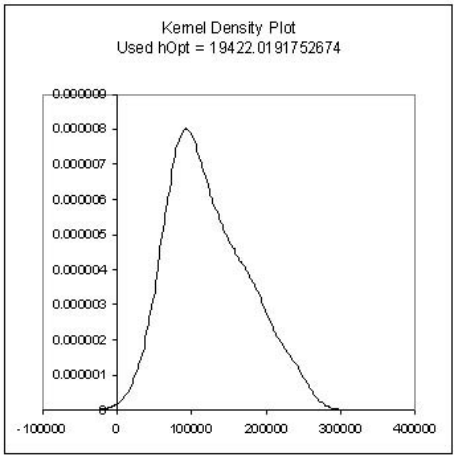


Fig. 5: Full data set: Kernel density estimation for 2007

Fig. 6: Reduced data set: Kernel density estimation for 2007

The rat's tail in the full data set, being made up by the extreme members of the primary core, can be clearly seen and stays relatively constant over time. When eliminating the primary core regions from the data set, there is significant change in the density estimation. Contrary to the reduced set, it can be seen that especially in 1998 the Russian regions showed a structure slightly reminiscent of the twin peak structures seen for example in the regions of the European Union[21]. Though, the two peaks did develop from 1998 onwards, they merge over time so that in 2007 only a single peak exists for the reduced set. Even

[21] See QUAH (1995) and CANTNER et al. (2004).

though this structure in combination with the last section gives credit to the implementation of a two-group structure for the periphery.
Furthermore, the figures strengthen the results that a convergence process has been happening over time from 1998 to 2007 - though mostly in the later years. If only the reduced data set is observed, the figure for 2004 clearly shows a density function with more than one peak so that the result of inner periphery divergence - at least up to 2004 can be held. Even though, this figure also shows that from 2004 to 2007 there is also a distinct level of inner group convergence.

3.2.3 Visualization of the results and preliminary conclusions

Following the last sections and the grouping of regions in the three convergence clubs of primary core, inner and outer periphery, it is necessary to consider the geographical structure of those groups. While the archetypical design would be for the primary core regions to cluster in the center and the inner periphery to surround them and the outer periphery being the regions farthest away from the center, other constellations are possible. The following figures[22] give an overview over the constellation of regions in 1998, 2001, 2004 and 2007. Herein, the black regions are the primary core, the dark grey ones are the inner periphery, the light grey ones are the inner periphery regions of Eastern Russia that have before been part of the primary core and the white regions are those of the outer periphery as well as those not considered in the analysis.

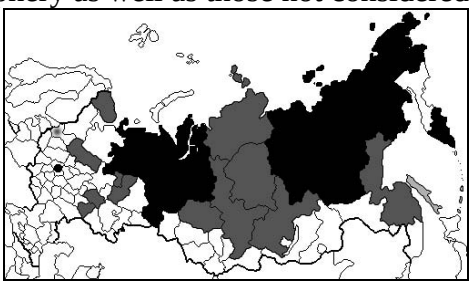


Fig. 7: Regional constellation in 1998

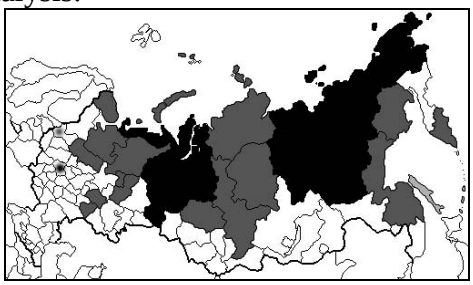


Fig. 8: Regional constellation in 2001

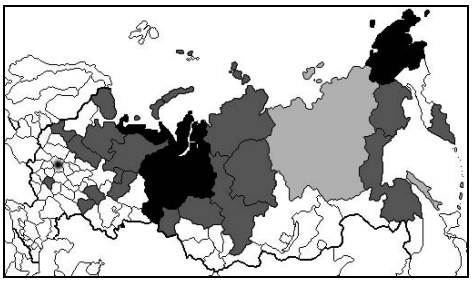


Fig. 9: Regional constellation in 2004

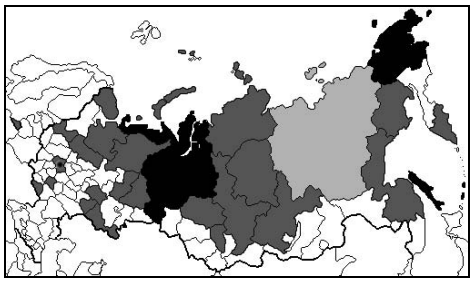


Fig. 10: Regional constellation in 2007

The figures show that the present constellations do not match the traditional single-centered ones - especially not the model by KRUGMAN (1991), which implies an industrialized core and an agricultural periphery. Instead, there are three central clusters:

[22] Maps are taken from THEODORA (2008).

the city of Moscow, the oblast Tyumen and the northeast of Russia. Furthermore it can be seen that the inner periphery does indeed surround the primary core. Even though, it does so mostly for the oblast Tyumen and the northeast, while Moscow is rather isolated. It can also be seen that the outer periphery mostly consists of regions in the south and the southwest. Comparing the maps with BERKOWITZ and DEJONG (1999) it can be seen that the regions of the outer periphery are mostly comprised of regions of the so-called *Red Belt*[23] of Russia. Also noticeable is that most of the westernmost inner periphery regions are clustered on the eastern outside of the Golden Ring of Russia. Whereas the regions of the Golden Ring themselves are neither primary core nor inner periphery regions.
The question as to why the federal city of St. Petersburg and the surrounding oblast are not members of the primary core is indirectly answered by TRUMBULL (2003), who shows that St. Petersburg, contrary to Moscow, is less based on economic dynamics and more on non-economic drivers of development. The peripheral position within Russia and within Europe is also impairing the economic dynamics of St. Petersburg. Promoting growth of ICT industries and of other *weightless goods* sectors might thus be considered by policy makers.
Comparison of the four figures shows that the most noticeable change in the overall structure is a westward movement of the inner periphery and a change from primary core to inner periphery of the northeastern regions.
While indeed little structural change took place in Russia in the last decade and there have been little to no efforts in establishing a working structural policy for Russia, the figures show that indeed a process of change has been in progress. Even though, it is not clear where this process will lead, especially in light of the still ongoing economic crisis and the high resource dependence of the Russian economy.

3.3 Future development prospects

Using the three groups established in the last section as possible states a region can achieve, it is possible to calculate steady states using ideas from the field of the Markov chain analysis. For more comprehensive results the ten-year timehorizon is split into two parts: the early years from 1998 to 2002 and the later years from 2002 to 2007. Whereas, in the early period the last year is varied and in the later period the first year is varied. Table 5 gives an overview of the achievable steady states. It is obvious that in the earlier years a distinct downward trend could be observed, while in the later years the trend depicts an upward trend.

Table 5: Markov chain analysis - Steady states / Percentage of regions in respective group

	Primary Core	Inner Periphery	Outer Periphery
2002 – 2007	100	0	0
2003 – 2007	100	0	0
2004 – 2007	100	0	0

[23] Regions that voted for the communist party in the 1992 election.

1998 – 2002	0	0	100
1998 – 2001	0	0	100
1998 – 2000	0	0	100

Combined with the insights gained from the previous section, it can be seen that the years following the Russian-Asian crisis still had to tackle some problems even though the economy itself was already recuperating[24]. Combined with the convergence results above, it can be seen that the Russian-Asian crisis lead to a divergence process across regions while single regional groups began merging, leading to lesser groups but increasingly more diversified ones. The turnaround came only around 2006, 2007 when a slow convergence across regions began, followed by an even more pronounced economic upward movement.

4. Growth spillovers in Russia

While the preceding analysis has been on economic welfare of the Russian regions, in this section the influence the regions have on each other is estimated. This approach might help to explain the structure observed in section 3.2.

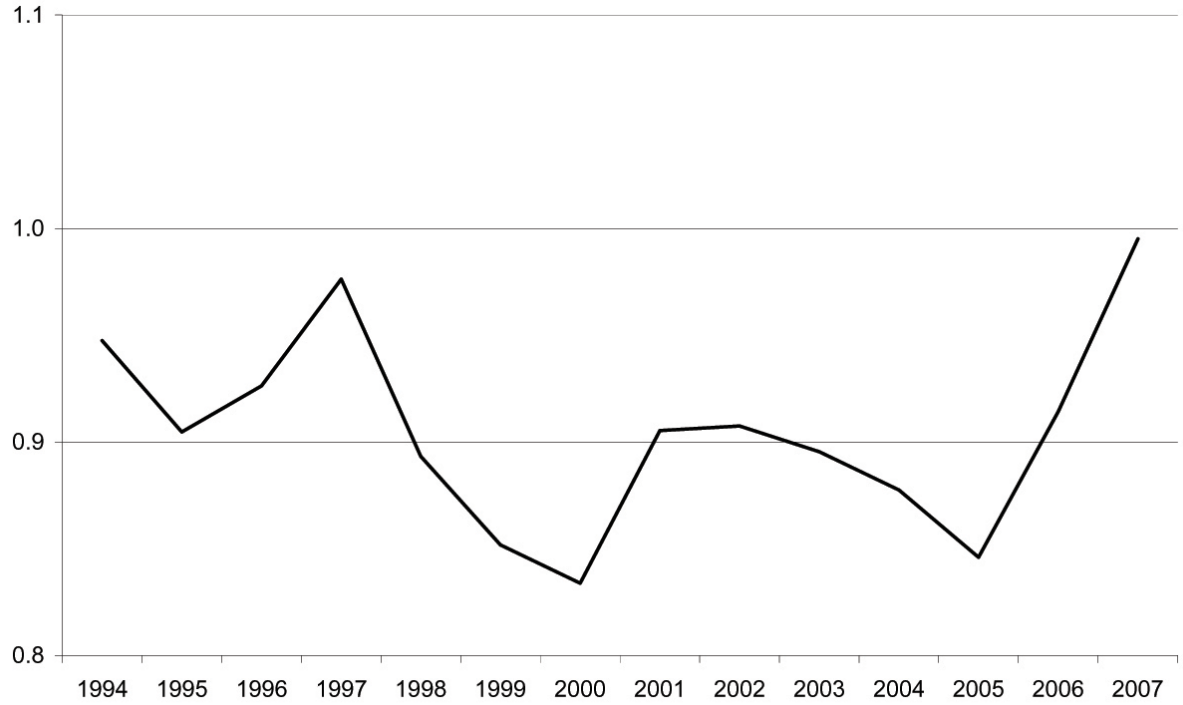
The influence of region *i* on region *j* can be seen as the level of spillovers from region *i* into region *j*. As has been argued in section 2, those spillovers can be measured by using indicators of spatial autocorrelation as Moran's I and the Getis Ord statistic.

It has to be stressed that the spillovers that are estimated below are mainly indirect spillovers. Indirect insofar as spillovers are related to knowledge transfers; though, we take a look at growth spillovers - if the level of GRP per capita in one region has an influence on the GRP per capita on a neighboring region. As growth impulses are transfered via knowledge transfers, the knowledge transfers are only indirectly estimated. Nonetheless, it is necessary to mention that spillovers are generated by trade of high technology goods, transfer of human capital (tacit knowledge) or transfers of codified knowledge. As interregional labor mobility is rather low in Russia (ANDRIENKO and GURIEV (2004)), it stands to reason that the spillovers generated in Russia are mainly due to interregional trade in goods and transfers of codified knowledge. Though, the exact importance of the three types of spillovers requires an analysis of interregional knowledge input and output, which is not done here. Furthermore, as the main aspects of spillovers are through tacit knowledge transfers, the low mobility combined with the size of some regions leads to expectations of rather low levels of spillovers in general.

To give a first impression of the interactions of the Russian regions over the fourteen years of transition, Figure 12 shows the global Moran's I statistic.

[24] See WIEGERT (2003) or WELFENS and WIEGERT (2002).

Fig. 11: Global Moran's I statistic - Traditional Neighborhood Matrix



As eighty regions are used in the analysis, the mean for the statistic is approximately 0.01266. Figure 11 shows that in all fourteen years the statistic is significantly above the mean, even though it is oscillating around 0.9. It can furthermore be seen that the process loosely follows the Russian business cycle and therefore, in the last period, is following an upward trend. This also shows that in years of good overall economic development the interaction between regions rises. This motivates the question whether Russian growth spillovers determine economic growth or whether economic growth determines spillovers.
The role the regions play in the overall growth process is illustrated in the following eight figures 12-19. The regions highlighted in light grey are regions showing positive spillover effects while the regions in dark grey are regions showing negative spillover effects. The positive spillover effects can be interpreted as the presence of a cluster of high valued regions, while negative values show a cluster of very low valued regions.

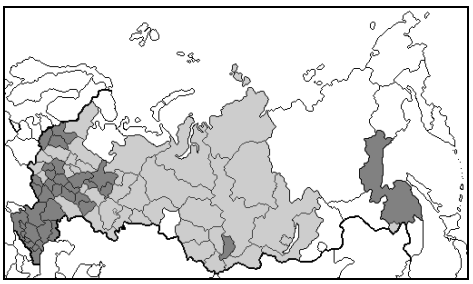


Fig. 12: Regional structure in 1994 – Getis Ord 400 km Cut-off Matrix

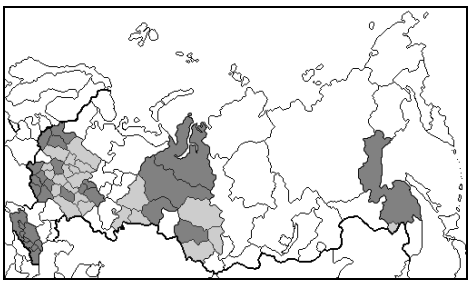


Fig. 13: Regional structure in 1994 – Getis Ord 200 km Cut-off Matrix

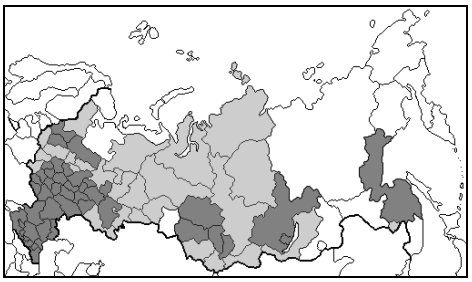


Fig. 14: Regional structure in 1998 – Getis Ord 400 km Cut-off Matrix

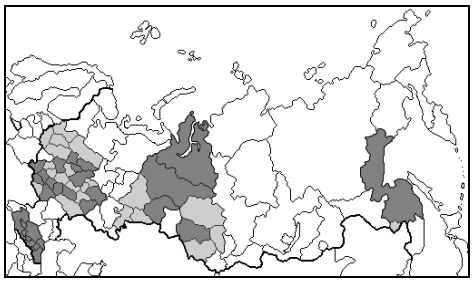


Fig. 15: Regional structure in 1998 – Getis Ord 200 km Cut-off Matrix

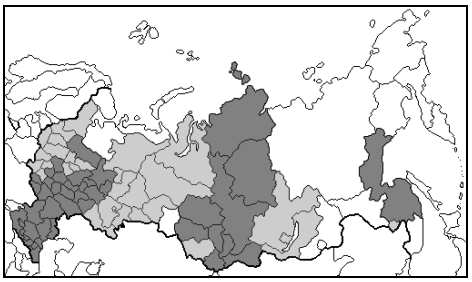


Fig. 16: Regional structure in 2003 – Getis Ord 400 km Cut-off Matrix

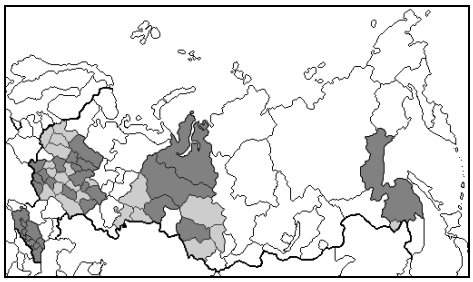


Fig. 17: Regional structure in 2003 – Getis Ord 200 km Cut-off Matrix

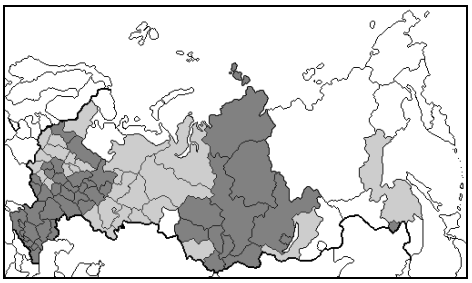


Fig. 18: Regional structure in 2007 – Getis Ord 400 km Cut-off Matrix

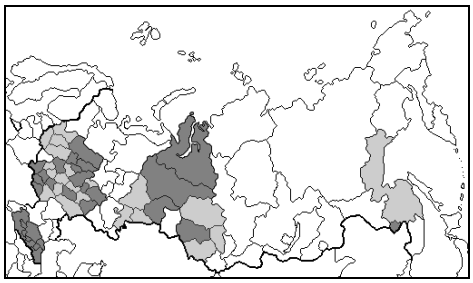


Fig. 19: Regional structure in 2007 – Getis Ord 200 km Cut-off Matrix

The charts for the 200 km cut-off matrix show that very little spillover activity has been present in Russia across the observed time horizon. This is due to two reasons. Almost 40 percent of the Russian regions, including nearly all regions highly endowed in natural resources are farther away from each other than 200 km. Aside from the area surrounding Moscow, very few changes have taken place in the structure of grow enhancing and diminishing regions.

It is mentionable that a large part of the Caucasian is showing distinct negative spillover effects and thus signifies an area of bad economic development and also bad economic development prospects.

In contrast to that, the cluster made up by the oblasts Chelyabinsk, Kurgan and Sverdlovsk is the most resistant high value cluster over all periods. If the radius of influence is increased to 400 km as shown in the figures for the 400 km Cut-Off matrix, the cluster of the above-mentioned three oblasts still stays highly positive. If furthermore it is assumed that all regions reporting values of around +/-10% of the mean show mere random fluctuations from the mean; the cluster of the oblasts Chelyabinsk, Kurgan and Sverdlovsk is the only area of significantly positive valued regions left.

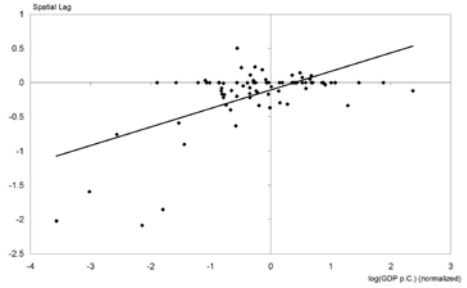


Fig. 20: Moran Scatterplot - 1994 200 km Cut-off Matrix

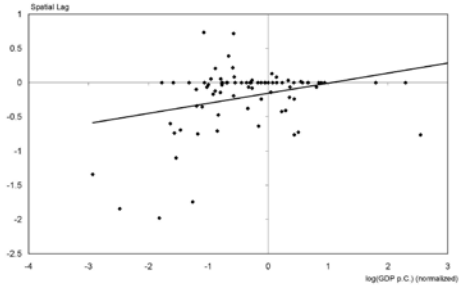


Fig. 21: Moran Scatterplot - 2007 200 km Cut-off Matrix

The Moran scatterplots in Figures 20 and 21 furthermore illustrate that in 1994, as well as in 2007, there are distinctly more regions with a low GRP per capita also reporting a low spatial lag[25] as there are rich regions with a positive spatial lag. The most noticeable difference from 1994 to 2007 is that the number of regions that lie in the upper left and the lower right quadrant rises over the 13-year-period. This is a possible explanation for the decrease of clustering activities over the years concerning a 200 km radius as observed in the figures above.

The figures for the 400 km cut-off matrix also show trends that are reminiscent of what could already be seen in Figures 7 - 10 on the structural composition of the Russian regions. The westward movement is noticeable as well as the fact, that over time eastern Russian regions change from positive to negative effects. Furthermore, it can be seen that many resource endowed regions report negative values as is also true for almost all Caucasian regions reaching northward till the edge of the Golden Ring and many of the Red Belt regions. As still many of the far eastern regions of Russia are beyond the 400 km distance it is not possible to get full results on the future prospects of primary core versus periphery regions.

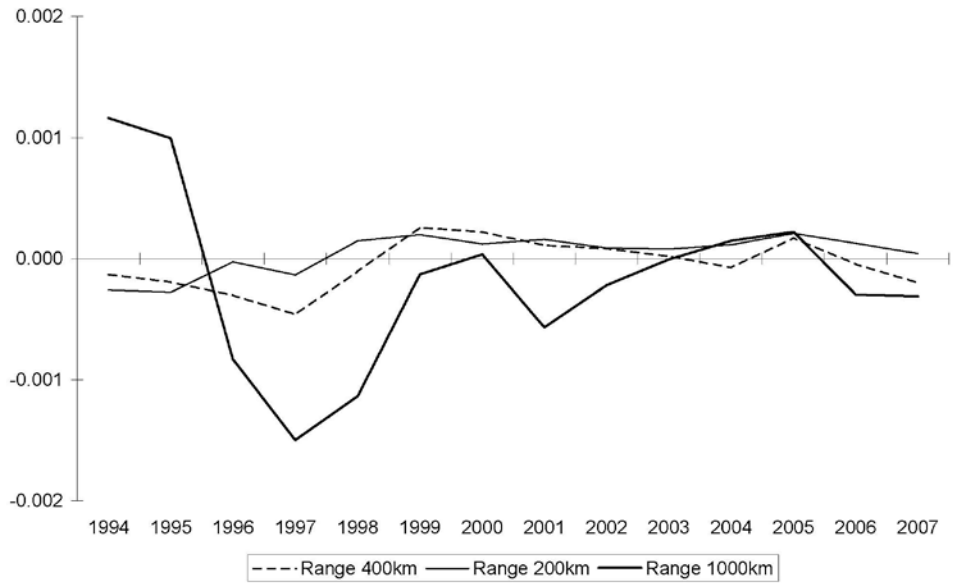
What can be seen from the figures is that while the primary core is strong by itself and seems to have some marginal influences on neighboring regions, these influences are not very strong. This is mainly because the primary core region, Moscow, is only a single region surrounded by parts of the inner periphery, which nonetheless is made up of lower valued regions and therefore stands alone. It is nonetheless mentionable that the regions

[25] The spatial lag of a region is the sum over all weighted deviations from the mean of the considered variable. In mathematical notation:

$$Spatial\ Lag_i = \sum_{j=1}^{N} w_{i,j}\left(\bar{x} - x_j\right)$$

surrounding Moscow report positive spillover effects, which go along with the findings of BERKOWITZ and DEJONG (2003a) who show that the distance to Moscow is still relevant for growth in Russia. Therefore, the reported spillover levels of the surrounding regions might merely be an artifact of the nearness to Moscow and less so of high levels of cross regional spillovers.
Tyumens reported positive values are very low, showing that the positive spillover effects are only of a marginal nature.
The inner periphery by itself cannot clearly be divided into growth enhancers or diminishers as especially the eastern regions around the krai Krasnoyarsk report in the later years more and more negative valued regions. Additionally, the change in western Russia happens mostly in the northwestern part and on a far smaller scale.
As for a smaller cut off distance and the introduction of a level of fuzziness of 10% around the mean, almost no spillover effects remain, it seems that if spillovers are present in Russia they are only generated over a larger distance and if so only on a very small level, which might be due to a low mobility of tacit knowledge in Russia. It adds to the comments in section 2.1 and CANIËLS and VERSPAGEN (2001) who show that rise in spillover levels leads to a rise in regional convergence - concluding that a low level of spillovers implicates a low level of regional convergence.
The general low level of interregional convergence and spillover activities might be explained by the trend of sinking levels of interregional trade in contrast to rising levels of international trade of the regions[26]. Additionally, GUENTHER (2010) shows that while the regions are not too far apart, they mostly lack the infrastructure to absorb foreign knowledge and technologies. Concerning the formation of clusters, GOLOVANOVA (2010) shows that cluster formation in general is low in Russia. She also argues about the motivation for the lack of interenterprise cooperation.

Fig. 22: Development of Local Getis Ord statistic for the federal city of St. Petersburg



[26] For this development see BERKOWITZ and DEJONG (2003b) and ECKEY et al. (2005).

Finally, to give an example of the development trends, Figure 23 illustrates the local Getis Ord statistics for the city of St. Petersburg and a neighborhood of 200 km, 400 km and 1000 km cut-off matrices. The first insight gained is that even though the approaches to measure the neighborhood differ, the development trends are similar. In all these cases the statistic more or less fluctuates around the mean with a relatively stable periodicity while the amplitude of the fluctuations decreases over time. Furthermore, the downward trends due to the Russian-Asian crisis as well as the one due to the dot-com crisis can be identified. Finally, for the last periods a new downward trend can be seen to begin. If the cyclic development keeps on, it can be that the transatlantic banking crisis will coincide with a depression according to the figure, but starting around 2010 a turnaround should lead to improvement again.

5. Conclusions and Policy Implications

5.1 Policy Implications

The discussion of the regional structure and growth effects in Russia has shown that the drivers of economic development are mostly regions well endowed with natural resources. However, this is only restating the obvious insights gained by looking at the population structure. From a theory-oriented point of view a growth pole oriented approach[27] or a Kaldorian cumulative causation approach[28] might be more appropriate in describing the economic development than a spillover or convergence club oriented approach.

While regions of the richer part of the periphery are mostly located around primary core members, almost all economically weak regions are located on the outer parts of Russia, especially in the southwestern area of Caucasia. It has also been shown that a cluster showing significant levels of regional spillovers only exists in one place and with only three members it is considered to be rather small. This leads to two fundamental policy implications.

It is necessary to establish a systematical structural policy in Russia with a special focus on those regions termed outer periphery, especially those in the Caucasian area. Incentives for more private investments are necessary but also more public investment and possibly higher government expenditures on education and research and development. An economic strengthening of the Caucasian regions might also improve the political situation in those regions. This in turn might have a positive feedback effect on the economic development.

Following the studies by KEILBACH (2002), CANIËLS and VERSPAGEN (2001), DE LA FUENTE (2000) and AHREND (2002), the most important aspects when trying to influence the national convergence process as well as spillover and cluster formation activities is the formation of highly qualified human capital. The formation of human capital works in the direction of creating and strengthening the regional potential for absorbtion of foreign knowledge and technologies.

[27] See PERROUX (1948) and PERROUX (1988).

[28] See KALDOR (1957).

Second, it is necessary to facilitate and promote the establishment of clusters or structures similar in nature to clusters - on a regional as well as on a national level. A reasonable starting point in this endeavor is to take a look at the cluster policies implemented for example in the European Union and especially in Germany, where a large number of clusters for example in the automotive industry exist. Given the different situations in Russia and the European Union, it is necessary to adapt the European cluster policies to the Russian situation before implementing them. Additionally, it is necessary to keep in mind that policy makers only have limited possibilities in influencing the convergence process directly[29].

Aspects also necessary to be considered when implementing European structural policy in Russia are the large distances between economic centers in Russia. A solution for this problem can be found by promoting approaches as discussed in the literature on Far- and Nearshoring and especially aspects such as long-distance-Just-in-Time as well as labor mobility enhancing policies.

Even though, before any options can be implemented, it is necessary to design the economic environment insofar as the regions have to become fully functional market economic entities without serious problems such as massive corruption or a high level of bureaucracy and a negative investment climate. In short, it is necessary for Russia as a whole to finish its transition process and abolish the last remnants of the former soviet system and at the same time pave the way for new economic developments. In this context it is necessary to tackle the problems already mentioned by VASILIEV (1994) which are mostly still unsolved till today or even simply guarantee contract rights as mentioned as a major problem by GOLOVANOVA (2010).

Most of the mentioned aspects can be subsumed to the establishment of fully functional institutions[30] and high quality stock of human capital.

5.2 Conclusions

The regional structure and related growth spillover effects and therefore the clustering of regions in Russia have been studied in this paper. It has been shown that Russia can be divided into three groups reminiscent of the core-periphery structure refered to in economic geography, with the exception that the periphery can be divided into an inner and an outer periphery. In contrast to traditional results, the core regions are not clustered in one place but mainly in three, surrounded mostly by inner periphery regions. The main insight gained from this analysis has been that there is indeed movement to a single structure in Russia but it is still very weak and has only been present in the last years observed in this study. Furthermore, the convergence process has mostly been across convergence clubs being accompanied by a slight divergence process inside the convergence clubs.

In a second part, the ties between the regions have been analyzed using indicators of global and local regional autocorrelation. It has been shown that while growth-enhancing ties are present, clusters reporting high values can mostly be found in the center of Russia or in the

[29] See CAPPELEN et al. (2003).

[30] See POPOV (2001) for the importance of working institutions for the Russian regions.

area surrounding Moscow. Considering the significance of spillovers in the analysis, it is revealed that only a cluster of three regions remains. This leads to the conclusion that in Russia there are some growth spillover effects present but mostly of a minor, insignificant nature.

What still needs to be done is an in-depth study of spillovers of economic growth but more so by directly analyzing potential knowledge spillovers on a disaggregated level. Here it is especially important to take a look at the different aspects of knowledge spillovers, as in spillovers generated by codified knowledge transfers by patents, especially patent citations or by tacit knowledge transfers via human capital mobility measured by inventor mobility. Third, the influence of interregional trade on knowledge generation and spillovers as well as the resulting economic growth needs to be analysed. Though, before knowledge spillovers can be studied satisfactorily, a basic description of the Russian system of knowledge generation and consumption is necessary.

In the field of economic policy, it is necessary to establish a feasible system of structural policy that fits the Russian characteristics while in nature implementing important aspects as being present in the structural policy of the European Union. Particular fields that have to be discussed are related industrial policy issues. In more detail, questions as to whether it is reasonable to establish and support local growth centers or whether a strategy of industrial dispersion should be supported, have to be discussed and a description of possible gains is necessary. Even more so, it is necessary that aspects of the economic system that are counter productive to establishing working growth oriented policy need to be named and a strategy has to be found to alleviate these aspects.

Acknowledegments

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