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Distribution Dynamics of Russian Regional Prices

By: Konstantin Gluschenko

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Konstantin Gluschenko
Institute of Economics and Industrial Engineering,
Siberian Branch of the Russian Academy of Sciences,
and
Department of Economics, Novosibirsk State University,

pr. Lavrentieva 17, 630090 Novosibirsk, Russia
E-mail: glu@nsu.ru

Abstract
This paper studies the behavior of the entire distribution of consumer prices across Russian regions over the decade of 2001–2010. The analysis uses non-parametric techniques, exploiting the distribution dynamics approach. The results obtained evidence that regional relative prices in Russia remained fairly stable during 2001-2010. No significant changes are found in price dispersion and cross-region price distribution over this time span. Rank mobility was very low with seasonal surges. The pattern of quantity mobility manifests neither convergence nor divergence of regional prices. However, a long-run price distribution has an unpleasant feature, predicting potential emergence of a price convergence club in the Russian Far East.

Keywords
price convergence; price dispersion; price mobility; market integration; stochastic kernel

JEL classification: P22, R10, R15

1. Introduction

Spatial price dynamics in Russia significantly changed during the transition from a centrally planned to market economy. Following the price liberalization in January 1992, consumer prices diverged across regions of the country; and segmentation of the Russian goods markets increased dramatically. About the middle of the 1990s, a turn for price convergence occurred, giving rise to almost persistent improvement of market integration. By the beginning of the 2000s, this process came to an end. Since that time on, the degree of market integration in Russia remained approximately constant; the global crisis did not affect this pattern (Gluschenko 2009, 2013).

However, the evolution of an aggregated measure of market integration does not reveal many aspects of spatial price dynamics. For example, price polarization of Russian regions could be happening, while the degree of integration remains near-constant. Or, “cheap” regions can swap their places with “expensive” regions, again, without significant changes in the degree of integration. The aim of this paper is to answer questions of this kind.

A traditional tool of analyzing price behavior is the regression analysis, either time-series or cross-sectional, sometimes combined in the panel analysis. An observation in these analyses is, respectively, a point in time or a location (country, region within a country, city, etc.). There is one more pertinent methodology, namely, (non-parametric) distribution dynamics analysis. It considers the entire cross-location distribution of an economic variable as an observation, studying its evolution over time. Such an approach finds use in empirics of economic growth (see e.g., Durlauf and Quah, 1999), where income inequality is dealt with. An analogy can be drawn between cross-location income dynamics and dynamics of prices, interpreting price differences between locations as their “price inequality.” Thus, methodologies developed in the economic growth (and income inequality) literature can be used for spatial price analysis to reveal new aspects of price behavior. It is this methodology that is exploited in this paper.

The analysis covers all but one regions of Russia and the time span of 2001–2010. The cost of a staples basket (relative to its cost for Russia as a whole) serves as a price representative. The analysis includes three veins. First, it traces the evolution of price dispersion and changes in the shape of the cross-region price distribution over time. Having obtained a sequence of the distributions, the transition process between them, i.e., price mobility of regions, receives study. In doing so, both rank and quantity mobility are analyzed. Yitzhaki and Wodon’s (2004) methodology serves as a tool for studying rank mobility (i.e. changes in price ranking of regions). The evolution of the degree of rank mobility suggests a tendency of “cheap” and “expensive” regions to swap their places. To characterize quantity mobility, a transition probability function (stochastic kernel) is estimated, following Quah (1996). It provides the law of motion of the price distribution. The estimated stochastic kernel yields also a long-run limit of the price distribution.

The results obtained are in good agreement with those in Gluschenko (2009). They suggest that regional relative prices in Russia remained fairly stable during 2001–2010. No significant changes are found in price dispersion and cross-region price distribution over this time span. Rank mobility was very low with seasonal surges. The pattern of quantity mobility manifests neither convergence nor divergence of regional prices. However, a long-run price distribution has an unpleasant feature, predicting potential emergence of a price convergence club in the Russian Far East.

The issue of cross-region difference in prices in Russia and its evolution in the 1990s was of great interest for economists. Berkowitz, DeJong and Husted (1998), Berkowitz and DeJong (1999, 2001), de Masi and Koen (1996), Gardner and Brooks (1994), Goodwin, Grennes, and McCurdy (1999), and Koen and Phillips (1992, 1993) analyzed this issue, using different product and location samples as well as time spans and exploiting various methodologies. Their results together suggest the above-described pattern of price dynamics to the late 1990s. This paper extends the analysis in Gluschenko (2004, 2010), where the period of 1992–2000 is considered, to the first decade of the 2000s. It contributes to the above literature in two aspects. First, it exploits the distribution dynamics approach that did not find use in analyzing behavior of prices in Russia. Second, it relates to the 2000s which are not as yet covered by other authors.

The rest of the paper is organized as follows. In the next section, the data and methodology used for the analysis are described. Section 3 reports the results obtained. Conclusions are drawn in Section 4.

2. Data and Methodology

The Russian Federation consists of federating units (republics, *oblasts*, one autonomous *oblast*, *krais*, autonomous *okrugs*, and cities of Moscow and Saint Petersburg) termed federal subjects. Despite different designations, all these are equal in legal terms. There is a feature of the political division of Russia, namely ‘composite’ federal subjects, i.e. *oblasts* or *krais* that include one or more other federal subjects, autonomous *okrugs*. (The Chukchi Autonomous Okrug is the only one that is not a part of another federal subject.) Beginning in 2006, the autonomous *okrugs* have been uniting with the *oblasts*/*krais* that include them, ceasing to be separate federal subjects; by now, only two ‘composite’ federal subjects remain. In this study, a federal subject is meant by region; however, the composite federal subjects are considered as single regions. This makes it possible to eliminate the mentioned changes in the political system of Russia during the time span under consideration. The spatial sample covers 79 regions, i.e. all regions of Russia except for the Chechen Republic (lacking statistical data on prices). This sample is referred to as “Russia as a whole.”

Russian regions are very heterogeneous from the economic geographical viewpoint. To take this into account, empirical analysis is performed also over sub-samples of regions. The first one contains 73 regions and represents Russia excluding difficult-to-access regions. These are the Murmansk Oblast, Republic of Sakha (Yakutia), Sakhalin Oblast, Magadan Oblast, Kamchatka Oblast, and Chukchi Autonomous Okrug. They are remote regions lacking (except the Murmansk Oblast) railway and highway – at least, year-round – communication with other regions. Therefore these regions feature the highest consumer prices in the country. Besides, goods arbitrage can hardly be bilateral there, consumer goods being imported only in these regions. This results in a different pattern of price behavior than in the rest of Russia. Thus, it seems reasonable to consider spatial price dynamics, eliminating difficult-to-access regions.

Another sub-sample represents the European part of Russia excluding its northern territories (the Arkhangelsk Oblast, Murmansk Oblast, and Republic of Komi); it is hereafter referred to simply as ‘European Russia.’ This sub-sample contains 54 regions. As the transport infrastructure is more developed in this part of the country, and regions are closer to one another, one might *a priori* expect European Russia to be more integrated than the remainder of the country and price behavior to differ.

The cost of a staples basket is used as a representative price for the analysis. This basket was introduced by the Russian statistical agency, Rosstat (formerly Goskomstat), from 2000. It includes 33 foods; Rosstat (2006, p. 161) describes the composition of the staples basket (see also Gluschenko, 2009, Table A1). The data on the cost of the staples basket by region are drawn from the online statistical data base, Rosstat (2013). To eliminate inflation, the empirical analysis deals with the relative cost of the staples basket, i.e. the cost normalized to the national one (which is a weighted average over all regions). The raw data are monthly. The analysis uses annual prices as well. They are computed as geometric averages of monthly relative prices.

Let p_{rt} denotes the relative cost of the basket (hereafter, simply price) in region r (r $=1,\ldots,R$) in period t; P_{rt} stands for its logarithm, $P_{rt} = \log(p_{rt})$. The first issue is whether regional prices converge (or diverge) over time. A simple testable version is widely known as σ-convergence. Regional prices are deemed converging if their dispersion tends to decrease over time: $D(p_{t+\tau})/D(p_t) < 1$, where $D(\cdot)$ is a measure of price dispersion, e.g. the standard deviation of prices, Gini coefficient, etc., over $r = 1,\ldots, R$.

Being merely one of characteristics of the price distribution, the evolution of price dispersion provides fairly poor information on features of price dynamics. In particular, σ-convergence can be consistent with the case of price convergence within two (and more) region clusters without convergence to the national-market price. Such a fact would imply that there are "price convergence clubs" among regional markets, an analog of convergence clubs in economic growth (see, e.g., Barro and Sala-i-Martin, 2004).

To reveal more detailed properties of the evolution, the behavior of the entire distribution of regional prices, $f_t(P_t)$, is analyzed. The cross-section distributions are non-parametrically estimated in a number of points in time with the use of a kernel density estimator

$$\hat{f}_t(P_t) = \frac{1}{Rh}\sum_r K\left(\frac{P_t - P_{rt}}{h}\right). \qquad (1)$$

The Epanechnikov kernel is adopted: $K(x) = 0.75(1 - x^2)$, if $x \in [-1, 1]$, otherwise $K(x) = 0$; $h = 0.9 \cdot 15^{0.2} \cdot (4\pi)^{0.1} \cdot R^{-0.2} \cdot \min(\hat{\sigma}, (Q_{0.75} - Q_{0.25})/1.34)$ is the smoothing bandwidth (Silverman, 1986; Marron and Nolan, 1989), where $Q_{0.75}$ and $Q_{0.25}$ are quartiles of the distribution. Judging from unimodality or multimodality of the distribution, the question of whether there are price convergence clubs is to be answered.

Having estimated such a sequence of the distributions, the transition process between them, i.e. price mobility of regions (or, equivalently, intra-distribution dynamics), is analyzed. In doing so, two concept of mobility are exploited, rank mobility and quantity mobility. In the literature they sometimes are referred to as relative mobility and absolute mobility, respectively. However, these terms are ambiguous: in some other publications, they relate to measuring mobility with the use of relative or absolute indicators. Rank mobility concerns changes in ranking of regions by price level, i.e. the concern here is only with shifts of regions relative to one another. Quantity mobility concerns changes in regions' price levels themselves. That is, the interest here is with shifts of regions along the price axis irrespective of their relative positions.

Yitzhaki and Wodon (2004) propose to measure rank mobility by the Gini symmetric index of mobility:

$$S_t = \frac{G_t M_{t+\tau,t} + G_{t+\tau} M_{t,t+\tau}}{G_t + G_{t+\tau}}, \qquad (2)$$

where $M_{t,t+\tau} = (1 - \Gamma_{t,t+\tau})/2$ and $M_{t+\tau,t} = (1 - \Gamma_{t+\tau,t})/2$ quantify mobility forward and backward in time (for easier interpretation, the original indexes are divided by 2). In turn, Γ is the Gini correlation coefficient:

$$\Gamma_{t,t+\tau} = \frac{\mathrm{cov}(p_t, g(p_{t+\tau}))}{\mathrm{cov}(p_t, g(p_t))},\ \Gamma_{t+\tau,t} = \frac{\mathrm{cov}(p_{t+\tau}, g(p_t))}{\mathrm{cov}(p_{t+\tau}, g(p_{t+\tau}))},$$

where $g(p_t)$ represents ranks of regions in ascending prices, i.e. $g(p_{rt}) \equiv g_{rt}$ is region's number in the sequence of regions sorted by ascending p_{rt}.

It is readily seen that $\Gamma \in [-1, 1]$ and $S_t \in [0, 1]$. The greater the S_t, the higher the rank mobility, while the smaller (in the algebraic sense) the Γ, the higher the mobility. No mobility occurs if $S_t = 0$ ($\Gamma_{t,t+\tau} = \Gamma_{t+\tau,t} = 1$). With $S_t = 1$ ($\Gamma_{t,t+\tau} = \Gamma_{t+\tau,t} = -1$), mobility is "perfect", i.e. there is a total reversal in the ranks. When p_t and $p_{t+\tau}$ are statistically independent, there is no Gini correlation: $\Gamma_{t,t+\tau} = \Gamma_{t+\tau,t} = 0$; in that case, $S_t = 0.5$, implying random mobility.

Indexes Γ, hence, S_t, are not sensitive to monotonic transformations mapping the price distribution at t into that at $t + \tau$. It is this property that allows measuring only rank mobility. Such a transformation can be decreases or increases of inter-regional price gaps, suggesting price convergence or divergence. The absence of rank mobility indicates only the fact that the order of regions along the price axis has remained unchanged. But given this, the absolute positions of regions on this axis could have changed, e.g. "price distances" between regions have decreased. Such changes are characterized by quantity mobility.

To analyze absolute price mobility of regions, a methodology put forward by Quah (1996) is exploited. It considers the evolution of, in our case, prices as a homogeneous Markov process with discrete time and continuous state space; price classes being the states. Let $M(P_t^{(i)}, P_{t+\tau}^{(j)})dP$ be the fraction of regions being in (infinitesimal) price class i with prices from $P^{(i)}$ to $P^{(i)} + dP$ at t, and in price class j with prices from $P^{(j)}$ to $P^{(j)} + dP$ at $t + \tau$. Covering all classes, $P \in (-\infty, \infty)$,

M is an operator mapping the price distribution from period t to period $t + \tau$:

$$f_{t+\tau}(P_{t+\tau}) = \mathbf{M}\cdot f_t(P_t). \quad (3)$$

This operator is a stochastic kernel, or a transition probability function which is a generalization of transition probability matrix. (**M** may be viewed as such a matrix with continuous, hence infinite, number of rows and columns.) It is readily seen that the transition function is a probability density of prices at $t + \tau$ conditional on prices at t: $\mathbf{M} = f(P_{t+\tau} | P_t)$. Then we can rewrite (3) as $f_{t+\tau}(P_{t+\tau}) = \int_{-\infty}^{\infty} f(P_{t+\tau}|P_t)\, f_t(P_t) dP_t$.

The stochastic kernel is estimated in a manner like the univariate distributions are; see (1):

$$\hat{f}(P_{t+\tau}|P_t) = \frac{\frac{1}{Rh^2}\sum_r K\left(\frac{P_{t+\tau} - P_{r,t+\tau}}{h}\right) K\left(\frac{P_t - P_{rt}}{h}\right)}{\hat{f}_t(P_t)}. \quad (4)$$

The numerator in (4) is the estimate of the joint distribution of $P_{t+\tau}$ and P_t, and the denominator is the estimate – by Formula (1) – of the marginal distribution; $h = \max(h_t, h_{t+\tau})$.

Under the assumption of time-invariance of the transition function, i.e., of the underlying transition mechanism, the application of transformation (3) n times yields a distribution for $t + n\tau$, that is, $f_{t+n\tau}(P_{t+n\tau}) = \mathbf{M}^n\cdot f_t(P_t)$. Taking $n \to \infty$ yields the ergodic distribution, $f_\infty(P)$, i.e. such that $f_\infty(P) = \mathbf{M}^\infty\cdot f_\infty(P)$, where $\mathbf{M}^\infty = f(P_{t+\infty} | P_t)$ is the limit of $\mathbf{M}^n = f(P_{t+n\tau} | P_t)$ with $n \to \infty$. The ergodic distribution is the long-run limit of the distribution of prices. Depending on unimodality or multimodality of the ergodic distribution, it can be judged whether the existence of convergence clubs is to be expected in the long run.

With sufficiently great n, $\mathbf{M}^n$ approximates $\mathbf{M}^\infty$. Numerically integrating (with the use of a 101×101 grid) in relationship

$$f(P_{t+n\tau}|P_t) = \int_{-\infty}^{\infty}\ldots\int_{-\infty}^{\infty} f(P_{t+n\tau}|P_{t+(n-1)\tau})\ldots f(P_{t+2\tau}|P_{t+\tau})\, f(P_{t+\tau}|P_t) dP_{t+(n-1)\tau}\ldots dP_{t+\tau} dP_t$$

yields an estimate of $\mathbf{M}^n$. Since $\mathbf{M}^\infty$ degenerates into $f(P_{t+\infty}|P_t^{(i)}) = f(P_{t+\infty}|P_t^{(j)})$ for each pair $P_t^{(i)}$ and $P_t^{(j)}$, the fulfillment of this condition accurate to 10^{-3} is used as a criterion of convergence of $\mathbf{M}^n$ to $\mathbf{M}^\infty$.

3. Empirical Results

3.1. *Price Dispersion and the Shape of Distribution*

Figure 1 plots the dynamics of price dispersion measured as $\sigma_t = \sigma(P_t)$, the standard deviation of the log relative prices. As expected, the maximum price dispersion takes place over all regions (with the time average of 0.19). The exclusion of difficult-to-access regions crudely halves it, reducing the average to 0.11. At last, European Russia yields the minimum price dispersion, with the average of 0.08.

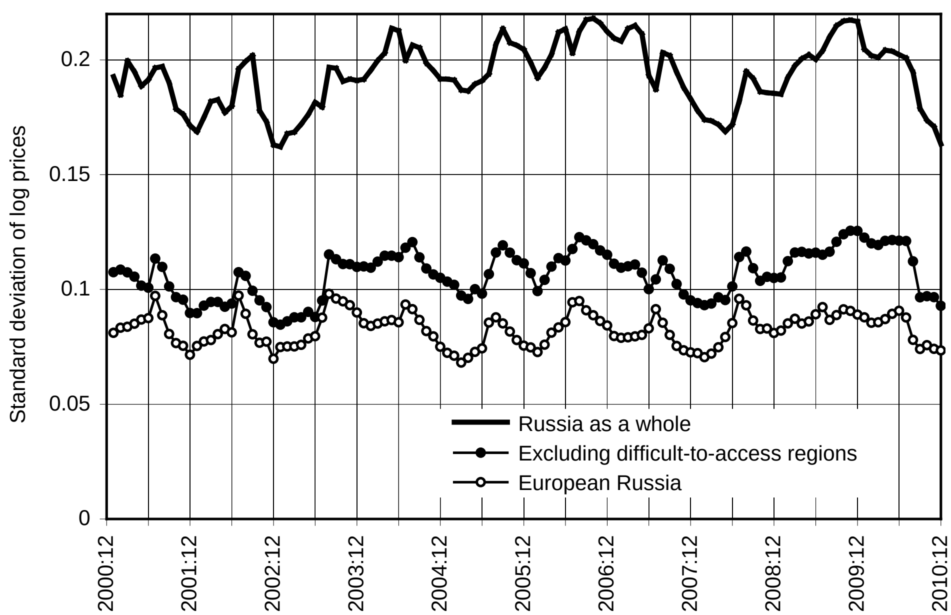


Figure 1. The evolution of inter-regional price dispersion.

Figure 1 suggests that the dispersion paths are fairly stable, fluctuating around some constant levels (in particular, no pronounced effects of the global crisis are seen on the paths). Nonetheless, statistically significant (at the 1% level) – albeit weak – upward trends do exist in Russia as a whole and Russia excluding difficult-to-access regions. In the former, the trend factor equals 0.000106, which gives a 0.7% rise in price dispersion per year. In the latter, the figures are 0.000124 and 1.5%, correspondingly. (In European Russia, no statistically significant trend is found.)

However, being that weak, these trends seem a statistical artifact rather than an evidence of σ-divergence. Estimates of price dispersion on the annual basis corroborate this conclusion. They are depicted in Figure 2.

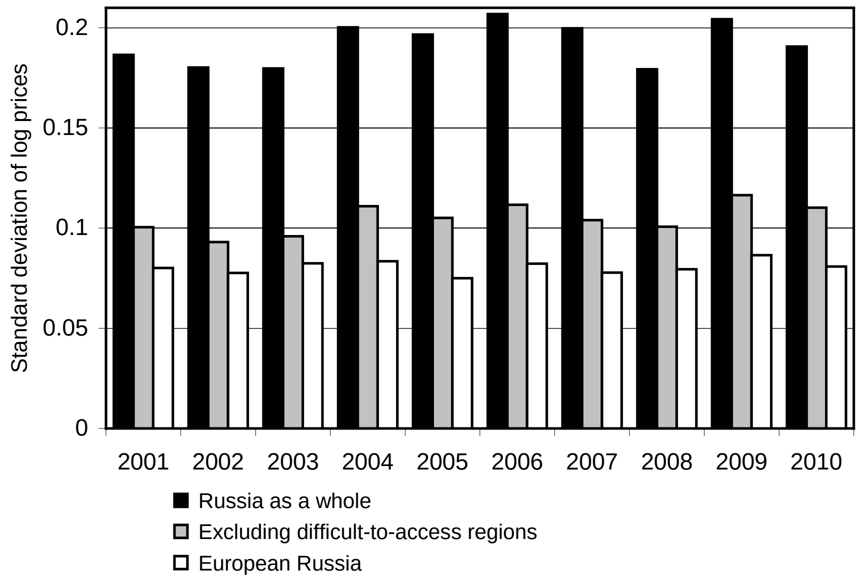


Figure 2. Inter-regional price dispersion by year.

To gain further insight into the behavior of regional prices in Russia, let us take a look at changes in the shape of the cross-region price distribution over time. To assess these changes, probability densities have been non-parametrically estimated using Formula (1) for each year from 2001 to 2010. Figure 3 depicts the distributions for the initial and final years. The distributions in intermediate years are very close to them; Appendix report the full set.

Some features of the cross-region distribution of prices in Russia are seen in this figure. The rightmost small mode is due to the only region, the Chukchi Autonomous Okrug, the most expensive region of the country. The cost of the staples basket fluctuated here in the band of 264% to 327% of the national average in 2001–2010. The heavy right-hand tail of the distribution, circa from $P = 0.3$ to $P = 0.6$ (or 135% to 180% of the national average), comprises Far-Eastern difficult-to-access regions with prices from 147% to 174% of the national average: the Republic of Sakha (Yakutia), Sakhalin Oblast, Magadan Oblast, and Kamchatka Oblast. A gap between the left end of this group and the adjacent region was 20 percent points in 2001. In 2010, two more Far-Eastern regions entered into this group, the Khabarovsk Krai and Primorsky Krai. The left end of the group became 134% of the national average; the gap shrinking to 5 percent points.

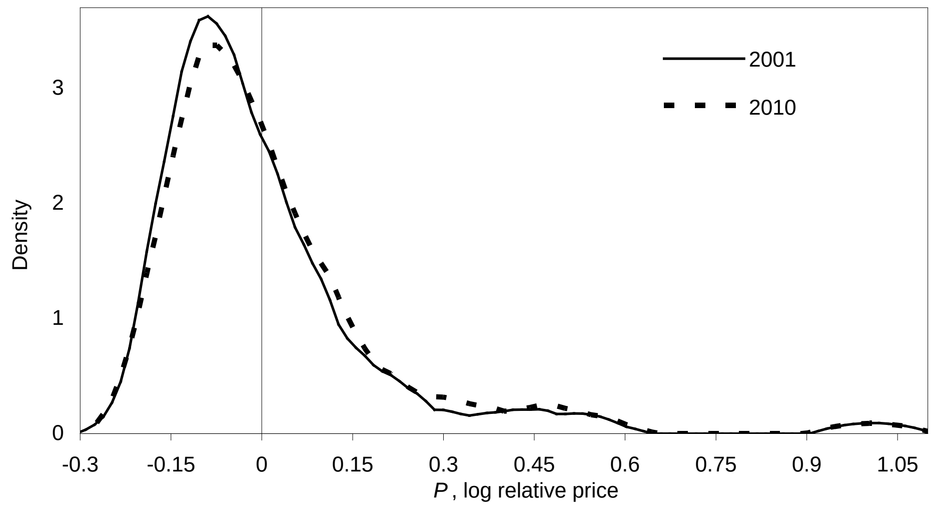


Figure 3. Estimates of price distributions over Russia as a whole.

The cross-region distribution of prices is unimodal. Although the right-hand tail looks like a small mode in some years (e.g., in 2001), statistical tests for multimodality reject the hypothesis of that there is more than one mode in the distribution for all years. (As for the rightmost "mode," it is in fact an outlier.) This suggests the absence of price convergence clubs. Nevertheless, there is an anxious tendency of Far-Eastern regions to concentrate in the right-hand tail of the distribution. Over 2001–2010, relative prices in the Russian Far East rose, while they fell in neighboring Eastern Siberia. This potentially can lead to that the Russian Far East will become a price convergence club, so fragmenting the Russian goods market.

Since the changes in the shape of the price distribution over time prove to be minor, their statistical significance is to be checked. To test the hypothesis of stability of the cross-region price distribution over time, the two-sample Kolmogorov-Smirnov test is implemented, applying it to each pair of the annual distributions. Table 1 tabulates the results of testing, reporting *p*-values of the null hypothesis that the samples are drawn from the same distribution (i.e. that two income distributions under consideration are identical).

As Table 1 suggests, the null hypothesis is highly significant in all comparisons (the minimum significance level across the table equals 32%). Thus, it may be concluded that the cross-region price distribution in Russia remained very stable during 2001–2010 (moreover, the hypothesis cannot be rejected that the distribution remained the same over years).

Table 1. Comparisons of annual price distributions: the Kolmogorov-Smirnov test *p*-values

	2002	2003	2004	2005	2006	2007	2008	2009	2010
2001	0.813	0.977	0.997	0.997	0.977	0.916	0.428	0.813	0.813
2002		0.997	0.551	0.916	0.322	0.813	0.551	0.684	0.813
2003			0.916	1.000	0.684	0.997	0.813	0.813	0.977
2004				0.916	0.997	0.916	0.684	0.977	0.916
2005					0.916	0.977	0.551	0.916	0.977
2006						0.916	0.684	1.000	0.813
2007							0.813	0.977	1.000
2008								0.813	0.551
2009									0.997

3.2. *Rank Mobility of Regions*

Figure 4 plots monthly Gini symmetric index of mobility, S_t, – see Formula (2) – as compared to price dispersion measured by the Gini coefficient, G_t. It is worth noting that the behavior of G_t in Figure 4 and σ_t in Figure 1 is similar; being rescaled, the paths of G_t and σ_t almost coincide.

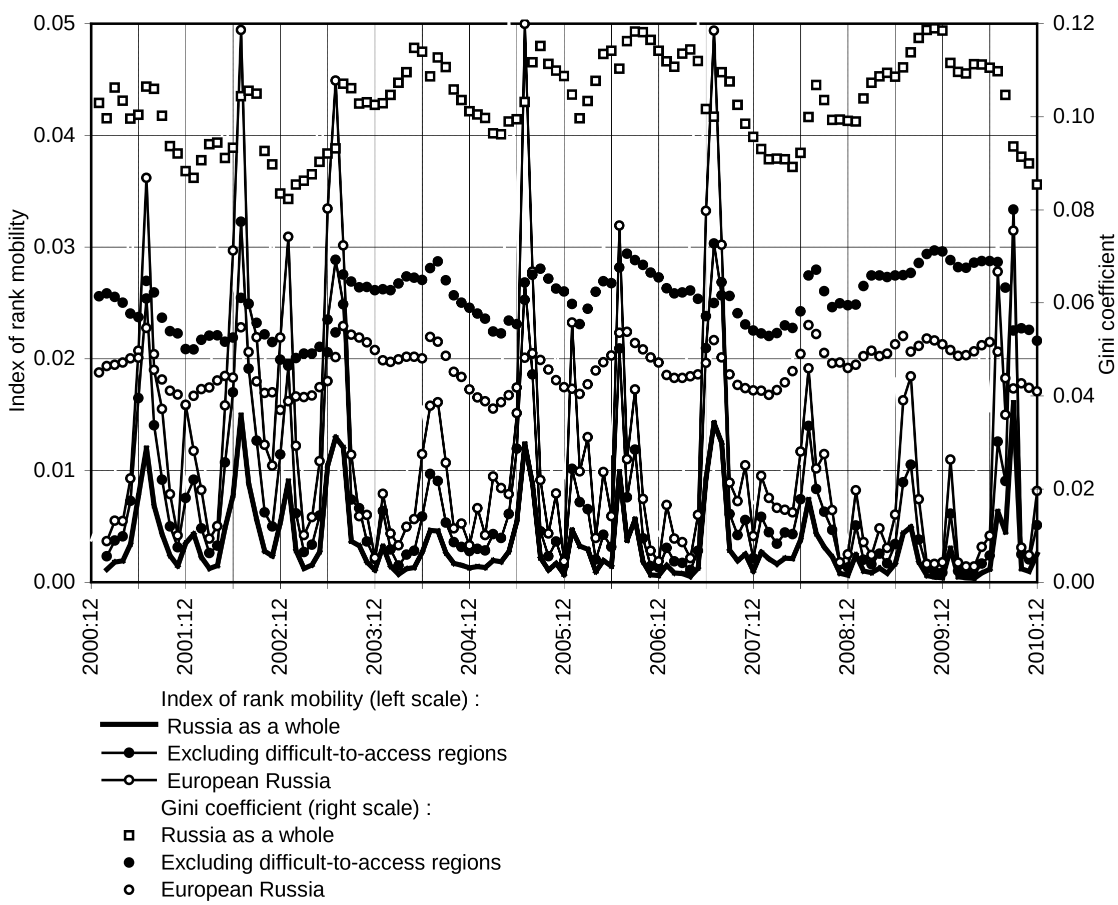


Figure 4. Price dispersion and rank price mobility of Russian regions.

Rank mobility proves to be very low. Its time average equals 0.0035 in Russia as a whole, 0.0074 in Russia excluding difficult-to-access regions, and 0.0117 in European Russia. In contrast to price dispersion, relative mobility rises when we pass to more narrow sub-samples. This implies that that the price ranks of difficult-to-access regions are rather stable, as might be expected, and that changes in ranks of Siberian and Far-Eastern regions are less than in regions of the European part of the country. Figure 4 suggests that there is a connection between changes in price dispersion and relative price mobility of regions. Indeed, the correlation coefficient between $|(G_{t+\tau} - G_t)/G_t|$ and S_t is equal to 0.49 in Russia as a whole, 0.64 in Russia excluding difficult-to-access regions, and 0.67 in European Russia. The correlation is greater with the increase in price dispersion (positive $(G_{t+\tau} - G_t)/G_t$), equaling to 0.54, 0.72, and 0.78 across the respective spatial samples, while it equals to –0.40, –0.47, and –0.40 in the case of the decrease of price dispersion.

Qualitatively, the behavior of S_t (as well as G_t) across spatial samples is very similar. Upsurges of mobility occur at regular intervals, having peaks, as a rule, about July of each year. Lesser peaks occur, for the most part, about Januaries. They thus seem to be a seasonal phenomenon. In summer, the rate of rise in prices for many items covered by the staples basket decreases dramatically, not infrequently to negative values. This process is asynchronous across regions, depending on natural conditions in a given region and its agricultural specialization. As a consequence, sufficient changes in the region ranks happen; and then the ranking returns to its original (or close to original) state within a few months. During 2001–2010, inflation was higher in Januaries than in other months, inflation rates significantly differing across regions. This also resulted in changes in the price ranking of regions.

A possible reason for low relative mobility might be the fact that transitions for very short run are considered. Usually, the distribution of prices changes more or less gradually, and so, monthly changes could be rather small. It might be expected that mobility over longer transitions can turn out to be considerable. To verify this, the index of relative mobility is computed for longer time spans, one to nine years. Table 2 presents the results.

Table 2. Rank price mobility of Russian regions over different time horizons

τ (years)	t	$t + \tau$	Russia as a whole		Excluding difficult-to-access regions		European Russia	
			$G_{t+\tau}/G_t$	S_t	$G_{t+\tau}/G_t$	S_t	$G_{t+\tau}/G_t$	S_t
1	2001	2002	0.945	0.009	0.916	0.020	0.942	0.024
	2002	2003	1.009	0.007	1.044	0.015	1.081	0.021
	2003	2004	1.143	0.009	1.163	0.018	1.043	0.019
	2004	2005	0.965	0.004	0.932	0.009	0.891	0.017
	2005	2006	1.068	0.006	1.077	0.013	1.112	0.014
	2006	2007	0.955	0.004	0.931	0.008	0.943	0.012
	2007	2008	0.905	0.007	0.976	0.016	1.042	0.028
	2008	2009	1.158	0.005	1.147	0.011	1.089	0.019
	2009	2010	0.925	0.005	0.940	0.010	0.926	0.019
2	2001	2003	0.954	0.015	0.956	0.033	1.018	0.054
	2002	2004	1.153	0.015	1.214	0.031	1.127	0.038
	2003	2005	1.103	0.011	1.085	0.023	0.929	0.028
	2004	2006	1.031	0.009	1.004	0.020	0.991	0.031
	2005	2007	1.020	0.006	1.003	0.012	1.049	0.020
	2006	2008	0.864	0.010	0.908	0.020	0.983	0.033
	2007	2009	1.048	0.006	1.120	0.013	1.135	0.021
	2008	2010	1.071	0.012	1.079	0.024	1.008	0.041
3	2001	2004	1.090	0.018	1.112	0.038	1.062	0.064
	2002	2005	1.113	0.016	1.132	0.034	1.004	0.047
	2003	2006	1.178	0.017	1.169	0.035	1.034	0.040
	2004	2007	0.984	0.012	0.935	0.024	0.935	0.045
	2005	2008	0.923	0.013	0.979	0.027	1.093	0.042
	2006	2009	1.001	0.010	1.042	0.021	1.070	0.033
	2007	2010	0.969	0.012	1.053	0.023	1.050	0.038
4	2001	2005	1.052	0.025	1.037	0.052	0.946	0.093
	2002	2006	1.189	0.021	1.220	0.046	1.117	0.050
	2003	2007	1.125	0.020	1.087	0.042	0.975	0.059
	2004	2008	0.891	0.015	0.912	0.030	0.974	0.044
	2005	2009	1.069	0.011	1.123	0.022	1.190	0.034
	2006	2010	0.926	0.017	0.980	0.035	0.990	0.050
5	2001	2006	1.124	0.023	1.117	0.049	1.053	0.079
	2002	2007	1.135	0.024	1.135	0.051	1.053	0.073
	2003	2008	1.018	0.026	1.061	0.053	1.016	0.067
	2004	2009	1.032	0.017	1.047	0.034	1.060	0.055
	2005	2010	0.989	0.014	1.056	0.028	1.101	0.046
6	2001	2007	1.076	0.029	1.040	0.062	0.993	0.107
	2002	2008	1.027	0.030	1.108	0.062	1.097	0.077
	2003	2009	1.179	0.026	1.218	0.053	1.106	0.078
	2004	2010	0.954	0.022	0.984	0.044	0.981	0.073
7	2001	2008	0.974	0.031	1.015	0.064	1.034	0.097
	2002	2009	1.190	0.031	1.271	0.065	1.195	0.096
	2003	2010	1.090	0.031	1.145	0.062	1.024	0.093
8	2001	2009	1.128	0.037	1.164	0.078	1.126	0.134
	2002	2010	1.100	0.037	1.195	0.076	1.106	0.114
9	2001	2010	1.043	0.045	1.095	0.094	1.042	0.160

Indeed, the rank mobility tend to be the higher, the longer the transition. For annual transitions, S_t has averages of 0.0063, 0.0132, and 0.0191 across spatial samples, being 1.6–1.8 times as high as the averages of monthly transitions. Nonetheless, mobility remains fairly low even in transition over the whole time span, 2001 to 2010. Interestingly, the respective latter mobility index is approximately twice as high in Russia excluding difficult-to-access regions, and three times as high in European Russia as in Russia as a whole. Over 2001 to 2010, about a half of regions changed their ranks by no more than 8 with the maximum (10.1%) at 4; 6.3% of regions did not change their ranks. In general, the majority of regions that had been "cheap" (with prices below the Russian average) in 2001 remained such in 2010; for the most part, the situation did not change for "expensive" regions as well.

Figure 5 provides a better insight into the pattern of rank price mobility of regions and compares it with quantity mobility. For more clearness, the outlier of the Chukchi Autonomous Okrug (with relative price about 2.7) is omitted in Figure 5b. The diagonals in Figure 5 are immobility lines. The scatter plot of ranks, Figure 5a, suggests a mixed pattern of relative mobility. In the quadrant with ranks from 1 to 40, mobility is similar to random one. In the quadrant of 41 to 80, the ranks are concentrated in a band around the immobility line; the band borders can be crudely deemed to be parallel to this line. The last five regions here (all difficult-to-access regions, excluding the Murmansk Oblast, with ranks 75 to 79) lie on the immobility line.

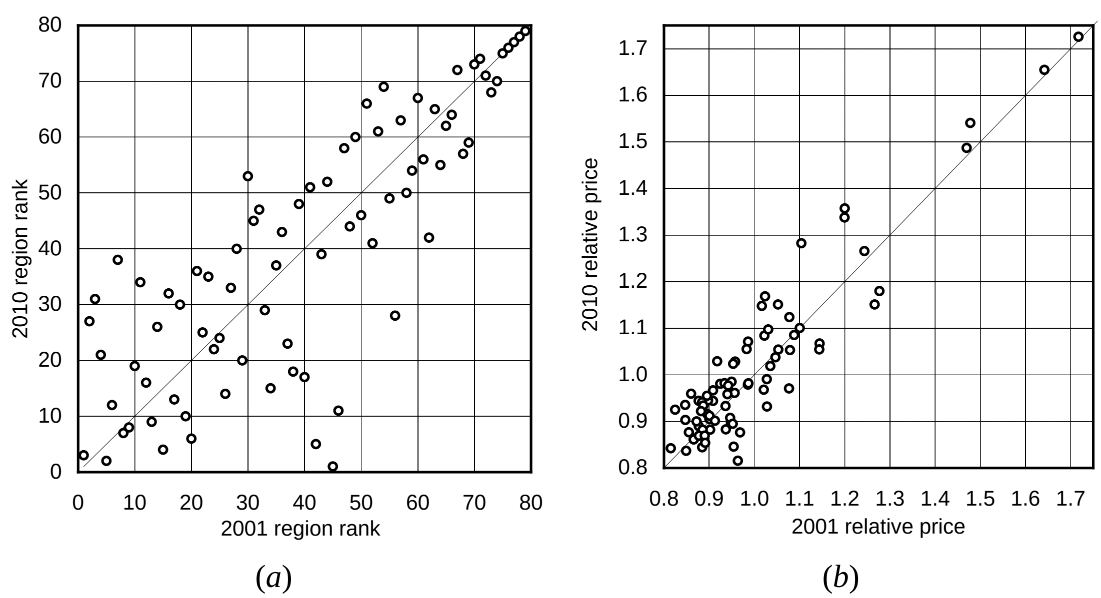


Figure 5. Scatter plots of (a) ranks and (b) prices.

The prices themselves (Figure 5b) behave in quite different manner, concentrating around the immobility line. This implies neither convergence nor divergence of prices among Russian regions. A difference in ranks by 1 was equivalent to a difference in the relative cost of the staples basket by, on average, 0.012 both in 2001 and 2010 (the outlier excluded); that is, the average distance between regions on the price axis remained stable. The average change in ranks over 2001 to 2010 is 10.3, while the average absolute change in prices, $|p_{r,2010} - p_{r,2001}|$, is 0.052. However, the regions are not distributed on the price axis evenly. Many regions are close to one another on this scale, so that less than a 1% change in region's price can cause a change in its rank by up to 10. This sheds light on the pattern of rank mobility. For the most part, it is due to regions with close prices (which concentrate in Figure 5b in the area with relative prices below 1). A change in rank by a few units implies a small change in the relative price, so that clusters of "cheap" and "expensive" regions remain generally the same.

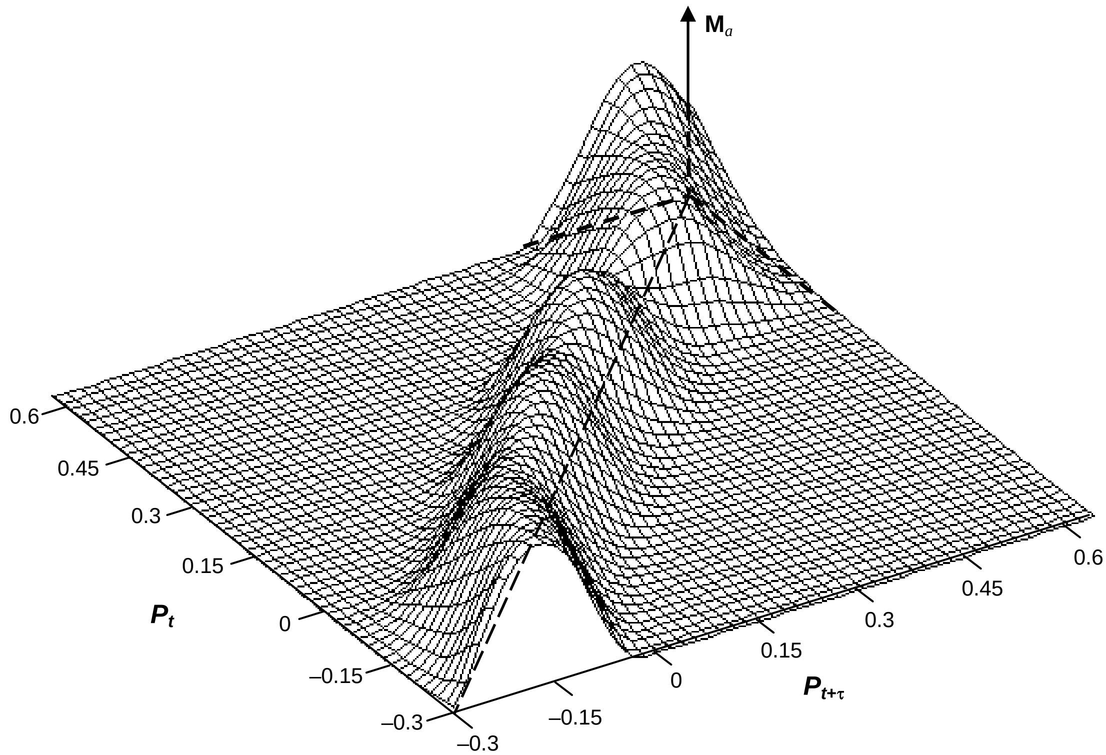
3.3. *Quantity Mobility of Regions*

A usual way of estimating stochastic kernel is to take the transition from the initial period to the final one; in our case, it would be $\mathbf{M}_b = f(P_{t+\tau} \mid P_t) = f(P_{2010} \mid P_{2001})$. However, such a way possesses two shortcomings. First, there may be accidental differences in the shape of the distributions, which potentially could bias the law of motion as compared to the "true" one and distort the ergodic distribution (long-run forecast of the price distribution). Second, we lose information on the evolution of the distribution within the time span under consideration.

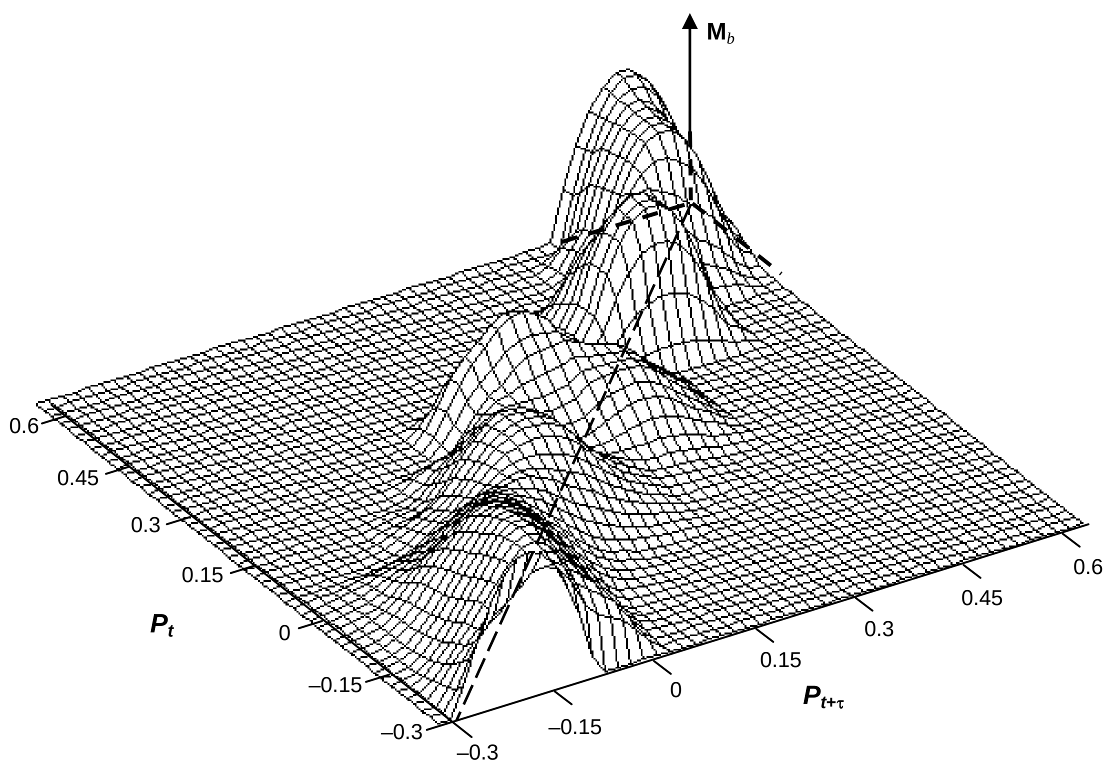
To benefit from this information and to smooth random deviations, one more stochastic kernel is estimated with the use of all annual transitions. In this estimate, the more distant is a transition from the final period, the lesser importance is attached to it. Namely, the estimate of the stochastic kernel is a weighted average of year-to-year estimates:

$$\mathbf{M}_a = f(P_{2002} \mid P_{2001})\cdot 1/45 + f(P_{2003} \mid P_{2002})\cdot 2/45 + \ldots + f(P_{2010} \mid P_{2009})\cdot 9/45.$$

Both estimates of **M** omit the outlier of the Chukchi Autonomous Okrug to make the stochastic kernels well-defined. The point is that, as Figure 3 suggests, the event $0.65 < P < 0.90$ (in 2001; it is somewhat different in other years) is of zero probability, hence $f(P_{t+\tau} \mid P_t)$ is indeterminate on this interval of the conditioning variable.



(*a*)



(*b*)

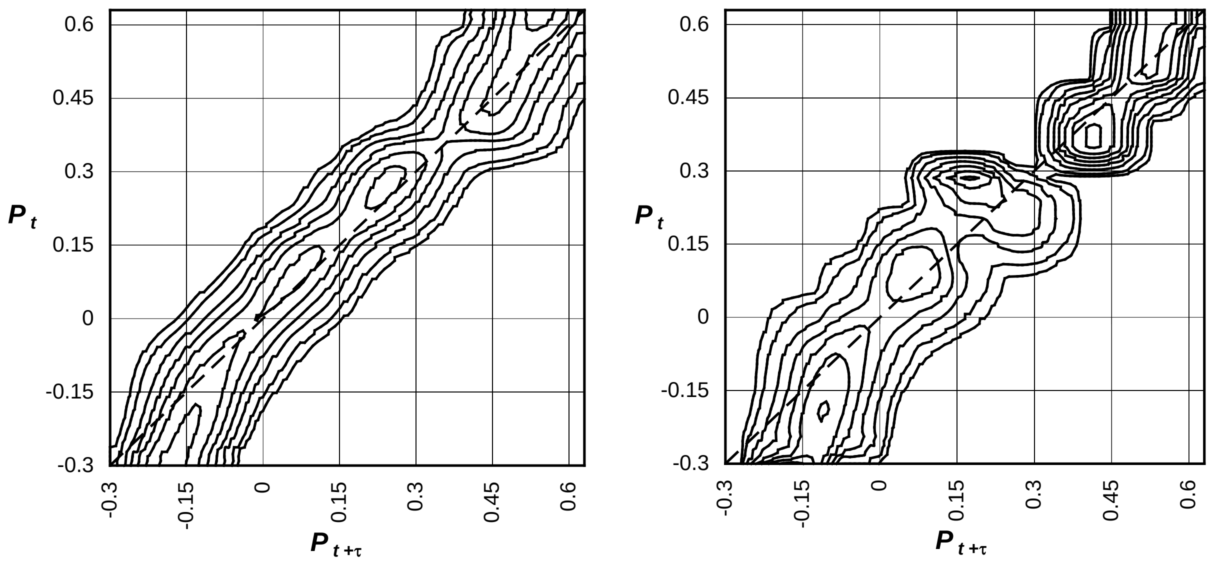
Figure 6. Stochastic kernels: (a) estimated with the use of nine yearly transitions, (b) estimated using the nine-year transition from 2001 to 2010.

Figure 6 demonstrates three-dimensional plots of estimates of $\mathbf{M}_a$ and $\mathbf{M}_b$. (The plots are drawn with the use of Matrixer, econometric software developed by Alexander Tsyplakov; see http://matrixer.narod.ru.) A line projected from a fixed P_t, parallel to the $P_{t+\tau}$ axis, characterizes probability to transit to particular values of prices at $t + \tau$, given the value of the price at t. That is, a respective plane, orthogonal to the price plane, cuts the surface of the stochastic kernel; this cross-section is a probability density of the price having had a given fixed value at the initial period. Thus we can see the movement of different parts of the price distribution over time.

The dashed line in the figures mark the diagonal which is an immobility line (the line of equal prices at t and $t + \tau$). If most of the probability mass concentrates along this line, this evidences low quantity mobility, indicating a tendency of prices to remain unchangeable. A stochastic kernel with a ridge parallel to the $P_{t+\tau}$ axis indicates random mobility: a future position of a region on the price axis does not depend on its initial position. Perfect price convergence would take place if the stochastic kernel had a ridge parallel to the P_t axis with $P_{t+\tau} = P^*$ and degenerated into a delta-function, $\delta(P_{t+\tau} - P^*)$, in each P_t-cross-section.

Comparing two stochastic kernels in Figure 6, $\mathbf{M}_b$ looks more "bumpy" than $\mathbf{M}_a$. This is of no surprise, as averaging in the latter smoothes accidental distinctions between the yearly price distributions, while such distinctions between distributions for 2001 and 2010 remain as they are in estimating the former. In general, however, both stochastic kernels suggest quantitatively the same pattern. First, we observe fairly low quantity mobility in the price distribution, since probability mass concentrates around the diagonal $P_t = P_{t+\tau}$. Second, a peak is observed in the area of high prices; it is more pronounced in $\mathbf{M}_b$. Such a feature of the stochastic kernels is suspicious from the viewpoint of emergence of a convergence club over time.

To discern more details of the price-transition dynamics, it is helpful to view the stochastic kernels "from above." Figure 7 provides this top view, demonstrating contour plots, i.e. projections of cross-sections of the stochastic kernel by horizontal planes corresponding to densities $\mathbf{M} = 0.5$ and 1 to 7 (to 6 in the case of $\mathbf{M}_a$) on the price plane ($\mathbf{M} = 0$). Differences between the two estimates of the stochastic kernel are much more pronounced then in the three-dimensional plots. Although price distributions for 2001 and 2010 are very similar to each other, as figure 3 suggests, and to distributions for the rest years, $\mathbf{M}_a$ and $\mathbf{M}_b$ demonstrate fairly distinct patterns. While there is only a narrow about point (0.35, 0.35) in the former, $\mathbf{M}_b$ almost breaks up into two parts at point (0.3, 0.3). One may suppose that the area of high prices is a potential location of convergence club, a small one according to $\mathbf{M}_a$, and a higher one according to $\mathbf{M}_b$. Except for this, both kernels suggest neither convergence nor divergence of prices, being concentrated along the immobility line.



(*a*) (*b*)

Figure 7. Stochastic kernels, contour plots at levels 0.5, 1, 2,…,7: (a) $\mathbf{M}_a$; (b) $\mathbf{M}_b$.

An ergodic distribution, $f_\infty(P)$, reveals eventual results of such dynamics, being an estimate of long-run limit of the price distribution. Figure 8 presents the estimated ergodic distributions generated by the two estimates of the stochastic kernel and compares it with the actual distribution for 2010. Quah (1996) considers a peak that sits on (or almost on) the 45-degree diagonal as an indication of "convergence club behavior." However, this seems to be not the case. There are four such peaks in $\mathbf{M}_a$, and five peaks in $\mathbf{M}_b$, as Figure 7 shows. Then one would expect engendering four to five convergence clubs in the long run. But we see only two convergence clubs in the limiting price distributions. Probably, Quah's (1996) statement is due to features of empirical data he deals with. Indeed, his distributions both at t and $t + \tau$ are bimodal, which produces a stochastic kernel with two relevant local maxima. It seems probable that this "twin-peakedness" will still hold in the long run, but it is impossible to assert for sure, as Quah (1996) does not report the ergodic distribution generated by his stochastic kernel.

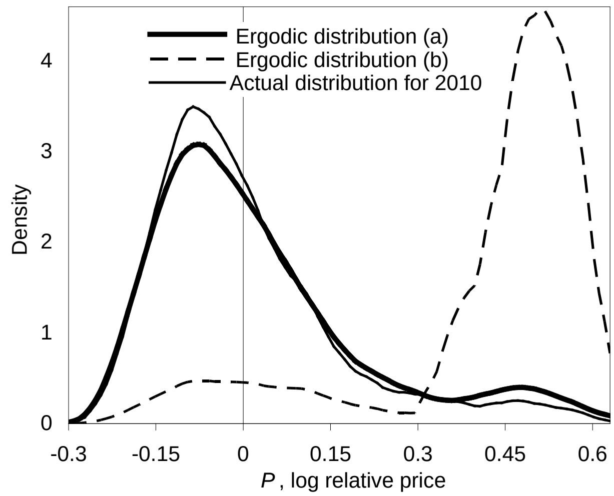


Figure 8. Long-run limit of the distribution of regional price; ergodic distribution (a) is that generated by $\mathbf{M}_a$; ergodic distribution (b) is that generated by $\mathbf{M}_b$.
.

The two estimates of the ergodic distribution are quite different. That generated by the stochastic kernel based on averaged yearly transitions is fairly close to the actual cross-region price distribution for 2010, which implies stability of relative prices across Russian regions. However, a small but important distinction does exist. In the long-run, a convergence club in the area of high prices can emerge. Regions in the right-hand tail of the distribution are those from the Russian Far East. This suggests that, under unchangeable price dynamics, integration of the Russian goods market would become fragmented. That is, the market would split up into two internally integrated parts: the Far-Eastern regions and the rest of Russia. The ergodic distribution generated by the stochastic kernel estimated from a single nine-year transition from 2001 to 2010 predicts much more pronounced splitting up into two convergence clubs, the most distribution mass being concentrated in the area of high prices. However, the first pattern seems more probable. First, according to the Kolmogorov-Smirnov test (see Table 1), the differences between price distributions for 2001 and 2010 can be merely random shocks. Second, the applied procedure of estimating ergodic distributions assumes operator **M** to be time-invariant. It is inconceivable that this assumption is overly strong. Stochastic kernel $\mathbf{M}_a$ smoothes gradual changes (if they really exist) in the law of motion, while $\mathbf{M}_b$ could accumulate them, so distorting the long-run dynamics.

4. Conclusions

Using the cost of a stales basket as a price representative, dynamics of cross-region price distribution in Russia in 2001-2010 have been analyzed. Price dispersion measured as the standard deviation of prices proves to be more or less stable during the decade; the global crisis has not affected it. The shape of the annual cross-region distribution of prices is also similar across years. Rank mobility is found to be very low and stable with seasonal deviations from a more or less constant level. Thus, ‘expensive’ and ‘cheap’ regions generally remain such. To characterize intra-distribution absolute price mobility of regions, a transition probability function (stochastic kernel) has been estimated. The pattern of quantity mobility manifests neither convergence nor divergence of regional prices. However, a long-run price distribution has an unpleasant feature, predicting potential emergence of a price convergence club in the Russian Far East.

Thus, there were no sizeable changes in the nature of spatial price dynamics in Russia during 2001–2010. It was fairly stable; the global crisis did not affect this pattern. Regarding the evolution of relative prices across regions, the first decade of the 2000s can be called ‘the decade of stability”

The pattern obtained dramatically differs from that for 1992–2000. As Gluschenko (2004) finds, prices diverged across regions in the early 1990s and then started to converge. Stochastic kernels estimated over the 1994-2000 data, unambiguously evidenced price convergence. Along with this, there were signs that convergence completed by the 2000s. The above results demonstrate that it was not a transitory feature, but a new tendency of the behavior of regional prices in Russia. This tendency holds up to 2010. Regarding relative price mobility, the pattern for 2001–2010 is qualitatively similar to that obtained by Gluschenko (2010) for 1994-2000.

Acknowledgements

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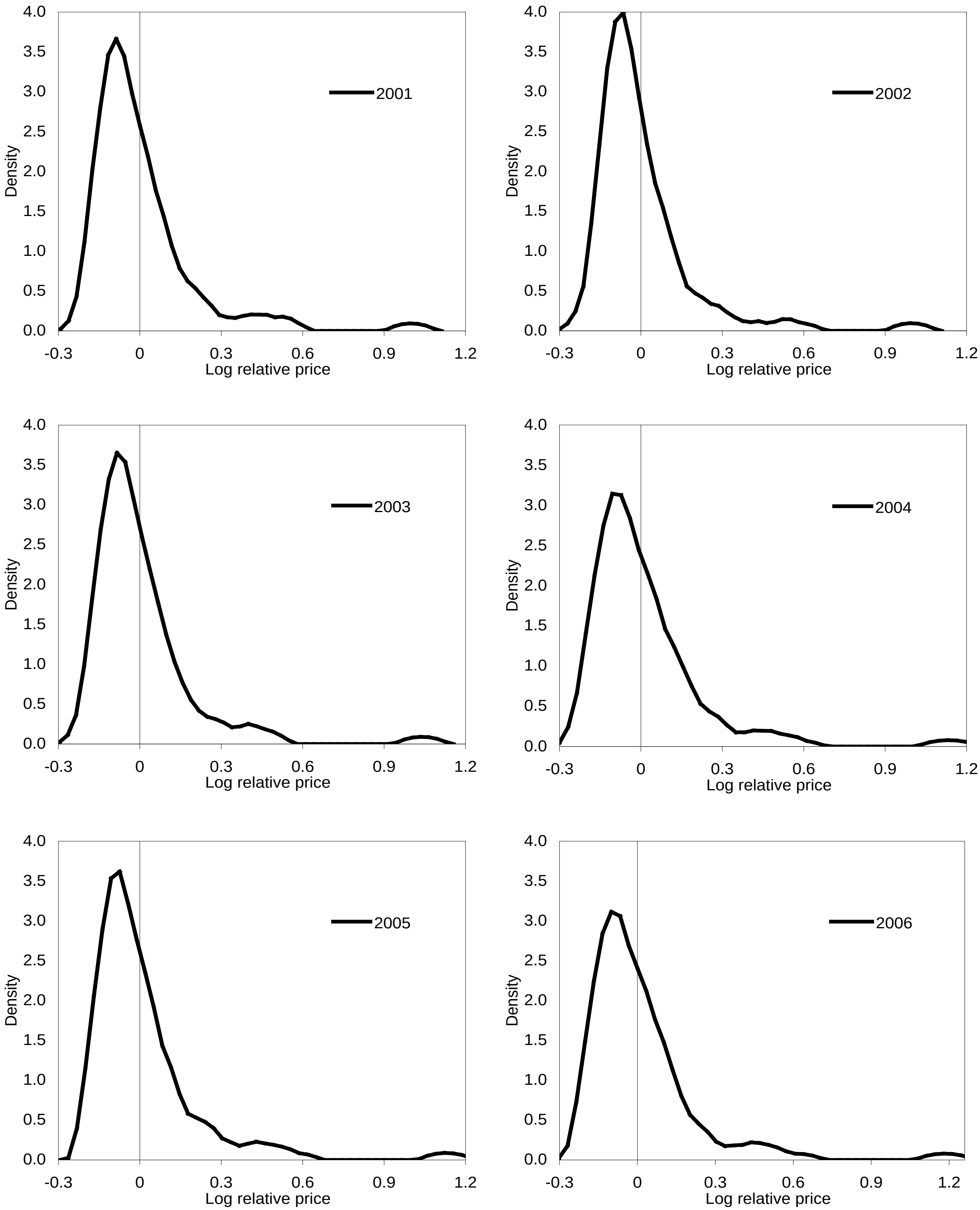
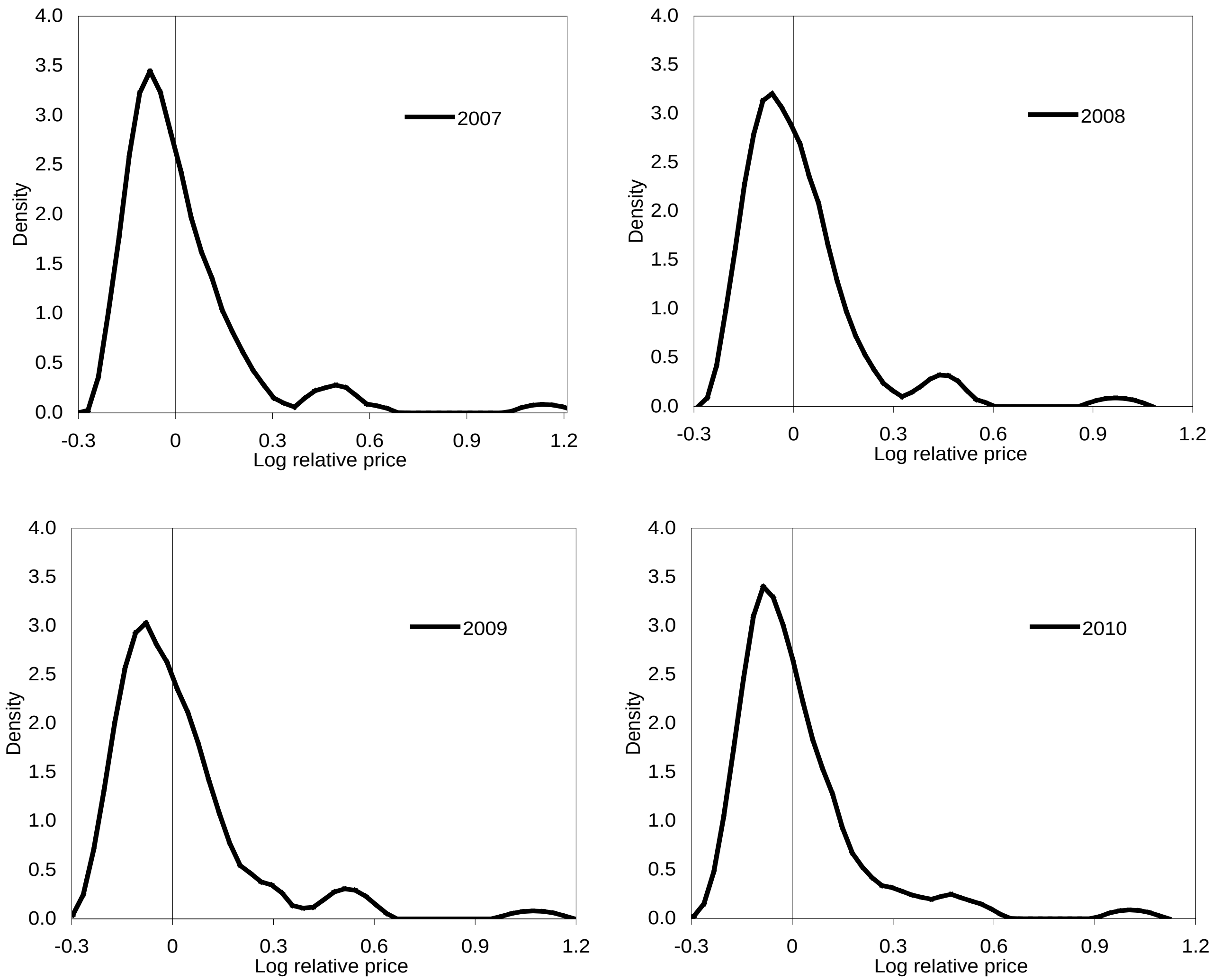
APPENDIX
Annual price distributions in 2001-2006 for Russia as a whole




2007
2008
2009
2010
Density
Log relative price
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
-0.3
0
0.3
0.6
0.9
1.2

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