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THE EVOLUTION OF CROSS-REGION PRICE DISTRIBUTION IN RUSSIA*

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ABSTRACT

The behavior of the entire cross-section distribution of prices in Russian regions is analyzed from 1992 through 2000, using non-parametric techniques. The cost of a staples basket is used as a price representative. Price dispersion measured as the standard deviation of prices is found to be diminishing since about 1994; and the shape of the cross-region distribution of prices tends to be more regular over time. To characterize intra-distribution mobility, a transition probability function (stochastic kernel) is estimated. It is also used to derive a long-run limit of the price distribution. Overall, the results suggest that, excluding a few years following the price liberalization, price convergence has been happening among Russian regions.

JEL classification: P22, R10, R15.
Keywords: price convergence, price dispersion, distribution dynamics, market integration, Russia.

1. INTRODUCTION

After many decades of centralized pricing based on the Marxian concept of socially necessary costs, prices in Russia were freed in January 1992 (according to the President Decree of December 3, 1991), allowing them to be market determined. In fact, the centralized pricing deviated from the underlying concept (needless to say, vulgarized and oversimplified in practice). For example, the so called "turnover tax" was included in final prices for some

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consumer goods; on the other hand, prices for some other goods (mainly, for foodstuffs) did not even cover production costs and were subsidized. Nonetheless, the demand-supply parity was the last thing receiving regard, if any; as a result, distorted prices gave rise to numerous shortages (and, rarely, to overstocks). Therefore no wonder that the price liberalization caused a surge in prices. The surge was heterogeneous across goods, depending on good-specific gaps between demand and supply.

These gaps were location-specific as well. Administratively set prices were almost uniform throughout the country. Though the so called "zone prices" were set for a number of consumer goods, there were only three such zones, and differences in prices between zones were not high. If one tested the law of one price across Russian locations at that time, a pattern of "perfect integration" would be obtained. As soon as prices were freed, this "perfection" began to ruin, changing to growing fragmentation of the economic space of Russia. However, this process may be believed to be merely a transient. It is reasonable to expect that as market institutions were coming into being, price divergence across locations would have been changing to price convergence. This means that after some period of growing disconnectedness of the Russian market, the movement would have turned "back" towards integration, but this time to market one rather than administratively forced.

Much effort has been devoted to finding out whether this is the fact (see below), applying the traditional tool of analyzing price behavior, which is regression analysis, either time-series or cross-sectional one (sometimes combining them in panel analysis). However, there is one more pertinent approach: distribution dynamics analysis, that is, studying the entire distribution of prices across locations and its evolution over time. Such an approach finds use in empirics of economic growth (Durlauf and Quah, 1999), considering income data. But, to my knowledge, it has not yet been applied to analyzing price behavior. It is this tool of empirical analysis that is exploited in the paper.

First, dynamics of the standard deviation of prices across Russian regions is considered, which characterizes the evolution of price dispersion. Then, the entire cross-region price distribution is estimated for a number of points in time with the use of a kernel density estimator, tracing changes in the shape of the distribution over time. Having obtained a sequence of the distributions, the transition process between them, i.e., price mobility of regions, receives study. To characterize intra-distribution mobility, a transition probability function (stochastic kernel) is estimated. It is a generalization of the transition probability matrix, pioneered by Quah (1996). At last, this function is used to derive a long-run limit of the price distribution.

Two main issues are to be clarified with this analysis. The first is that of the predominant trend in dynamics of prices in Russia: whether it is price divergence or price convergence. The second issue is that of price convergence clubs, i.e., whether there is price convergence within two (or more) groups of regions rather than common convergence to a uniform (national) price level. In terms of distribution, it is the issue of multimodality vs. unimodality of the price distribution.

The cost of a staples basket (relative to its cost for Russia as a whole) is used as a price representative. The spatial sample covers most – 75 of all the 89 – regions of Russia; the time span is 1992 through 2000. Analyzing price dispersion, σ-convergence of regional prices is found to take place since about 1994, which implies that the predominant trend is the improvement in market integration. The shape of the cross-sectional distribution of prices tends to be more regular and narrower over time, however, keeping a long right-hand tail that is due, in the main, to difficult-to-access regions. The distribution is unimodal, suggesting the absence of price convergence clubs. The estimated transition probability function evidences, too, price convergence during 1994-2000. The long-run limit of the price distribution is unimodal, so predicting no emergence of price convergence clubs in the long run.

The spatial aspect of prices in the transition came to the attention of researchers from the very beginning of the price liberalization. Apparently, the first were Koen and Phillips (1992, 1993), who found that the decontrol of prices in Russia had caused a dramatic rise in geographical price dispersion. Subsequently, De Masi and Koen (1995, 1996), having made a cautious reservation that their data did not allow to judge whether prices across Russian regions had converged or diverged, indicate, nevertheless, that the degree of integration of the Russian goods market seems to have increased since early 1992. Using time-series analysis, Gardner and Brooks (1994), Berkowitz, DeJong and Husted (1998), and Goodwin, Grennes and McCurdy (1999) examine price dispersion among Russian cities in the early years of the transition (up to 1995). They find the Russian market weakly integrated yet having encouraging signs of the improvement.

Exploiting cross-sectional analysis, Berkowitz and DeJong (2001, 2003) estimate a segment of the market integration trajectory for Russia. Gluschenko (2003) also obtains such a trajectory for 1992-2000 with the use of a different methodology; Gluschenko (2004a) reports some other estimates of the degree of Russia's market integration. These recent results suggest that after a few years following the price liberalization, the Russian domestic market did start the movement towards integration. Moreover, that, over time, prices have converged across regions within countries, Koen and De Masi (1997) regard as a stylized fact for transition economies.

This paper contributes to the above literature, providing an evolving pattern of the price distribution across Russian regions, which gives an idea of how regional prices changed over time relatively each other. 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

Characterizing goods price dynamics, it is desirable to consider as wide set of goods as possible. Seemingly, the food and industrial goods components of consumer price index (CPI) by Russian region would be an adequate price representative from this viewpoint. But the trouble is that the regional CPIs are sufficiently biased with respect to "true" spatial price indices, as found by Gluschenko (2001). Thus, even having information on regional price levels for some base period, a temporal pattern would prove to be distorted. Published information on prices for individual goods by Russian region is fragmentary, which does not allow obtaining more or less comprehensive pattern of price dynamics.

Therefore, the only available proper price representative for the analysis is the cost of the basket of 25 food goods (unfortunately, there is nothing like that for industrial consumer goods). This basket covers about one third of foodstuffs involved in the Russian CPI; but unlike the CPI, it has constant weights across regions and time. The basket includes: rye-wheat bread, wheat bread, flour, rice, millet, vermicelli, potatoes, cabbages, carrots, onions, apples, sugar, beef, poultry, cooked sausage, partially smoked sausage, frozen fish, milk, sour cream, butter, cottage cheese, rennet cheese, eggs, margarine, and vegetable oil; Goskomstat

(1996) reports their quantities in the basket. These goods jointly represent 56.7% of the food CPI at the 1993 CPI weights drawn from De Masi and Koen (1995) (data on more recent weights are not available). Moreover, using the cost of the 25-item basket as well as a food spatial price index to measure the degree of market integration in Russia, Gluschenko (2004a) obtained close results. This gives ground to believe this basket to be a good representative of foodstuffs as a whole (i.e., covered by the Russian CPI).

The 25-item basket was defined as the standard by the Russian statistical agency, Goskomstat, from January 1997 through June 2000. Besides that, Goskomstat has calculated its earlier costs up to February 1992; the data for July through December 2000 are available as well. The costs of the basket with monthly frequency (spanning February 1992 through December 2000) were obtained directly from Goskomstat's office. The data relate to capital cities of the Russian regions; 75 of the 89 regions of Russia are covered. The information is lacking for 10 autonomous *okrugs*, the Chechen Republic, and the Republic of Ingushetia. Since capital cities of the Moscow and Leningrad *oblasts* are at the same time separate subjects of the Russian Federation ("city-regions"), Moscow and St. Petersburg, these two *oblasts* are omitted as well. Goskomstat computes the cost of the basket for the whole of Russia as a weighed average of regional costs; the weights are shares of regions' population in the population of Russia. For brevity, it will be sometimes referred to as the Russian average.

There are missing observations in the raw data, mostly in 1992-1994. They are restored by interpolation with the use of relevant regional food CPIs; see Gluschenko (2003) for details. To eliminate inflationary effects, the relative costs of the 25-item basket are used in the analysis rather their absolute values. The relative cost is calculated as the ratio of regional cost to the cost of the basket for Russia as a whole, the latter being considered as a representative of the national-market price level. The logarithmic representation of such a cost is used, which implies the percentage differential between the cost of the basket in a region and its national level.

Let P_{rt} denotes the log relative cost of the basket (hereafter, simply price) in region r ($r = 1,\dots,R$) in period t. The first issue is whether regional prices converge over time. When the behavior of prices varies across regions, the resulting trend of the entire market is *a priori* unclear. Then dynamics of the entire cross-section distribution of prices can shed light on the issue. A simple testable version is known in the economic growth literature – e.g., Barro and Sala-i-Martin (1995) – as σ-convergence. Reformulated in terms of prices, it is defined as follows: regional prices are converging, if their dispersion tends to decrease over time, that is,

$$\sigma(P_{t+\tau})/\sigma(P_t) < 1, \tag{1}$$

where $\sigma(P_t)$ is the standard deviation of prices P_{rt} over $r = 1,\dots, R$ at a given point in time, t. The occurrence of σ-convergence is evidence that, at least, the trend to convergence of prices prevails over the trend to divergence induced by regions not tending to market integration.

Being merely one of characteristics of the price distribution, the evolution of $\sigma(P_t)$ provides rather 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, 1995).

To reveal more detailed properties of the evolution, the behavior of distribution of regional prices as such, $f_t(P_t)$, 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. The Gaussian kernel is adopted; formally, the estimate of a probability density looks like

$$\hat{f}_t(P_t) = \frac{1}{\sqrt{2\pi}Rh}\sum_r \exp\left(-\frac{1}{2}\left(\frac{P_t - P_{rt}}{h}\right)^2\right), \tag{2}$$

where R, recall, denotes the number of regions, and h is the Silverman (1986) smoothing bandwidth. 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, is analyzed, following Quah (1996). 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 $t + \tau$:

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

This operator is a stochastic kernel,[1] or a transition probability function which is the generalization of a transition probability matrix. (**M** may be viewed as such a matrix with infinite number of rows and columns, $\{i\}$ and $\{j\}$ being continuous.) 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 (3) can be written as

$$f_{t+\tau}(P_{t+\tau}) = \int_{-\infty}^{\infty} f(P_{t+\tau}|P_t) f_t(P_t)\,dP_t\,. \tag{4}$$

The stochastic kernel is estimated in a manner like the univariate distributions are; see (2):

$$\hat{f}(P_{t+\tau}|P_t) = \frac{\dfrac{1}{2\pi R h_{t+\tau} h_t}\sum_r \exp\left(-\dfrac{1}{2}\left(\dfrac{P_{t+\tau} - P_{r,t+\tau}}{h_{t+\tau}}\right)^2\right)\exp\left(-\dfrac{1}{2}\left(\dfrac{P_t - P_{rt}}{h_t}\right)^2\right)}{\hat{f}_t(P_t)}. \tag{5}$$

[1] Quah (1996) as well as Durlauf and Quah (1999) provide much more general formalization.

(The numerator in (5) is the estimate of the joint distribution of $P_{t+\tau}$ and P_t, and the denominator is the estimate – by Formula (2) – of the marginal distribution.)

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,

$$f_{t+n\tau}(P_{t+n\tau}) = \mathbf{M}^n \cdot f_t(P_t). \qquad (6)$$

Taking $n \to \infty$ yields the ergodic distribution, $f_\infty(P)$, i.e., such that

$$f_\infty(P) = \mathbf{M}_\infty \cdot f_\infty(P), \qquad (7)$$

where $\mathbf{M}_\infty$ is the limit of $\mathbf{M}^n$ 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.

To estimate $\mathbf{M}_\infty$, relationship (6) is applied, with numerically integrating in (4). Since $\mathbf{M}_\infty$ degenerates into $f(P_{t+\tau} | P_t^{(i)}) = f_\infty(P_t)$ for each $P_t^{(i)}$, the fulfillment of this condition accurate to 10^{-7} is used as a criterion of convergence of $\mathbf{M}^n$ to $\mathbf{M}_\infty$.

3. EMPIRICAL RESULTS

Figure 1 plots the dynamics of price dispersion measured as $\sigma_t = \sigma(P_t)$, the standard deviation of the log relative prices. There are two trajectories of σ_t in the figure. The first one is estimated over all 75 regions ("Russia as a whole"), and the second relates to 69 regions excluding five regions with difficult access, namely, the Murmansk, Sakhalin, Magadan, and Kamchatka *oblasts*, and the Republic of Sakha (Yakutia). These are remote regions lacking (except the Murmansk Oblast) railway and highway communications with the rest of the country. Due to high transportation costs and seasonality of deliveries, one would expect them to account for a significant share of price dispersion in Russia. As seen from the comparison of the two trajectories, this is the fact indeed.

Both trajectories start in February 1992 from almost equal values of about 0.17, implying that regional prices were dispersed, on average, within the 19-percent band (in real terms) above and below the Russian average price. (It is a pity that extremely interesting data, for December 1991 and January 1992, are not available. These would characterize the "Big Bang" of switching from planned to market pricing.) From this point on, price dispersion increases, the gap between difficult-to-access regions and the rest of Russia widening more and more. In the whole of Russia, the dispersion peaks at 0.31 (36 percent) in August 1994; omitting difficult-to-access regions, the maximum equals 0.23 (26 percent) in December 1993. [2]

[2] There is a caveat, however. First, most of restored observations occur just in 1992-1994, for up to 15 regions in some months. (But as shown by Gluschenko (2003), the impact of this filling the data gaps is minor.) Second, the data themselves for those years are not too reliable. At that time, the Russian statistics had no experience of data collecting under market conditions, the coverage of outlets changing during the early years of transition.

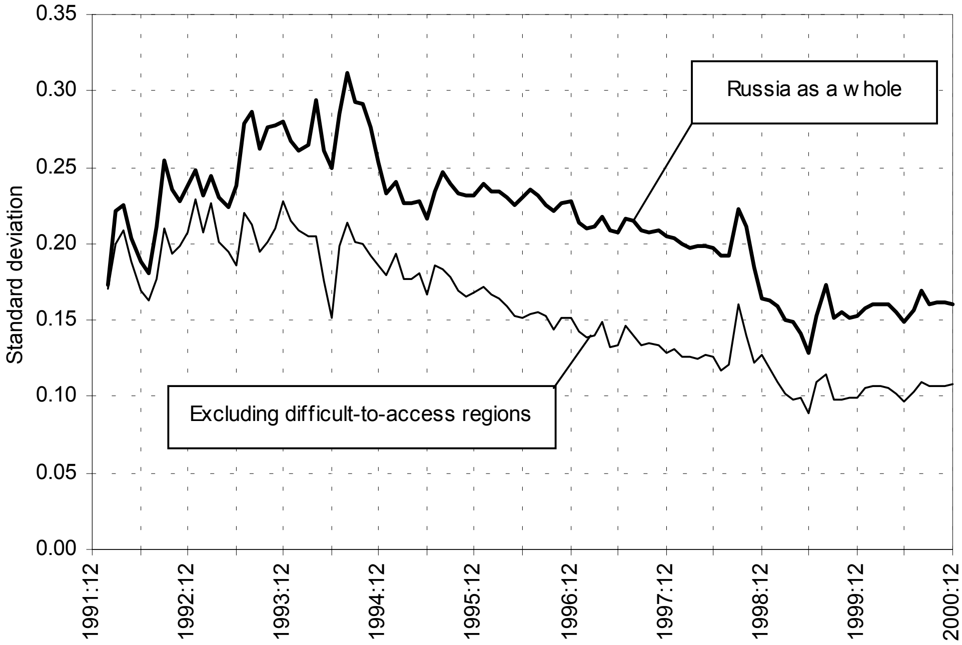


Figure 1. The evolution of inter-regional price dispersion

Having peaked, price dispersion almost permanently decreases from this point on, at least till the middle of 1999. The second half of 1994 can be deemed as a turning point from growing disconnectedness of Russian regions to the improvement in market integration. Comparing relatively distant points of the trajectories, e.g., with τ = 12 months, Formula (1) holds since 1994, which is clear evidence of σ-convergence in 1994-2000. For more thorough analysis of σ-convergence, $\{\sigma_t\}_{t=1994:01,\ldots,2000:12}$ was treated as a time series, testing it for unit root. Both trajectories, indeed, proved to be trend stationary over this time span, with a highly significant negative trend factor, which suggests σ-convergence.

There is a pronounced peak in the descending branches of the trajectories that is due to the August 1998 financial crisis in Russia. The crisis caused a dramatic surge of prices that varied across regions, so forcing a rise in price dispersion. However, this impact turned out to be very short-run: as early as in November 1998, the dispersion came back to roughly pre-crisis values. Moreover, its subsequent decrease accelerated dramatically as compared to the pre-crisis times. Thus, the crisis had an unexpected effect of reducing price dispersion across Russian regions. A reason is believed to be the different rise in prices of foreign and domestic goods (as the hard currencies went up much faster than domestic prices), and the subsequent shakeout of imported goods. For example, the difference in price dispersion between Russia as a whole and the country excluding difficult-to-access regions became 1.5 times smaller. The share of foreign foods had been smaller in these regions; therefore, the sharp devaluation of ruble lowered relative prices there, so narrowed the price gap between regions with difficult access and the rest of Russia.

Nonetheless, the trend is doubtless; it accords well with the practical evidence as well as with analyses of data on some individual goods.

By the last months of 1999, price dispersion stabilized at the level of about 16 percent in the whole of Russia, and 10 percent in Russia excluding difficult-to-access regions. The latter figure is comparable with that for the US (calculated using the relative cost of a basket of 27 grocery items across US cities); see Gluschenko (2004b). Judging from this, it may be supposed that, by the early 2000s, the Russian market has reached a feasible minimum degree of geographical price disparities.

Table 1 provides one more view on changes in price dispersion in Russia during 1992-2000. To compute yearly figures, prices are averaged over each year (for 1992, over 11 months). Since the relative prices are averaged, and not the absolute ones, such an averaging is proper even for years with high inflation. For more clearness, minimum and maximum prices as well as spreads are represented in real terms rather than in logarithms.

Table 1. Inter-regional price dispersion by year

Year	Russia as a whole				Excluding difficult-to-access regions			
	Minimum price	Maximum price	Spread (max/ min)	Standard deviation	Minimum price	Maximum price	Spread (max/ min)	Standard deviation
1992	0.56	1.70	3.1	0.186	0.56	1.27	2.3	0.161
1993	0.44	2.07	4.8	0.239	0.44	1.47	3.4	0.191
1994	0.57	2.67	4.7	0.267	0.57	1.53	2.7	0.185
1995	0.64	1.96	3.1	0.226	0.64	1.48	2.3	0.169
1996	0.67	2.28	3.4	0.228	0.67	1.43	2.1	0.153
1997	0.78	2.06	2.6	0.209	0.78	1.43	1.8	0.134
1998	0.74	1.94	2.6	0.193	0.74	1.37	1.8	0.123
1999	0.75	1.63	2.2	0.148	0.75	1.29	1.7	0.097
2000	0.78	1.76	2.3	0.157	0.78	1.36	1.8	0.102

As it must, the lower bound of regional prices is common for the whole of Russia and the country excluding difficult-to-access regions. For the former, the maximum price is that in one of regions with difficult access. At a peak, the difference between the lowest and highest prices was as great as almost 5 times over Russia as a whole; excluding regions with difficult access, such a difference equaled about 3.5 times. By the end of the period under consideration, they approximately halved over both region samples. The same is valid for the standard deviations; they fell – in real terms – from 31 percent to 16-17 percent, and from 21 percent to 10-11 percent, correspondingly.

The price spread as well as the standard deviation decreased due to the approach of both lowest and highest prices to the national average, that is, the minimum prices rose and the maximum prices fell over time. Being roughly as low as half of the national average in the early years of transition, the minimum price differed from the national one by a quarter in the late years. The fall-off of the maximum price is most pronounced in the difficult-to-access regions. From the value of as high as 2.7 times of the national average, it reduced to 1.6-1.8 times; the 1998 crisis markedly contributed to the fall-off as well as to narrowing the spread. As for Russia excluding difficult-to-access regions, the peak of the highest price was half again the Russian average; in 1999-2000, this price exceeded it by 30-35 percent, with a minor impact of the 1998 crisis to the price spread.

To gain further insight into the behavior of prices, dynamics of the entire cross-section distribution of regional prices is to be considered. At first, the issue of interest is the degree to which the shape of the price distribution changed over time. To assess these changes, probability densities have been non-parametrically estimated using Formula (2) for each year from 1992 through 2000. The distributions have been estimated using cross sections averaged over each year, as above, in order to smooth accidental changes occurring in instantaneous distributions. (Gluschenko, 2004b reports a number of instantaneous distributions.) The estimated densities are plotted in Figure 2.

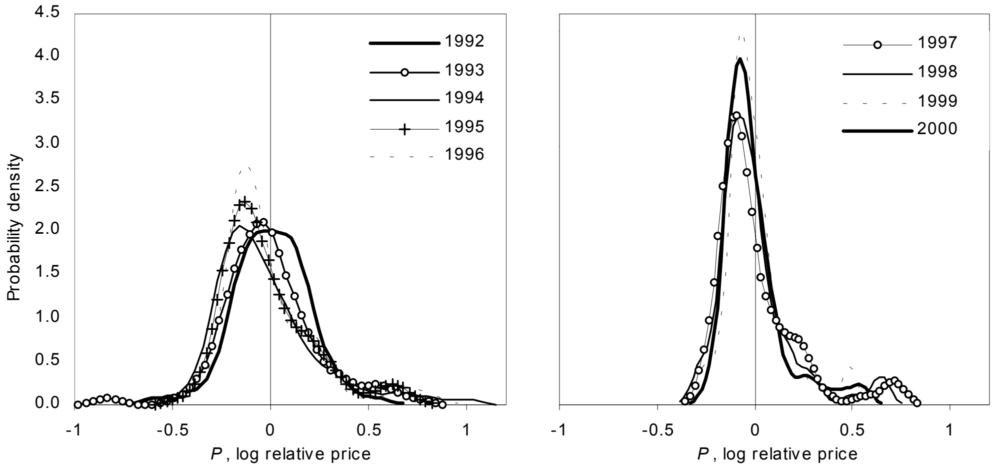


Figure 2. Estimates of price distributions over Russia as a whole

The densities in the figure reveal several features in the distribution shape dynamics over the 9-year period of 1992 through 2000. The mode of the distribution, being near $P = 0$ in 1992, shifted towards more negative values of P till 1994, and then it has been shifting back to zero, or, in terms of prices, from the cost of the 25-food basket below the Russian average to this average. Along with this, the left-hand tail of the distribution shortens over time. But the long right-hand tail is persistent during the entire period, and prevents the distribution from becoming symmetric by the end of the period. Along with this, the right-hand tail did somehow shorten. The most prominent shifts occurred after 1997, which can be assigned to the 1998 crisis. (Prices to the right of $P = 0.5$, i.e., 65 percent above the national average, are those in 3 to 4 Far-Eastern difficult-to-access regions.)

Taking the 2000 distribution, the excess part of the right-hand tale can be deemed as beginning from about $P = 0.25$ (that is, from prices roughly 30 percent above the Russian average). Regions falling into the area of $P \geq 0.25$ are all the 5 difficult-to-access regions, and a few more Far-Eastern ones: the Primorski Krai in 1993-2000 but 1999, the Khabarovsk Krai in 1993-1998 (these two are almost the easternmost regions of Russia), the Chita Oblast in 1994-1996, the Amur Oblast in 1993-1994, and the Jewish Autonomous Oblast in 1994-1995. Besides, the Moscow City entered into this part of the tail in 1999-2000. Thus, in 1999-2000, the excess right-hand tail of the price distribution included all difficult-to-access regions and Moscow as well as the Primorsky Krai in 2000. In these years, this region cluster is well separated from the rest regions: the nearest "neighboring" price is less than the lowest price in the cluster by 6 to 9 percent points.

Figure 2 gives a visual impression of a small secondary mode in the right-hand tail of distributions for some years, so seemingly suggesting the presence of a price convergence club among the high-price regions. But this is not the fact. This "mode" occurs when prices in two (sometimes, three) of difficult-to-access regions accidentally become close. Since the observations are sparse in that part of the distribution, the estimator given by Formula (2) smoothes such an "outlier" in a histogram into a small mode. (It can be seen from the sequence of distributions that the secondary mode is not persistent: it appears in 1995, disappearing in the next year; then it shows up again, and vanishes in 2000.) Moreover, testing for multimodality in the manner of Silverman (1986) and Bianchi (1997), bimodality of the distributions with seeming secondary mode is confidently rejected.

So, the cross-region distribution of prices is in fact unimodal, which suggests the absence of price convergence clubs. The shape of the distribution tends to be more regular and narrower over time, however, keeping a long right-hand tail. This part of the distribution is due, in the main, to the difficult-to-access regions and a few more utmost ones, the most of the latter leaving it during the period under consideration. As for the difficult-to-access regions, their prices – at least, all of them – can be hardly believed to lower so that the right-hand tail will become similar to the left-hand one. Thus, taking account of this geographical feature, the changes in the distribution shape evidence price convergence among Russian regions.

There is a way to see an "anatomy" of the changes. Using time-series analysis, Gluschenko (2004b) has divided Russian regions into three groups: (a) regions integrated with the national market over 1994-2000; (b) regions that are not integrated with the national market, but are tending to integration with it; and (c) non-integrated regions without such a trend. For brevity, hereafter they are referred to as integrated regions, regions tending to integration, and non-integrated regions, correspondingly. Figure 3 reports estimates of price distributions over each of these groups for selected years.

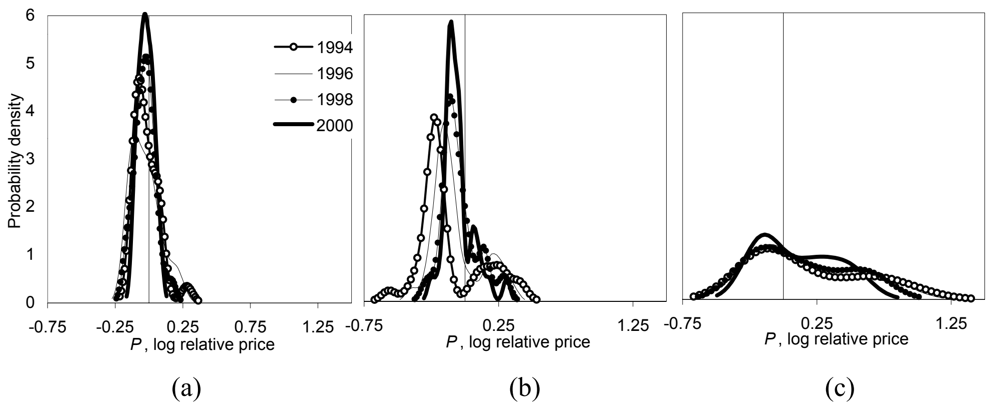


Figure 3. Estimates of price distributions by group:
(a) integrated regions, (b) regions tending to integration, and (c) non-integrated regions

The group of non-integrated regions (Figure 3c) contains all difficult-to-access ones. There are two main differences from the entire-country distribution from Figure 2. Firstly, the distribution mode does not shift with time, staying at almost the same value of *P*. Secondly, the right-hand tail of the distributions is much heavier. It comes as no surprise, as it is non-integrated "expensive" regions that concentrate in this tail. Now, it is clearly seen that there is no additional mode in the area of the difficult-to-access regions. The distribution for non-integrated regions has the following statistics in 2000 as compared to those for the whole of Russia (in parentheses): the mean: 0.104 (–0.009), the median: –0.100 (–0.042), the standard deviation: 0.281 (0.157).

The main mode of the distribution of regions tending to integration (Figure 3b) sufficiently shifts to higher prices over time. This distribution has transient (spurious?) additional modes in the area of prices above the national average. The distribution has the following statistics in 2000: the mean: –0.050, the median: –0.076, the standard deviation: 0.111. The distribution for integrated regions (Figure 3a) tends towards a symmetric one; its mean and median are close to one another and to zero: they equal –0.023 and –0.032, respectively, in 2000. The distribution is much narrower than that for Russia as a whole; the standard deviation of the former equals 0.055 (while that of the latter is equal to 0.157). Besides that, the distribution for integrated regions tends to normality. For example, the hypothesis of normality has significance of 64 percent (by the Jarque-Bera statistic) in 2000.

Overall, it can be concluded that the distribution of prices in regions tending to integration has a tendency of coming closer to the distribution of integrated regions (both in shape and position). However, the distribution for non-integrated regions almost does not change over time, except for somehow shortening its right-hand tail. Because of this, the distribution for the whole of Russia keeps the long right-hand tail as well.

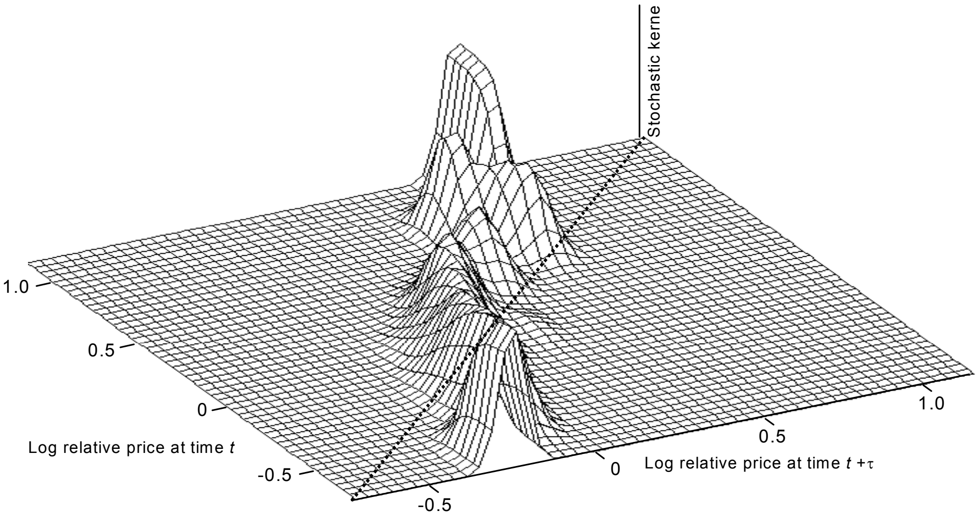
Having obtained the sequence of price distributions, the next issue is that of a law of motion. The evolution of the entire across-region distribution of prices is modeled by the transition probability function (stochastic kernel); see Formulae (3) through (5). It can be also interpreted as a characterization of (absolute) mobility of regions in terms of prices, being a continuum version of a transition probability matrix (which finds rather wide use in studies of income mobility). Since the issue of price convergence is of interest, the time span of only 1994-2000, where regional prices exhibit such a trend, is dealt with.

From considerations of robustness of results, the transition function is estimated in two ways. The first uses information only on price transition of regions between the initial and final points of the time span concerned: $\hat{f}(P_{t+\tau}|P_t) = \hat{f}(P_{2000}|P_{1994})$. The second way makes use of information on transitions within 1994-2000; however, the more distant is a transition in time, the lesser importance is attached to it. That is, the estimate of the transition function is a weighted average of year-to-year estimates:

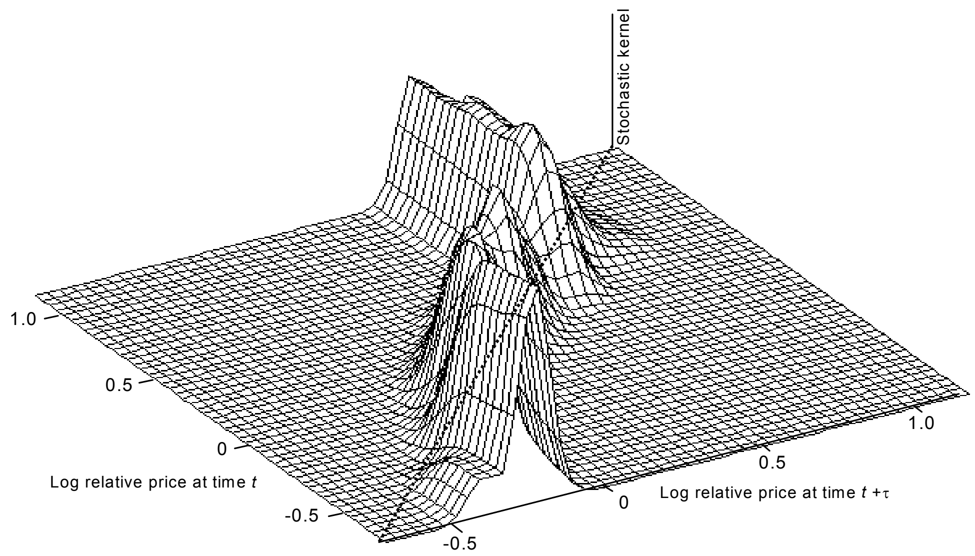
$$\hat{f}(P_{t+\tau}|P_t) = \alpha(\hat{f}(P_{1995}|P_{1994})/6 + \hat{f}(P_{1996}|P_{1995})/5 + ... + \hat{f}(P_{2000}|P_{1999})/1),$$

where α (= 1/2.45) is a normalizing factor making the weights to sum to unity. The estimations are run over yearly averaged cross sections.

Figure 4 reports three-dimensional plots of both estimates of the transition function.[3] 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, it traces out the surface of the transition function, so providing a probability density of the price having had a given fixed value at the initial period. The dashed lines in the figure mark diagonals which are the lines of equal prices at t and $t + \tau$.



(a) Estimated using transition from 1994 to 2000



(b) Estimated with the use of year-to-year transitions

Figure 4. Relative-price dynamics across Russian regions: estimated transition probability functions

[3] These plots were drawn with the use of Matrixer, an econometric software developed by Alexander Tsyplakov; see http://matrixer.narod.ru.

In spite of some differences between the transition functions obtained, they are very similar qualitatively, suggesting the same features of price distribution dynamics. Mapping each value of P_t to the same (point) value of $P_{t+\tau}$, the diagonal is the "line of immobility." Be most of the probability mass concentrated along this line, it would evidence low price mobility, indicating a tendency of prices to remain unchangeable. However, this is not the case; the pattern suggests that the degree of mobility is rather high.

The essence of transition dynamics is clearly demonstrated by Figure 5 plotting the mode lines of both transition probability functions. In fact, the figure is the views from above of Figures 4a and 4b, superimposed on one another; for clarity, all level lines but ridges are omitted.

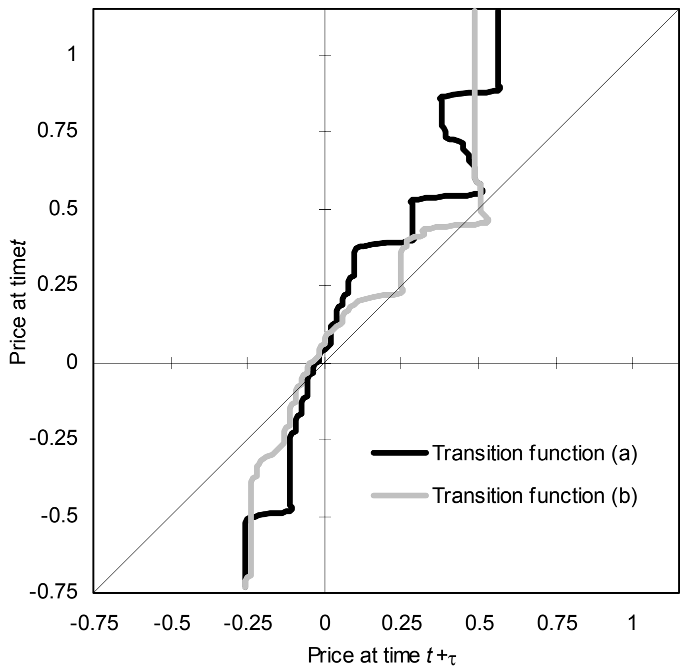


Figure 5. Mode lines of the transition probability functions

The mode lines of both transition functions are turned counter-clockwise, crossing the diagonal approximately at the zero point. This implies that regions with prices below the Russian average tend to transit to higher prices, and those with high prices tend to transit to lower prices; only regions with prices close to the national average are near-immobile. Such a pattern bears one more witness to price convergence. The lowest and highest prices have the lowest chances to retain their initial values. The former have the maximum probability to increase to –0.25 (or circa three forth of the national average); the latter should, most probably, decline to about 0.5 (65 percent above the national level).

As described in Section 2, the transition probability function can be used for estimating a long-run limit of the price distribution, the ergodic distribution. Figure 6 presents estimates of ergodic distributions obtained with the use of both transition functions obtained; the actual price distribution in 2000 is reported for comparison.

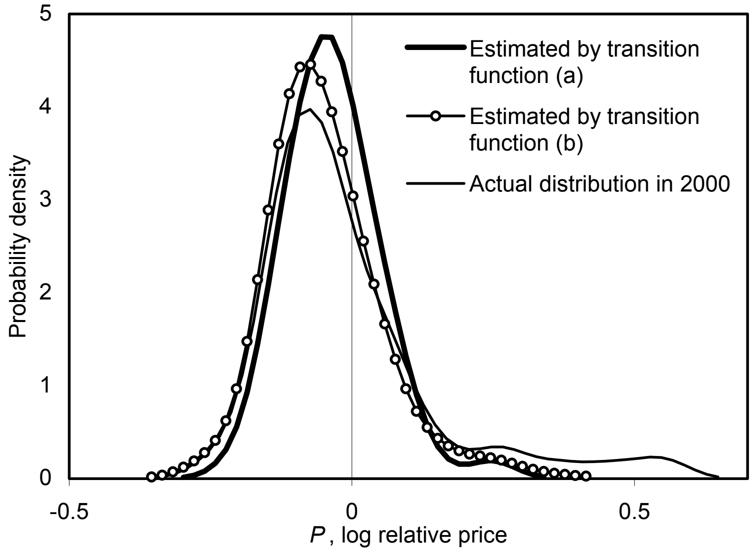


Figure 6. Long-run limits of the distribution of regional prices

While estimating the ergodic distribution, 23 iterations (exponentiations) according Formulae (6) and (7) were sufficient for transition probability function (a) to converge to it, and 89 iterations were needed for function (b). The two estimated distributions are rather close to each other. They are almost symmetric except for a long right-hand tail which shortens but still persists. Both distributions are unimodal, thus suggesting the absence of price convergence clubs in the long run. The most interesting feature is the fact that the actual price distribution in 2000 is similar to the long-run limits, especially to that based on information on yearly transitions, assimilated by transition function (b). It follows herefrom that, most likely, the process of price convergence in Russia is nearing to complete, unless it already did.

4. CONCLUSIONS

Using the cost of the basket of 25 basic food goods as the price representative, dynamics of cross-region price distribution in Russia in 1992-2000 have been analyzed. The results obtained unambiguously suggest that, excluding a few years following the price liberalization, price convergence has been happening among Russian regions. An exception is the group of the difficult-to-access regions, which is hardly involved in this process (nevertheless, their prices did come closer to the Russian average over time). However, the difficult access is an irremovable market friction; non-integration of these regions owes to geographical features of the country rather than to some economic policy, either national or regional.

There are two facts found providing reasons to assume that price convergence in Russia is nearing completion, or even that it has completed by 2000. The first is the stabilization of price dispersion across Russian regions since the end of 1999, lasting up to now, as Gluschenko (2004b) reports. The second fact is the closeness of the actual price distribution for 2000 to the long-run limits. It seems that the Russian market has been reaching a minimum feasible degree of market integration. Reasoning from comparison of recent price dispersion across Russian and US cities (Gluschenko, 2004b), this degree is comparable to that inherent in large countries having advanced market economy.

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