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Inter-regional output distribution: a comparison of Russian and Chinese experience

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Several studies report increasing inter-regional inequality in transition countries over the course of economic reforms, but most of them fail to look at the underlying dynamics. Using the cases of Russia and China, this article analyses the evolution of inter-regional output distribution during economic transition. One non-parametric method, kernel density estimation, and one parametric method, a Markov chain transition matrix, are used to evaluate the shape of the inter-regional output distribution and to evaluate regions' mobility within this distribution. Estimated distributions for both countries are skewed with long right tails. Whereas the distribution for Russian regions shows multiple modes, the hypothesis of unimodality could not be rejected for Chinese regions over the last two decades. Stationary distributions of the Markov chain transition matrices support this finding. It turns out that increasing inequality and multimodality in both countries are driven by a few outliers with very distinct characteristics.

Regional inequality is an important issue in several countries. Non-scholarly publications blame especially the economic and political transformation processes as a driving force of increasing regional inequality in Central and Eastern European countries as well as China. Baum and Weingarten (2005) as well as Förster *et al.* (2003) give an extensive survey of the emerging disparities in transition countries focusing on Central and Eastern Europe. The two largest transition countries, Russia and China, enjoy a prominent position in the discussion as documented in many scientific publications. A comparative view on these two countries calls for attention for various reasons: first, both countries are characterised by sub-national administrative units with varying political competencies. Whereas local administration in China is commonly claimed to support private firm development and foreign direct investment, in Russia extensive regulation, corruption and taxation by local authorities are accused of hampering private industry's growth (Blanchard and Shleifer 2000). Second, in both Russia and China growing inter-regional inequality and related aspects, such as inter-regional migration and unemployment, are important political issues. Even possible economic disintegration is discussed in the literature by some authors (for example, Qian and Weingast 1996). Third, China and Russia have followed and continue to pursue rather different ways of economic and political transformation. Whereas the first opted for a strategy of gradualism, the latter figures as a prominent example of a shock therapy. China is still governed by the Communist Party, prohibits democratic elections and controls mass media. The Russian political system, despite recent criticism, is characterised by competing political parties, elections and comparatively free

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media (Shleifer and Treisman 2005).[1] Finally, initial conditions varied crucially, with Russia entering the transition as a heavily industrialised economy and endowed with rich natural resources while China relied mainly on agriculture and relatively few large enterprises at the end of the 1970s (Sonin 2005).

Albeit analysing similar hypotheses, using the same type of data and deriving related conclusions, the existing literature fails to compare the two largest transition countries. The broad literature on regional inequality and regional economic growth using data from each of the two countries is far from having established a consensus. Many studies argue in favour of increasing stratification within both countries and the emergence of distinct convergence clubs. Finally, previous studies end up defining and comparing loosely defined groups of regions like East and West China but fail to look at developments at a lower level of aggregation.

Questions arising are: what has happened to regional output distribution in two of the largest economies in transition? In particular, how has inequality evolved over time and has it increased at a time of intense institutional changes? Which regions have profited from the economic development and which have lost? Following Quah's (1993) critique of 'Barro-type regressions' this article uses two more general approaches to answer these questions, one non-parametric and one parametric. Gross regional product (GRP) per capita is used as a proxy for wealth, and its development within China and Russia is analysed. More specifically, the econometric analysis disentangles the development of output distributions' shape from the mobility of single regions within the distributions. Following the literature cited, a bimodal distribution, reflecting China's coast–inland income gap and Russia's difference between resource-rich and resource-poor regions, is expected. The shape of the per capita output distributions is evaluated using kernel density estimation and the possible existence of multiple modes is assessed using a bootstrap multimodality test. Markov chain transition matrices are estimated and stationary distributions are derived to discuss the movement of regions within the distribution. The article is organised as follows. The first section gives some background information about the administrative division of both countries and presents a short summary of the existing empirical literature. The methodologies and data are introduced in the next section, followed then by the results. The last section concludes.

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Regional development in Russia and China

Sub-national administrative setting

Russian regions were set up following the Federal treaty of 1992, which marked the foundation of the Russian Federation. Up to August 2005 it consisted of 89 subjects: 49 *oblasti*, 21 republics, six *kraya* (territories), 10 autonomous *okruga* (districts) and one autonomous *oblast*' as well as two cities of federal importance (Moscow and St Petersburg). The autonomous *okruga* are parts of *oblasti* and *kraya*. Starting in September 2005, some of the autonomous *okruga* were merged with the relevant inclusive entities (Russian Analytical Digest 2006). As a consequence of this there are currently 83 regions.

The dissolution of the former USSR and a weakening of central power led to increasing autonomy of regions over the 1990s. Contradictions between new regional legislation and federal law were not isolated cases, and included intentions to introduce local currencies or an independent foreign policy (Desai *et al.* 2005, Konitzer and Wegren 2006). Similarly, trade barriers like border controls and tariffs for inter-regional trade were reported for 30% of Russia's regions during the early transition period (Berkowitz and DeJong 2001). The latter authors state that price dispersion between Russia's regions, especially those with more as opposed to less liberal administrations, is comparable with the impact of the US–Canadian border on intra-American price spreads. Additionally, political and financial relations between the federal and regional governments became the subject of two-way negotiations at the beginning of the 1990s. A variety of complex, shifting and often informal arrangements resulted from this development (Gerber 2006). President Putin started to implement several institutional changes in 2000. Based on these reforms authors from a political science perspective argue that central control over regions has increased (Dininio and Orttung 2004, Konitzer and Wegren 2006).

Whereas Russia exhibits a fully implemented federal system, Chinese regions have varying competencies and do not enjoy constitutional backing. The People's Republic of China consists at present of 22 provinces (excluding Taiwan), five autonomous regions and four metropolitan cities. The two special administrative regions, Hong Kong and Macao, are excluded from this analysis because of their very short history within the PR of China and their different political system. The current basic administrative division of China was set up in the years following the People's Republic's foundation in 1949.[2] Political reforms did not take place at the same time in all regions. For instance, some provinces were allowed to install their own foreign trade companies in 1979. Guangdong and Fujian were declared to have additional competencies to foster foreign investment and foreign trade. The first special economic zones were founded in these two provinces in 1980 (Qian and Xu 1993, Qian and Weingast 1996). With the beginning of the transition, competition between regions started and regional autonomy strengthened (Tian 1999). Qian and Weingast (1996) describe the emergence of 'dukedom' economies with considerable trade barriers in some regions.

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Convergence or divergence of Russian and Chinese regions?

Based on neoclassical growth theory, it is generally assumed poor regions display a higher marginal productivity of capital and, therefore, grow faster than rich ones. As shown by Barro and Sala-i-Martin (1998), this process should be more likely to occur for regions within one country than for a cross-country sample. Movement of goods and services should are easier within one country and, therefore, flows of factors to uses with the highest reward are expected to foster the economic catch-up of initially poor regions. Regarding Russia and China this traditional convergence hypothesis is debated. As one contrary statement, Qian and Weingast (1996) argue that inequality may be exacerbated across sub-national units. According to these authors, giving too much power to sub-national units via decentralisation puts the enforcement of a common market and a unified monetary system potentially at risk.

Thus hypotheses about ways in which the convergence process could differ between Russia and China are difficult to draw *a priori* from theory. For example, migration should contribute to an equalisation of inter-regional income differences from a theoretical point of view. Inter-regional migration is regulated quite differently in Russia and China. Whereas the latter officially restricts migration via a registration system (*hukou*) which limits movement from rural to urban areas and between provinces, the Russian government follows no nation-wide policy on restricting migration. However, residence permits are still in place in some major Russian cities and housing shortages impose an indirect constraint on migration (Gerber 2006). Additionally, resource-rich regions with potentially higher incomes are characterised by less favourable climatic conditions. Kwon and Spilimbergo (2005) point to a quite low and short-lived level of labour mobility between Russian regions due to income shocks. Thus it is less clear *a priori* whether there is more migration in China or Russia and whether migration flows are really directed towards regions with a higher per capita output.

Owing to the greater heterogeneity of Russian regions with respect to economic reforms and political orientation over the 1990s, a faster widening of the output per capita distribution is expected. Turning to similarities between the two countries, Vardomskii and Samburova (1994) attribute a significant role in economic development to metropolitan regions even before the period of state planning. Therefore, it can be expected that the large cities with province status will emerge as better-performing regions.

After having discussed some theoretical hypotheses, the findings of the broad empirical literature will now be summarised. The larger group of authors focuses on the development of measures of regional inequality and identifies its determinants quantitatively. Analyses starting from neoclassical growth models and estimating cross-region or panel data growth models econometrically form a smaller group.

There is a wide body of previous empirical analyses discussing various aspects of regional inequality of Russian as well as Chinese regions. As the main focus of this article is on the period of economic transformation, the following literature is limited to this period. The interested reader is referred to Kanbur and Zhang (2006) as well as Wei and Liu (2004), which provide very detailed surveys of studies on Chinese regional development including the pre-reform period. Irrespective of the type of wealth measure and underlying methodology, all studies agree on increasing inter-regional inequality in China as well as Russia over the period of economic reforms. However, declining inequality is reported for China over the early transition phase (Raiser 1998, Kanbur and Zhang 2006). Looking at the potential determinants behind this development, previous literature provides diverse explanations. For instance, Tsui (1991) and Raiser (1998) cite declining importance of Chinese government transfers as a cause of inequality reduction. Dolinskaya (2002) shows that relatively wealthier Russian regions have a significantly higher share of federal expenditure in their total budget. Natural resource endowment plays an important role in Russia too (Dolinskaya 2002, Galbraith *et al.* 2004). Several analyses highlight the impact of openness to trade for Russia as well as China (Fedorov 2002, Galbraith *et al.* 2004). Finally, agglomeration effects are pointed out by Fedorov (2002) as well as Kanbur and Zhang (1999).

Departing from neoclassical growth models, several studies apply Russian and Chinese regional data to this theoretical concept and test for the existence of convergence. Most of them find evidence of so-called unconditional or absolute convergence as, for example, Solanko (2003) in the case of Russia, Jian *et al.* (1996) and Démurger *et al.* (2002) in the case of China. Chen and Fleisher (1996), on the other hand, obtain a negative albeit statistically insignificant coefficient at conventional levels if real gross regional product (GRP) per capita growth between 1978 and 1993 is regressed on initial output. Results by Yao and Zhang (2001) point even towards unconditional divergence of Chinese provinces based on panel data from 1978 to 1995. Many studies find evidence of poor regions' catching-up after controlling for additional variables, resulting in conditional convergence. One exception is Brock (2005), who finds evidence of divergence, that is, initially wealthier regions growing faster, for a sub-sample of Russian regions. Factors which explain output growth differences between Russian regions are the number of new enterprises (Dolinskaya 2001, Berkowitz and DeJong 2003, Solanko 2003) and the relative initial share of extractive industries (Solanko 2003). Preferential policies in Chinese provinces turn out to increase GRP growth significantly (Démurger *et al.* 2002). Other significant drivers of growth in the case of China are foreign direct investment (FDI) (Chen and Fleisher 1996) and the share of light industry in total industrial production (Raiser 1998), whereas employment or population growth is found to negatively affect economic development of Chinese regions (Chen and Fleisher 1996, Weeks and Yao 2003).

Several sources agree upon increasing stratification and polarisation of regions. Whereas the former describes the emergence of more than two modes within the income distribution, the latter pictures the formation of two regional groupings at opposing sides of the distribution. Polarisation between Russian regions occurs, roughly defined, along an east–west axis, compared with an urban–rural and inland–coastal dimension in China (Vardomskii and Samburova 1995, Kanbur and Zhang 1999, Weeks and Yao 2003). The distinction between

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groups of regions is less data-driven in most cases. The majority of authors differentiate between East, Central and Western Chinese provinces, a distinction which is based on an administrative decision rather than provinces' strengths and weaknesses. Two exceptions are papers by Maasoumi and Wang (2006) and Aroca *et al.* (2006). Based on the similarities of provincial growth rates, Maasoumi and Wang (2006) find five Chinese regional clusters in the period after 1978. The composition of these clusters challenges the above-mentioned distinction as they contain rich Eastern as well as relatively poor Central provinces in the same group. Similarly but with quite a different outcome, Aroca *et al.* (2006) group Chinese regions into three states. Their analysis is based on the inclusion of neighbouring provinces' GRP per capita to capture spatial interactions between factors. Those regions with GRP per capita above the national average and with equally rich neighbouring regions are the three cities and the three provinces Jiangsu, Zhejiang and Fujian. All of them are located in the Eastern part of China.

As described in this section, previous literature highlights an increasing stratification of Russian as well as Chinese regions. Additionally, several authors assume the existence of convergence clubs. Thus regions are expected to converge to at least two distinct steady states. However, the existence of distinct modes of the output per capita distribution has not been tested so far.

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Statistical framework and data

One non-parametric and one parametric approach are used to gain insights into the shape and development of Russian and Chinese regional output per capita. Kernel density estimation and the associated multimodality test focus on the shape of the distributions. These approaches help to detect the emergence of modes within the inter-regional output per capita distribution but fail to give any insight into the relative position of single provinces. Thus the estimation of Markov chains aims to judge the mobility within the distribution and to detect regions moving up or down.

The methodological aspects of kernel density estimation are described by Silverman (1986) as well as by Wand and Jones (1995). Consider a sample of observations x_i grouped in intervals with bandwidth h. The kernel function K, in this case a univariate Gaussian kernel, weights each observation depending on its distance to the mean x of the interval. More centred observations receive a higher weight. The resulting density estimate consists of the vertical sum of frequencies at each observation. This procedure ensures a smooth curvature of the resulting distribution. The bandwidth h determines the smoothness of the density estimate, with larger values of h producing a smoother density estimate.

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

Silverman (1981, 1986) introduces the concept of critical bandwidth. A critical bandwidth (h_k) within this concept is the smallest h which produces a density estimate with, at most, k modes. Putting it differently, each bandwidth $h < h_k$ produces a density estimate with, at least, $k + 1$ modes. If the underlying income distribution among the population has two modes, a large value of h_1 is expected to produce a unimodal kernel density estimate. Therefore, h_k can be used as a statistic to test

H_0: $f(x)$ has k modes versus H_1: $f(x)$ has more than k modes.

The significance of the test is given by

$$ASL = \Pr ob_{\hat{F}_0}\{t(x^*) \geq t(x)\} = \{h_k^* > h_k\}/B \quad (2)$$

where $x^* = (x_1^*, x_2^*, \ldots, x_n^*)$ is the bootstrap sample drawn B times from the null distribution F_0. According to Efron and Tibshirani (1993), bootstrap samples have a larger variance than the sample variance; therefore, a small adjustment procedure following equation (3) is applied to the samples. Denoting the rescaled observation with y_i^*, σ^2 is the variance of the original distribution, x_i^* denotes the bootstrapped observation and ε_i is an independent error from a standard normal distribution.

$$y_i^* = \left(1 + \hat{h}_k^2/\hat{\sigma}^2\right)^{-1/2}\left(x_i^* + \hat{h}_k\varepsilon_i\right), \quad i = 1, \ldots, n \tag{3}$$

The Silverman test for higher values of k is not nested. Therefore, it is possible to detect several, for instance one as well as three, modes in the same distribution at subsequent stages of the test procedure.

This bootstrap test procedure has been applied by Bianchi (1997) as well as Henderson *et al.* (2002) to assess cross-country income distributions.

The mobility of regions within the distribution can be estimated using Markov chains. The methodology is described and applied to cross-country distributions in Quah (1993, 1997). In this article transition matrices are estimated for Russia and China. Each element of the transition matrix (p_{ij}) represents the probability of being in a state j, $t + m$ periods of time after being in a state i, for a total set of k states. Rows define the departure states and columns the arrival states, that is, a discrete state space and year-to-year transitions are considered. To make inferences on estimates of transition probabilities it is assumed that the process is stationary and has k states. The elements of the unobservable transition matrix, $p_{ij}(i, j \in \{1, \ldots, k\})$, that is transition probabilities, can be estimated by $\hat{p}_{ij} = n_{ij}/n_i = n_{ij}/\sum_{j=1}^{k} n_{ij}$, where n_i is the number of observations in state i, and n_{ij} is the number of observed transitions from state i to state j in a certain period t. These estimates are the maximum likelihood estimators of the true transition probabilities p_{ij}, as shown for instance in Norris (1997). The following assumptions are important in the interpretation of the estimated transition probabilities (Kemeny and Snell 1976, Bickenbach and Bode 2003):

- The transition process is memoryless and stochastic. This implies that the transition between t and $t + 1$ does not depend on any previous transitions and is independent of neighbouring regions' transition.
- The transition probability is time-invariant.
- An underlying regular Markov chain implies a convergence towards a stationary distribution which is independent of the initial distribution.[3]

This stationary or ergodic distribution is calculated following the approach proposed by Johnson (2000).

For the following empirical analysis gross regional product (GRP) per capita in national currencies is used. Data are obtained from the Federal State Statistical Office for Russia and cover the period from 1994 to 2004.[4] Regional data are not available before 1994 and therefore start after the implementation of mass privatisation and price liberalisation (Shleifer and Treisman 2005). Data for China cover the period from 1978 to 2004 and are drawn from publications by SSB and IFPRI (2003). The start of the sample of Chinese regions coincides with the implementation of the Household Responsibility System in agriculture, which is seen as the first step away from central planning (Lin 1992). For ease of comparison between the two countries, GRP per capita (z_i) is transformed into a relative measure. Per capita output at national level is used as denominator: $x_i = z_i/\bar{z}$. This transformation ensures that inflation and national as well as global business cycle movements which might affect all regions in the same way are

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Table 1. Descriptive statistics of gross regional product (selected years).

	Mean		Median		Variance		Skewness	
	Russia	China	Russia	China	Russia	China	Russia	China
Absolute gross regional product per capita								
1978		471.1		328		219.2		3.438
1983		713.9		542		318.3		2.967
1988		1,532.2		1,218		1,001.1		2.468
1994	3,333.4	4,287.1	3,015	3,177	2,548.8	8,229.8	1.759	2.340
1999	23,967.5	7,802.5	19,469	5,350	247,185.9	33,126.4	2.777	2.610
2004	84,960.2	14,079.4	66,714	9,608	5,275,824.9	113,431.8	4.560	2.495
Relative gross regional product per capita								
1978		1.243		0.866		1.526		3.438
1983		1.231		0.935		0.946		2.967
1988		1.131		0.899		0.545		2.468
1994	0.810	1.093	0.732	0.810	0.150	0.535	1.759	2.340
1999	0.841	1.191	0.683	0.817	0.304	0.772	2.777	2.610
2004	0.833	1.333	0.654	0.910	0.507	1.017	4.560	2.495

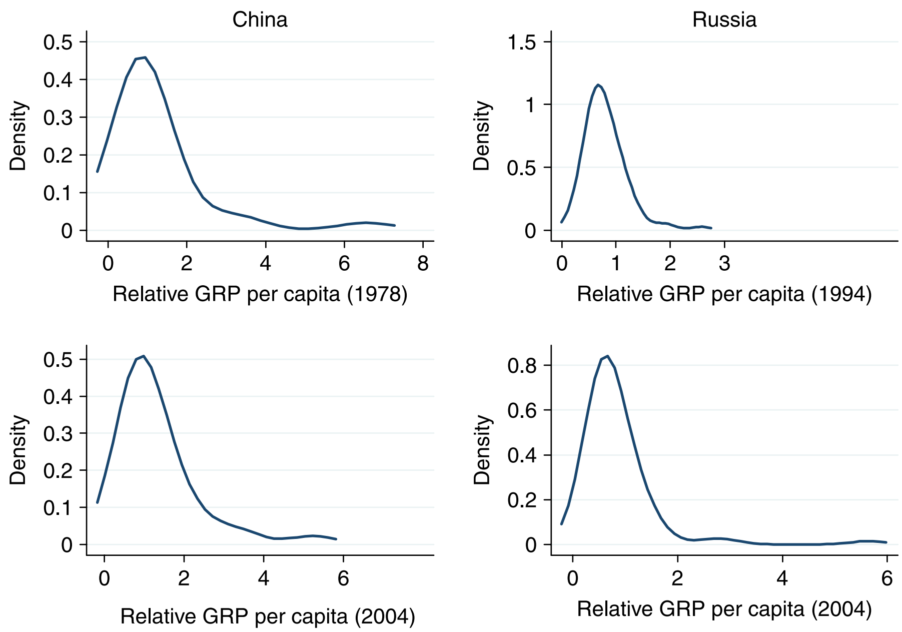
Note: Mean and median in national currencies (Russian rubles and Chinese yuan) and variances divided by 1,000.
Source: Own calculations based on national statistics.

excluded. Resulting changes in relative output per capita could be interpreted as net improvements or deteriorations of regional wealth. It should be kept in mind that significant differences in the size of the informal sector and significantly differing regional inflation rates might reduce the usefulness of the GRP measure. Additionally and beside general critiques of the data quality in both countries, Russian regional production data might be affected by the registering of their headquarters and dominance of large companies in some provinces (Solanko 2003). However, other measures like personal income data are not available for the whole period and are less comparable with previous studies. Table 1 presents descriptive statistics for selected years.

Empirical analysis

As a first step kernel density distributions are estimated for every year. The optimal bandwidths and the number of modes of the corresponding distributions are presented in Table A1 in the Appendix. As the selection of the optimal bandwidth involves a certain degree of arbitrariness two selection criteria are used: Silverman's rule of thumb (h_{Srt}) and Scott's oversmoothed bandwidth (h_{Sob}).[5] The corresponding distributions have between one and six modes, defined as local maxima. Multimodality seems to dominate the picture. A large bandwidth, like h_{Sob}, produces an oversmoothing of the underlying distribution and the estimated distribution shows fewer modes compared with the use of h_{Srt}. It is expected that the 'true' density will contain at least as many modes as observed for the estimated density using h_{Sob}. Figure 1 displays as an example the resulting graphs of relative regional incomes per capita in the first and the last years of the samples.

Obviously, all four graphs show a positively skewed distribution with at least two modes. However, the outer rightmost bumps represent one single region in each case. Comparing the two years, the two countries reflect a contrasting development. Whereas the distribution narrowed in the Chinese case between 1978 and 2004, the Russian distribution widened between 1994 and 2004. Shanghai is unquestionably the richest Chinese region and forms the second mode in both graphs in the left column. It is the largest Chinese city in terms of inhabitants and



Note: Underlying bandwidth is obtained following Scott's oversmoothed bandwidth selection rule (Scott 1992, p. 166) and equals 0.7257 (1978) and 0.5685 (2004) in the case of China and 0.1851 (1994) and 0.34 (2004) in the case of Russia.
Source: Own calculations based on national statistics.

Figure 1. Kernel density estimation of relative inter-regional income distribution.

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is located on the East coast. But the catching up of several Chinese regions leads to a diminishing relative distance between the two modes of the distribution. In contrast, the richest Russian *oblast*', Tyumen, gained relative importance and extended its distance from the national average. This *oblast*' belongs to the West Siberian economic region and is characterised by highly export-oriented industries. Additionally, it is the main oil and gas extracting region. At the same time the two regions Moscow city and Chukotka autonomous *okrug* took the second and third positions and form a third mode around 2.8. This first and preliminary observation does not support the hypothesis of different convergence clubs but rather the identification of some very rich outliers.

To give a picture of the development of regional income over the total sample Figure 2 presents two indices of inter-regional inequality: the coefficient of variation and the Gini coefficient for Russian and Chinese regional output per capita. Inequality between Chinese regions decreased between 1978 and 1990 and increased thereafter.[6] However, inter-regional inequality in Russia increased much faster. Measured by the coefficient of variation, inequality in Russia exceeded that of China after 2002. These results, especially the observation of U-shaped development of inequality in China, are in line with previous literature (for example Raiser 1998, Cai *et al.* 2002, Fedorov 2002, Bradshaw and Vartapetov 2003, Weeks and Yao 2003, Galbraith *et al.* 2004, Wei and Liu 2004). Jian *et al.* (1996) attribute the decrease of inequality between Chinese regions after 1978 to the decollectivisation of agriculture and growth of non-agricultural rural enterprises. Two conclusions could be drawn from Figure 2. First, inequality has reached a fairly high level in both countries compared with other large federal countries.[7] Second, excluding the richest regions in both countries results in much lower levels of inequality.[8] Additionally, the two inequality measures develop differently over time,

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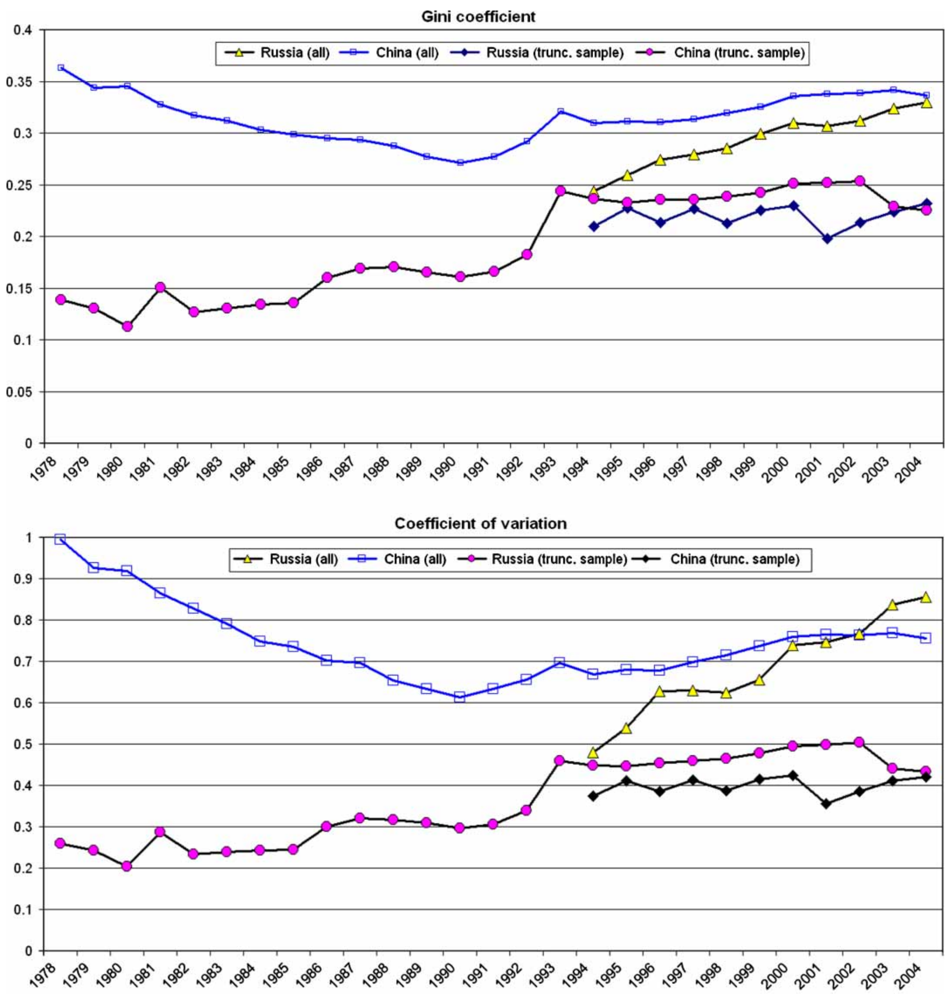


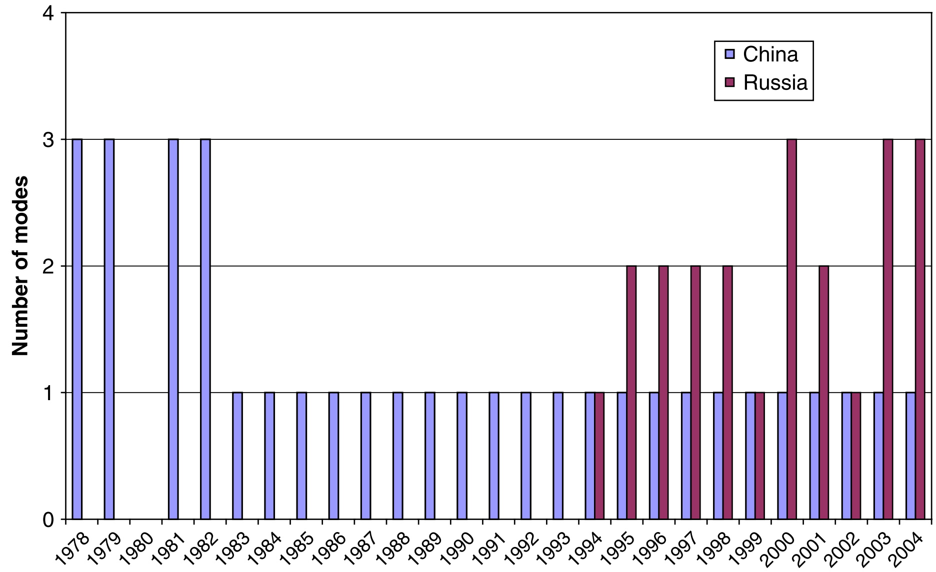
Source: Own calculations based on national statistics.

Figure 2. Inequality indices for Russian and Chinese GRP per capita.

which is a neglected issue in the majority of previous analyses. Rising inequality, especially over the most recent decade, seems to be driven by a very limited number of regions with special characteristics. This conclusion is supported by results of Démurger *et al.* (2002), who obtain much lower coefficients of variation for China if the three cities Shanghai, Beijing and Tianjin are excluded. Similarly, Yemtsov (2003) reports lower Gini coefficients for Russian inter-regional inequality if Moscow, St Petersburg and Tyumen are excluded.

The results of the bootstrap multimodality test are presented in Figure 3 and in the Appendix Tables A2 and A3.[9] The results for Russia clearly indicate that the hypothesis of bimodality of relative GRP per capita could not be rejected at a 10% significance level in five out of 11 years. Whereas a unimodal distribution appears only three times the later years point even to the emergence of three modes. Owing to the non-nested nature of the test, the hypotheses that the distribution shows one and three modes could not be rejected in 2002.

Subsequently, it is argued that Russia's regions developed towards two and even three distinct groups. Russian regions in the first and relatively poorest group have on average a lower relative



Source: Own calculations based on national statistics.

Figure 3. Number of modes which could not be rejected.

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GRP per capita in 2004 than 1994. A clear trend, however, is not observable. The second mode is formed by Moscow city, the capital, and Chukotka autonomous *okrug*. The third and final mode in 2004 contains Tyumen *oblast*'. The two latter regions are characterised by a low population density and rich natural resources. Tyumen is the richest region in all years. Chukotka exhibits some higher mobility: for example, it belongs to the second mode in 2002 and 2004 and to the third mode in 2003. These three regions differ in many respects from the remaining entities. Some authors exclude them from their analysis (see for example Solanko 2003).

Turning to China the results show a completely different picture (Table A3). Whereas a distribution with three modes could not be rejected for the years 1978, 1979, 1981 and 1982 the test favours a unimodal distribution in all subsequent years. Increasing the number of modes to be tested further leads to the non-rejection of distributions with three and four modes over the 1980s. The second mode in the 1978 distribution is formed by the two cities Beijing and Tianjin, whereas Shanghai forms a third mode. One possible explanation of the second mode's disappearance in the following years is that the difference in relative incomes between Beijing and Tianjin is growing from 1978 to 1991 and decreasing thereafter and the distance to the next richest provinces decreases from 1978 to 2004. Interestingly, the ranking of the pursuing regions changes dramatically. Whereas Liaoning and Heilongjiang, initially centres of heavy industry, hold the fourth and fifth ranks in the first year of the sample, Zhejiang and Guangdong, provinces in the Southeast, take over these places in the last year. Relative income per capita of the first two provinces is decreasing and those of the latter two increased over the 25 years.

The hypothesis that Russian and Chinese regions move to two distinct convergence clubs (Chen and Fleisher 1996, Weeks and Yao 2003, Solanko 2003) could not be supported with the help of the bootstrap multimodality test. The shape of the estimated distributions suggests that only some outliers, either resource-rich and sparsely populated regions or large cities, drive the emergence of distinct modes. The popular distinction between rich Eastern and poor Western Chinese regions or European and Asian Russian *oblasti* seems to oversimplify the reality.

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Table 2. Estimated Markov chains with grids based on 0.6σ.

		1	2	3	4	5	6
		Upper limit					
Russia (1994–2004)	Number of observations	$\leq \mu - 0.9\sigma$	$\leq \mu - 0.3\sigma$	$\leq \mu + 0.3\sigma$	$\leq \mu + 0.9\sigma$	$\leq \mu + 1.5\sigma$	∞
1	41	0.805	0.171	0.024			
		(0.06)	(0.06)	(0.02)			
2	317	0.003	0.934	0.063			
		(0.00)	(0.01)	(0.01)			
3	250		0.088	0.864	0.048		
			(0.02)	(0.02)	(0.01)		
4	101			0.218	0.693	0.079	0.010
				(0.04)	(0.05)	(0.03)	(0.01)
5	43				0.279	0.605	0.116
					(0.07)	(0.07)	(0.05)
6	38				0.053	0.132	0.816
					(0.04)	(0.05)	(0.06)
Starting distribution		0.101	0.342	0.228	0.203	0.076	0.051
Ergodic distribution		0.008	0.506	0.365	0.080	0.022	0.018
China (1978–2004)							
1	14	0.857	0.143				
		(0.09)	(0.09)				
2	382	0.008	0.942	0.050			
		(0.00)	(0.01)	(0.01)			
3	210		0.095	0.871	0.033		
			(0.02)	(0.02)	(0.01)		
4	79			0.063	0.924	0.013	
				(0.03)	(0.03)	(0.01)	
5	12					0.833	0.167
						(0.11)	(0.11)
6	67					0.015	0.985
						(0.01)	(0.01)
Starting distribution		0	0.5357	0.321	0.036	0.036	0.071
Ergodic distribution		0.008	0.141	0.071	0.032	0.064	0.684

Note: annual transitions, standard errors of estimated transition probabilities in parentheses. In 1978 no Chinese province had a relative income below or equal $\mu - 0.9\sigma$.
Source: Own calculations based on national statistics.

To have a closer look at the mobility of regions within the distribution, results of the estimated Markov chains are presented in Table 2. A division into six classes with varying upper limits is chosen and the elements of this table are the estimated probabilities of moving from one group to another from one year to the next.[10] Thus the entries on the diagonal indicate the probability of remaining in the same group from one year to the next. According to the estimates, persistence is highest in the second lowest and the highest income classes in both countries. Persistence in the upper middle groups (4 and 5) seems to be higher in China than in Russia. The estimated ergodic distributions point to a right-skewed distribution for Russia and a bimodal distribution for China. Whereas in Russia the second and third classes gain and all others lose relative weight, in China the gains are concentrated in the first, second, fifth and sixth classes. The increasing importance of the first class could be explained by the drop of the provinces Guizhou and Shaanxi from the second to the first class in the first half of the 1990s. However, the significantly increasing share of the richest class is driven by the income growth of the three municipalities Beijing, Tianjin and Shanghai. The category is almost an absorbing state and needs to be interpreted cautiously. Similar analyses have been performed by Dolinskaya (2002) using Russian data as well as Sakamoto and Islam (2006) and Bhalla *et al.* (2003) for China. Results are not completely comparable since all of them use a different number of classes and variant limits. Relative incomes are analysed in all three studies, but the latter two papers use fixed limits. Dolinskaya's (2002) results support this article's findings as they estimate the highest increase in the probability of staying below 0.7 of the mean, which corresponds to classes one and two in Table 2. Bhalla *et al.* (2003) base their findings on only three groups, which prevents drawing very detailed conclusions.

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Conclusion

The present study empirically examines the output per capita distribution of Russian and Chinese administrative units. Gross regional product per capita relative to the national GDP per capita is used as the relevant indicator. Parametric as well as non-parametric approaches are applied to assess the shape of the income distribution and the mobility within the distribution. We test for possible multimodality as suggested in previous studies using a bootstrap multimodality test and a Markov chain approach.

Evaluating the data at different optimal bandwidths determined by two different bandwidth selection rules results in multimodal distributions with up to six modes. The kernel density estimates point to regional output distributions with multiple modes for both countries. However, the development over time differs. Distributions of Chinese regions exhibit a higher number of modes over the first years of economic reforms than in the later period. For the Russian distribution the estimate points to an increasing number of modes in recent years. The results of the bootstrap multimodality test indicate a move of the distribution for Chinese regions from multimodality in the early 1980s to unimodality. Russian regions, on the other hand, seem to move from unimodality in 1994 to multimodality from 1995 onwards. The Markov chain approach reveals a bimodal distribution in the case of China and a right-skewed distribution for Russia in the long run. However, the ergodic distribution points to a widening of the income distribution in the middle income classes in both cases.

Most importantly, all approaches show that a very few regions with special characteristics drive the results in both countries. The increase of inequality is to a large extent related to the growing economy of the three municipalities Shanghai, Beijing and Tianjin in China and the capital city Moscow in Russia. Additionally, in the case of Russia natural resource-rich and sparsely populated regions like Tyumen or Chukotka join these outliers. Recent claims about increasing inequality in both countries neglected this fact and should be revised accordingly.

Generally accepted regional divisions into rich Eastern and poor Western Chinese provinces or Asian and European Russian regions could not be supported within this analysis.[11]

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Notes

1. For an extensive review of points of view evaluating Russia as democracy or autocracy see Söderlund (2006).
2. Tibet became a part of China as an autonomous region in 1965. Hainan was set up as a separate province in 1988 and Chongqing became a metropolitan city in 1997. Hereafter 'province' is used for all types of Chinese regions.
3. A stationary distribution exists if the Markov chain is aperiodic, irreducible and recurrent. In short, the matrix contains no absorbing state with a probability $p_{ij} = 1$ (Bode 1998, p. 116).
4. Over this period the Russian Federation still contained 89 regions. Data for the Republic of Chechnya and nine autonomous *okruga* are not available, which reduces the number of Russian regions in the sample to 79.
5. Silverman's rule of thumb is calculated as $h_{Srt} = 0.9An^{-1/5}$, with $A = \min$(standard deviation σ, interquartile range/1.34) and n = the number of observations (Silverman 1986, p. 47). Scott's oversmoothed bandwidth is defined as $h_{Sob} = 1.144\sigma n^{-1/5}$ (Scott 1992, p. 166). Both rules assume a Gaussian kernel function K and approximately normally distributed empirical data. All computations were performed with the software package STATA. For more detailed information on the STATA commands snp13 and snp6.2 see Saldago-Ugarte *et al.* (1995, 1997).
6. It has to be noted that inequality, based on figures of consumption expenditure, along the dimension urban–rural is nearly four times higher than inter-regional inequality in China (Kanbur and Zhang 2006). A similar result is reported by Yemtsov (2003) for Russian regions: within-regional differences account for more than two-thirds of total inequality.
7. To give an example of another large federal state, the highest inequality between the states of the USA, based on regional GDP per capita, never exceeded a Gini coefficient of 0.25 over the last century.
8. The smaller samples are based on all observations within the 25% and 75% percentiles. The outliers above the third quartile in 2004 are, in the case of Russia, Tyumen *oblast*, Chukotka autonomous *okrug*, Moscow city and the Republic of Sakha and in the case of China the three municipalities Shanghai, Beijing and Tianjin.
9. It could be argued that the chosen significance level is too low, since Silverman's test may be conservative and he offers no numerical value of a 'sufficiently large' ASL (Silverman 1981). Izenman and Sommer (1988) use a significance level of ASL = 0.40. As the authors do not perform simulations to assess the appropriateness of their ASL, a conventional significance level is chosen for this study.
10. We experimented with different numbers and definitions of matrix cells. Results support the main conclusions and are available upon request.
11. As mentioned earlier, inequality within regions exceeds that between regions and might require higher priority than the inter-provincial distribution. This type of inequality is masked using provincial GRP data. Therefore, to explore the within-regional dimension of income inequality and to derive policy conclusions the analysis of county-level or household data would be necessary.

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Appendix A

Table A1. Optimal bandwidths and observed modes.

	China				Russia			
	h_{Srt}	k	h_{Sob}	k	h_{Srt}	k	h_{Sob}	k
1978	0.119	6	0.726	2				
1979	0.095	5	0.673	2				
1980	0.099	6	0.665	2				
1981	0.131	3	0.627	2				
1982	0.122	4	0.599	2				
1983	0.133	5	0.571	2				
1984	0.124	5	0.523	2				
1985	0.115	6	0.498	2				
1986	0.139	5	0.467	2				
1987	0.143	3	0.368	2				
1988	0.168	4	0.431	1				
1989	0.138	4	0.328	2				
1990	0.185	4	0.406	2				
1991	0.179	4	0.410	2				
1992	0.182	3	0.425	2				
1993	0.219	3	0.443	2				
1994	0.247	3	0.424	2	0.124	3	0.185	2
1995	0.229	3	0.435	2	0.132	1	0.229	2
1996	0.241	2	0.438	2	0.127	3	0.262	2
1997	0.272	3	0.445	2	0.125	3	0.258	2
1998	0.231	3	0.470	2	0.111	2	0.257	2
1999	0.245	3	0.495	2	0.118	4	0.263	3
2000	0.261	3	0.518	2	0.113	5	0.287	3
2001	0.261	4	0.528	2	0.107	5	0.292	2
2002	0.264	4	0.540	2	0.115	5	0.303	3
2003	0.266	4	0.562	2	0.131	3	0.338	3
2004	0.272	3	0.569	2	0.123	3	0.340	3

Note: h_{Srt} – Silverman's rule of thumb; h_{Sob} – Scott's oversmoothed bandwidth.
Source: Own calculations based on national statistics.

Table A2. Results of bootstrap multimodality tests, Russia, all years.

	h_{crit}				ASL			
	$k=1$	$k=2$	$k=3$	$k=4$	$k=1$	$k=2$	$k=3$	$k=4$
1994	0.2499	0.1771	0.0711	0.0637	**0.210**	0.108	0.548	0.404
1995	0.5496	0.1288	0.0876	0.0710	0.006	**0.270**	0.342	0.300
1996	0.7427	0.2271	0.0710	0.0677	0.002	**0.164**	0.602	0.358
1997	0.6972	0.2305	0.1179	0.0928	0.000	**0.206**	0.274	0.212
1998	0.5331	0.2303	0.1001	0.0923	0.034	**0.220**	0.498	0.250
1999	0.4267	0.2704	0.1853	0.0769	**0.230**	0.172	0.136	0.484
2000	0.6581	0.4252	0.1491	0.1418	0.024	0.036	**0.254**	0.078
2001	0.7680	0.2883	0.1625	0.1623	0.002	**0.244**	0.250	0.024
2002	0.5279	0.4950	0.1670	0.0790	**0.240**	0.004	*0.264*	0.472
2003	0.8180	0.4440	0.1289	0.0770	0.004	0.028	**0.330**	0.492
2004	1.0294	0.3990	0.1479	0.0976	0.000	0.090	**0.242**	0.234

Note: 500 bootstrap replications; bold figures – hypothesis that the distribution has at least *k* modes could not be rejected at 10% level; italic figures – hypothesis that the distribution has at least *k* modes could not be rejected at 10% level in a second step.
Source: Own calculations based on national statistics.

Table A3. Results of bootstrap multimodality tests, China, all years.

	h_{crit}				ASL			
	$k=1$	$k=2$	$k=3$	$k=4$	$k=1$	$k=2$	$k=3$	$k=4$
1978	1.2508	0.6123	0.1794	0.1663	0.042	0.078	**0.330**	0.092
1979	1.0914	0.6035	0.1453	0.1372	0.058	0.062	**0.396**	0.108
1980	1.0197	0.6107	0.1999	0.1713	0.090	0.020	0.086	0.014
1981	1.0127	0.5630	0.1256	0.1132	0.076	0.092	**0.430**	0.188
1982	0.9122	0.5414	0.2064	0.1126	0.092	0.088	**0.162**	0.212
1983	0.7517	0.4997	0.3343	0.1356	**0.214**	0.084	0.042	*0.232*
1984	0.6267	0.5014	0.3143	0.1479	**0.284**	0.040	0.056	*0.140*
1985	0.6011	0.4722	0.2985	0.1427	**0.312**	0.048	0.042	*0.150*
1986	0.5079	0.4347	0.2841	0.1512	**0.402**	0.034	0.052	*0.116*
1987	0.4995	0.3351	0.0905	0.0694	**0.146**	0.062	*0.546*	0.438
1988	0.3807	0.3747	0.2526	0.1239	**0.588**	0.036	0.050	*0.250*
1989	0.3767	0.2714	0.1766	0.1002	**0.326**	0.094	*0.104*	0.232
1990	0.4716	0.3144	0.2368	0.1240	**0.264**	0.078	0.018	*0.254*
1991	0.5582	0.3220	0.2026	0.1064	**0.108**	0.086	*0.132*	0.185
1992	0.4772	0.4053	0.1774	0.1085	**0.344**	0.020	*0.220*	0.386
1993	0.5323	0.3231	0.1449	0.1393	**0.236**	0.152	0.478	0.198
1994	0.5601	0.2526	0.1817	0.1695	**0.142**	0.374	0.298	0.074
1995	0.5385	0.2637	0.1825	0.1684	**0.200**	0.352	0.260	0.078
1996	0.5643	0.2367	0.1904	0.1714	**0.174**	0.458	0.228	0.050
1997	0.6292	0.2375	0.215	0.1973	**0.132**	0.486	0.19	0.04
1998	0.6705	0.2723	0.2148	0.2104	**0.12**	0.44	0.22	0.062
1999	0.7125	0.2902	0.2354	0.2266	**0.136**	0.41	0.208	0.034
2000	0.7387	0.3084	0.253	0.2264	**0.13**	0.374	0.146	0.044
2001	0.675	0.3461	0.2954	0.2235	**0.214**	0.332	0.098	0.06
2002	0.6688	0.3506	0.2851	0.2107	**0.156**	0.34	0.128	0.116
2003	0.7005	0.3696	0.3003	0.2005	**0.22**	0.342	0.114	0.134
2004	0.7315	0.4127	0.2573	0.183	**0.184**	0.232	0.21	0.182

Note: 500 bootstrap replications; bold figures – hypothesis that the distribution has at least *k* modes could not be rejected at 10% level; italic figures – hypothesis that the distribution has at least *k* modes could not be rejected at 10% level in a second step.
Source: Own calculations based on national statistics.

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