Inter-Regional Price Convergence and Market Integration in Russia

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Abstract

The paper analyzes a spatial pattern of goods market integration in Russia. By the spatial pattern is meant a state of each individual region of the country: whether it is integrated, and if not, whether it moves towards integration. Time series of the cost of the basket of 25 basic foods across 75 regions of Russia for 1994-2000 with monthly frequency are used as the empirical stuff. With the use of nonlinear cointegration relationship that includes asymptotically subsiding trend capturing movement towards integration, 36% of Russian regions are found to be integrated with the national market; 44% of them are non-integrated, but are tending to integration with the national market; and 20% of regions are non-integrated and having no such a trend. It is found that σ-convergence of regional prices takes place, implying that, despite the presence of regions not tending to integration, the predominant trend is the improvement in market integration.

JEL classification: C32, P22, R10, R15

Keywords: market integration, law of one price, price dispersion, convergence, Russian regions.

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1. INTRODUCTION

The fast switch in the early 1990s from the centrally planned economy to that governed by the market principles, along with the political changes of that time, gave rise to dramatic regional fragmentation of the economic space of Russia. (Berkowitz and DeJong (2003) as well as Gluschenko (2003) discuss this process in more detail.) Therefore the creation – or recovery, if one would prefer to say so – of its single economic space became a severe problem challenging the country. It is even believed that a progress in solving this problem can be deemed as an important indication of successfulness of the Russian market reforms in general.

A "core" of the single economic space is goods market integration. Results of Gluschenko (2003, 2004a) suggest that after a period of growing disconnectedness of the Russian market, the improvement of market integration started in 1994. Nevertheless, the market still is not near to completely integrated. Gluschenko (2004a) reveals a number of region-specific economic forces impeding integration, and Berkowitz and DeJong (2001, 2003) find macroeconomic and some other region-specific "anti-integration" forces. These papers find the temporal pattern of market integration in Russia, but they do not provide an insight into its spatial pattern, since, exploiting the cross-sectional approach, the results are averaged across regions of the country.

It is to reveal the spatial pattern of goods market integration in Russia with the use of time series analysis that is the object of this study. By the spatial pattern is meant a state of each individual region of the country: whether it is integrated over a certain span of time, and if not, whether it moves towards integration. To model the movement towards integration (i.e., long-run inter-market price convergence), a new class of processes is introduced, which is intermediate between non-stationary and stationary ones, namely, non-stationary processes converging to stationarity over time. Such a process is represented by an autoregression with a non-linear, asymptotically subsiding trend. Two markets are deemed as tending towards integration with one another if their price differential satisfies this model. Otherwise it is tested whether the markets are integrated, using the conventional AR(1) model. (In both cases, a structural break characterizing the 1998 financial crisis in Russia is taken into account.) The source data for the empirical analysis are time series of the cost of a staples basket across 75 regions of Russia for 1994-2000 with monthly frequency, the average Russian cost being used as a representative of the national market.

With the use of this methodology, 36% of Russian regions are found to be integrated with the national market; 44% of the regions are classed with those tending towards integration with the national market (the speed of convergence of regional prices to the average Russian level varying from 0.7% to 8.9% per month); and 20% of the regions are found to be non-integrated without a trend to integration. Since there are both regions tending and not tending to integration, the resulting trend of the entire market is *a priori* unclear. Examining the behavior of price dispersion (analyzing σ-convergence) sheds light on the issue. It is found that σ-convergence of regional prices takes place, implying that, despite the presence of regions not tending to integration, the predominant trend is the improvement in market integration; non-integrated regions do not demonstrate σ-divergence either. Comparing price dispersion in Russia and the US, it can be believed that by the late 1990s the Russian market has achieved the degree of integration comparable to that peculiar to the US market deemed the most integrated.

The issue of market integration in transition economies has been the subject of a number of studies. Using cointegration analysis, Gardner and Brooks (1994), Goodwin *et al.* (1999), and Berkowitz *et al.* (1998) 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. (An early version of the paper by Berkowitz *et al.* (1998) was even titled "Transition in Russia: It's Happening".) Subsequently, Berkowitz and DeJong (1999) reveal the "Red Belt" as a culprit behind the segmentation of the Russian market; and then Berkowitz and DeJong (2001, 2003) estimate a segment of the integration trajectory for Russia (which is corroborated by Gluschenko (2003) who applies a different methodology). Cointegration and threshold relationships are analyzed across 7 regions of Western Siberia in Gluschenko (2001), and across 11 aggregated economic territories of Russia in Gluschenko (2002); both integrated and non-integrated region/territory pairs are found.

Conway (1999), using data from 1993–1996 for three commodities, examines price convergence among four market locations within Kiev, Ukraine. He finds significant evidence of price convergence due to arbitrage by buyers and sellers at these markets, but sizeable and sustained divergences from the law of one price have remained as well. Cushman *et al.* (2001) examine the law of one price with 5 food prices over an 11-month period in Kiev, during the early 1991–1992 period of Ukraine's transition to independence. They compare these prices with the prices of similar goods in the US. Cointegration between Ukrainian and US price time series with a (linear) trend is deemed as an evidence of price convergence. Although the law of one price did not hold during the period, the commodity real exchange rates are found to have possessed deterministic trends that were in the direction of closing the initial considerable price gap.

This paper also relates to papers analyzing internal market integration in advanced market economies, such as Engel and Rogers (1996), Parsley and Wei (1996), and Rogers (2002). More distantly, it relates as well to countless papers on analysis of the law of one price in the international context, and purchasing power parity, most sufficient of which were surveyed by Rogoff (1996), and Sarno and Taylor (2002). Noteworthy is also a relationship with the literature on empirics of economic growth (which is voluminous, too, see Durlauf and Quah, 1999).[1] The time series method of analyzing price convergence that is put forward in the paper seems to be useful to analyze, e.g., income convergence.

The remainder of the paper is organized as follows. In the next section, methodology of the analysis and the data used are described. In Section 3, empirical results are presented. Conclusions are drawn in Section 4.

2. METHODOLOGY AND DATA

2.1. Strategy of the analysis

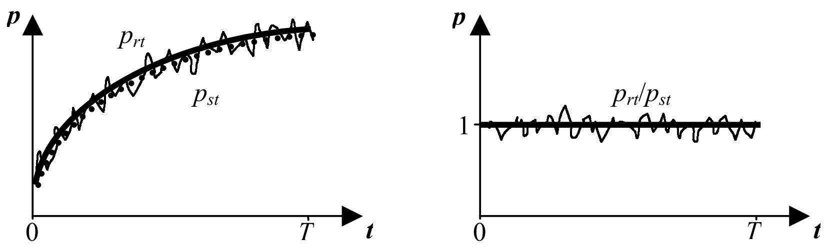
Perfect integration of a spatially separated goods market implies that there are no impediments to the movement of goods between all its spatial segments, i.e., regions of the country. In other words, perfectly integrated market operates like a single market despite its spatial separation. Then the price of a (tradable) good across regions is uniform, i.e., the law of one price holds, inter-regional arbitrage maintaining the law to hold. Thus, the law of one price can be used as a theoretical benchmark for empirically analyzing internal market integration.

As mentioned in Introduction, there are two stages in the evolution of market integration in Russia, namely, the early stage of progressive segmentation beginning in January 1992, and the late stage of improvement in integration beginning in about 1994. It is the late stage that is of interest in this study. It is hypothesized that the Russian goods market should eventually come to the final steady state of complete integration, that is, to the equality of prices across all regions. Currently, during the late stage of the integration evolution, the market may be believed to be in transition towards this steady state. Hence, it is expected that three groups of regions can exist at present: (a) integrated regions, i.e., those being in the steady state of equality of prices; (b) non-integrated regions tending to integration, i.e., those in which prices are converging to some common level; and, maybe, (c) non-integrated regions having no such a trend. For brevity, hereafter regions from the second group are referred to as "regions tending to integration", and regions from the third group are referred to as simply "non-integrated regions."

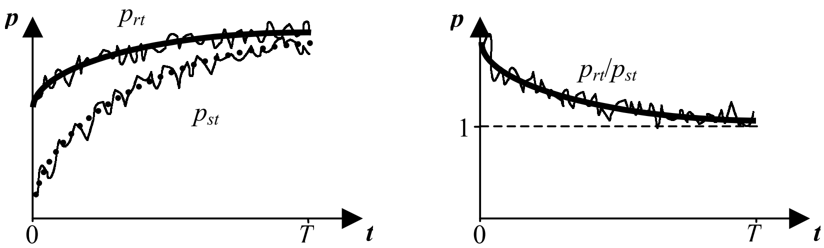
In the above context, the term *convergence of prices* becomes ambiguous. In fact, considering region groups (a) and (b), two fundamentally different concepts of convergence come into collision with one another. Let p_{rt} and p_{st} denote the price of a good in regions r and s at time $t \in [0, T]$, and $p_{rst} = p_{rt}/p_{st}$. Figure 1 illustrates the difference between the concepts; the thin lines in the figure depict actual dynamics of prices; and the thick lines represent their theoretical (long-

[1] Michael Beenstock has pointed out the resemblance of the convergence problem in economic growth and the problem of price dynamics.

run) trajectories.



(a) Short-run convergence (ordinary cointegration)



(b) Long-run convergence (catching-up)

Figure 1. Two concepts of price convergence

In words, these two concepts can be described as follows:

(I) Figure 1(a) implies that regions r and s fall into group (a) of those *being* in the spatial equilibrium; price disparities between regions are merely random shocks dying out over time. In other words, prices fluctuate around parity, permanently tending to return to it. This is just the case that the literature on the law of one price and purchasing power parity (PPP) deals with, calling it "convergence to the law of one price/PPP." That is, the term "convergence" relates to shocks, implying their convergence to zero. In fact, this characterizes the short-run behavior of prices, while their long-run behavior is described by the trajectory

$$p_{rt}/p_{st} = 1, \quad t = 0,\ldots,T. \tag{1}$$

Thus, such a concept can be called "short-run convergence."

(II) Figure 1(b) implies that regions r and s fall into group (2) of those *tending* towards the spatial equilibrium:

$$\lim_{t\to\infty} p_{rt} / p_{st} = 1\,. \tag{2}$$

(In the figure, prices in s are catching prices in r up.) In general, the price disparity permanently diminishes over time; and the prices fluctuate around this general trend due to random shocks. This is the case that the literature on economic growth deals with (regarding income data), calling it simply "convergence." This time, in the short run, prices converge to the long-run trajectory (i.e., random deviations from it dye out over time), while this trajectory itself converges to the parity line $p_{rt}/p_{st} = 1$ in the long run. It is the latter trend that is of main interest. Here, the term "convergence" relates to prices themselves, implying (long-run) convergence of their differences to zero over time. Hence, such a concept can be called "long-run convergence."

In (1) and (2), the absolute price parity is taken as the steady state. It implies perfect integration which is not a common instance in the real world. For example, Engel and Rogers (1996) as well as Parsley and Wei (1996) find price dispersion among US cities to depend strongly on distance. Then there may be a persistent (equilibrium) difference in prices between r and s that is induced by "natural" market frictions such as physical distance and difficult access to a number of regions. And so, it would be more realistic to relax the criterion for market integration, allowing for such market frictions. In that case the relative price parity would be dealt with, substituting 1 in the right-hand side of (1) and (2) for an arbitrary constant ratio of prices, α_{rs}. (Such a relaxation has been implemented in Gluschenko (2003, 2004a), exploiting cross-section analysis.)

The trouble is that this α reflects both the effect of "natural", irremovable, market frictions (which is compatible with the notion of integration) and the effect of artificial, transient, ones impeding market integration. This can be formalized as, e.g., $\alpha = \alpha_e(L_{rs})\cdot\alpha_f$, where α_e is the effect of transportations costs proxied by distance between regions r and s, L_{rs}, and α_f is the effect of "anti-integration forces." But in the context of pairwise time series analysis, there is no way to separately identify α_e and α_f. That is why the strict version of the law of one price is adopted as the benchmark of integration, any deterministic difference in prices interpreting as an indication of non-integration. Certainly, the degree of Russia's market integration may be understated to some extent because of this. Therefore, it is checked in Section 3 whether non-integration is predominantly due to persistent inter-regional differences in prices, or to (stochastic or deterministic) divergence of prices.

Testing for equality of prices (or price levels) – i.e., for relationship (1) – is the conventional exercise in papers on the law of one price and PPP. Denoting $P_{rt} \equiv \ln(p_{rt})$, $P_{st} \equiv \ln(p_{st})$, and $P_{rst} \equiv \ln(p_{rt}/p_{st})$, it is tested whether regional prices P_{rt} and P_{st} are cointegrated with predetermined cointegrating vector (1, –1), or, what is the same, whether price differential P_{rst} is stationary. However, providing the "all or nothing" answer, this traditional approach is impotent in revealing a transitional case (2), that is, the case when a process $\{P_{rst}\}_{t=0,\ldots,T}$ is not stationary, but tends to a stationary one over time. Using conventional cointegration analysis, such a process would be recognized simply as non-stationary, giving no way to separate groups (b) and (c).

There exist a few approaches to deal with this problem. The issue of (long-run) convergence is extensively addressed to in the economic growth literature; see a survey by Durlauf and Quah (1999).

The most widely used concepts of convergence in the economic growth context are called σ-convergence and β-convergence (Barro and Sala-i-Martin, 1992). Reformulating in terms of prices, σ-convergence occurs if the cross-sectional dispersion of prices, measured, e.g., by the standard deviation $\sigma(P_t)$, tends to decrease over time: $\sigma(P_t)/\sigma(P_{t-\tau}) < 1$. In the same terms, if the regression of P_{rt} on $P_{r,t-\tau}$ yields $\beta < 1$, where β is the coefficient on $P_{r,t-\tau}$, then it is said that the data set exhibits β-convergence. Being tested cross-sectionally, both approaches yield a spatially aggregated result, and not a spatial pattern of convergence. And so, they are not able to solve the problem put in this paper.

There are a few papers exploiting a time series concept referred to as forecast convergence by Bernard and Durlauf (1995), or stochastic convergence by Carlino and Mills (1996). The former paper defines convergence essentially in the same way as (2), but tests for convergence with the use of (1), applying standard cointegration analysis. Thus, in fact, the authors do not deal with long-run convergence as such, examining only whether it completed by the beginning of a given time span (i.e., they test for short-run convergence). Carlino and Mills (1996) employ a cointegration relationship with a deterministic linear trend. Provided that the trend is directed towards zero inter-location difference, stationarity around this trend is supposed to be an evidence of convergence. (Cushman *et al*. (2001) apply a similar way to analyze price convergence.) However, since this test is not compatible with (2), such evidence is rather unreliable: having reached the zero value, the difference would be driven further by the linear trend, increasing again (in absolute value) with the opposite sign.

Indeed, to analyze convergence in progress, a time series model should include a zero-directed trend. However, in order to satisfy (2), the trend should asymptotically subside, which leads to a nonlinear cointegration relationship. It is this approach that is adopted in this paper. Convergence of prices to equality is modeled as

$$p_{rt}/p_{st} = 1 + \gamma e^{\delta t}, \delta<0 \quad (3)$$

(to economize notations, the region indices for parameters – as well as for disturbances below – are suppressed).

Parameter δ defines the convergence speed. The sign of γ shows the direction of convergence: with $\gamma < 0$, prices in *r* catch up with prices in *s*, increasing over time faster that those in *s*; with $\gamma > 0$, the prices in *r* are rising slower than in *s*. *Per se*, γ is the initial – at $t = 0$ – deviation of prices from parity. With $\gamma = 0$, (3) degenerates into (1), which means convergence of prices to have completed by the beginning of the time span under consideration, hence, the law of one price holds for regions *r* and *s*.

2.2. Econometrics

To derive a testable version of the theoretical relationship (3), stochastic disturbances, ν_t, are taken into account, supposing them to be a (first-order) autoregressive process:

$$P_{rst} = \ln(1 + \gamma e^{\delta t}) + \nu_t, \quad \nu_t = (\lambda + 1)\nu_{t-1} + \varepsilon_t, \tag{4}$$

where ε_t is white noise, and γ, δ, and λ are parameters to be estimated; hereafter, $t = 1,\ldots,T$. Substituting the second equation in (4) into the first one gives the nonlinear model to be estimated and tested:

$$\Delta P_{rst} = \lambda P_{rs,t-1} + \ln(1 + \gamma e^{\delta t}) - (\lambda + 1)\ln(1 + \gamma e^{\delta(t-1)}) + \varepsilon_t. \tag{5}$$

It is tested whether time series $\{P_{rst}\}$ has no unit root, i.e., that the process is stationary around the trend, and if so, whether the time series does have a subsiding trend, i.e., $\gamma \neq 0$ and $\delta < 0$. That is, the hypotheses tested are H_1: $\lambda = 0$ (against $\lambda < 0$); H_2: $\gamma = 0$ (against $\gamma \neq 0$); and H_3: $\delta \geq 0$ (against $\delta < 0$). Throughout the paper, the 10% significance level is adopted.

To test hypothesis H_1, the Phillips-Perron test is performed, which eliminates serial correlation from the residuals, using the Newey-West (1994) automatic bandwidth selection method with the Bartlett spectral kernel. (This test is chosen in order not to lose degrees of freedom through adding additional lags to the regression itself.) However, the test statistic (which is the t-ratio of λ) for an AR(1) process of the form (5) is not documented in the literature. Therefore, to derive p-values of the test, the empirical distribution of this statistic under the null hypothesis was estimated, implementing a large set of simulations. Appendix provides details as well as results obtained.

If the unit root in (5) is rejected, hypotheses H_2 and H_3 are tested; provided the stationarity of the time series, the ordinary t-test is valid for this. If either of them is not rejected, this means that there is no deterministic trend of the given form in the time series (or – when $\delta > 0$ – that the trend is not subsiding). In such an event, as well as in the case of non-rejection of unit root, it is tested whether the process is governed by law (1), as described below.

The joint rejection of H_1, H_2 and H_3 is interpreted as evidence that the time series has asymptotically subsiding trend, fluctuating around it. Hence, prices in r and s are converging to equality, and these regions are classed with ones tending to integration. Parameter λ is interpreted as an indicator of the speed of dying out deviations from trajectory (3) that are caused by random shocks; $t_{HL} = \ln(0.5)/\ln(1 + \lambda)$ defines the half-life time of the deviations. (With a unit root, $\lambda = 0$, $t_{HL} = \infty$, meaning that the effect of random shocks is permanent; hence, there is no return to trajectory (3). With no autocorrelation, $\lambda = -1$, $t_{HL} = 0$; hence, the return to trajectory (3) is instantaneous).

Using the same way as above, a testable version of (1) is arrived at:

$$P_{rst} = \nu_t, \quad \nu_t = (\lambda + 1)\nu_{t-1} + \varepsilon_t, \tag{6}$$

or

$$\Delta P_{rst} = \lambda P_{rs,t-1} + \varepsilon_t, \tag{7}$$

which is the conventional AR(1) model.

The hypothesis tested is whether the time series has unit root, H'_1: $\lambda = 0$ (against $\lambda < 0$). The same procedure as for testing H_1 is used, taking MacKinnon's (1996) *p*-values for regression without intercept and trend. The rejection of the unit root is interpreted as evidence that the time series fluctuates around zero, that is, around equality of prices in *r* and *s*. Therefore, these regions are classed with integrated ones. If H'_1 is not rejected, regions are deemed as non-integrated.

Noteworthy are different roles of parameters γ and δ vs. parameter λ. The first two characterize the *long-run* behavior of a relative-price trajectory, while λ defines the *short-run* properties of adjustment toward this trajectory (which is, in the degenerate case of AR(1), the straight line along the time axis, representing the price parity).

There is a peculiarity in price dynamics in Russia: a number of regional price time series contain a structural break caused by the August 1998 financial crisis. The period of break is not uniform across regions, varying from 1998:08 through 1999:02. With such a break, a time series might appear to have a (spurious) deterministic trend, so biasing the inference towards non-rejection of a trend in (5), and towards non-rejection of a unit root in (7). To avoid this, (5) and (7) are augmented for breaks, taking the forms

$$\Delta P_{rst} = \lambda P_{rs,t-1} + \ln(1 + (\gamma + \gamma_B B_{\theta t})e^{\delta t}) - (\lambda + 1)\ln(1 + (\gamma + \gamma_B B_{\theta,t-1})e^{\delta(t-1)}) + \varepsilon_t, \tag{5*}$$

and

$$\Delta P_{rst} = \lambda P_{rs,t-1} + \gamma_B(B_{\theta t} - (\lambda + 1)\, B_{\theta,t-1}) + \varepsilon_t, \tag{7*}$$

where $B_{\theta t}$ is the structural change dummy such that $B_{\theta t} = 1$ if $t < \theta$, and zero otherwise.[2] The period of break is found by estimating (5*) and (7*) for θ = 1998:08,…,1999:02, and choosing its value that yields the least sum of squared residuals.

In (5*), the sign of $\gamma + \gamma_B$ shows the direction of convergence before the break; and that since the break point is shown by the sign of γ. This time γ can equal zero; such an event implies that

[2] Specification (7*) is derived from (6), augmenting the first equation in (6) with the break variable. It differs from the classical regression used to test for a unit root in the presence of structural break as specified by Perron (1990). (Note that the common use of two dummies to characterize the break, the level dummy and the pulse one, is superfluous, since the pulse dummy taking the value of 1 if $t = \theta+1$ and 0 otherwise can be represented as $B_{\theta t} - B_{\theta,t-1}$.) The Perron-type equation is a linear approximation of (7*), allowing coefficients on $B_{\theta t}$ and $B_{\theta,t-1}$ to be independent. This leads to that parameter estimates, while being consistent, are not asymptotically efficient. Hence it can be expected that obtaining efficient estimates with the use of more adequate nonlinear equation (7*) would provide a test with better properties. (See Gluschenko (2005) for details.)

prices in r and s have become close to equal from the break date on. If the signs of γ and γ_B are the same, the break causes a price jump towards parity; and opposite signs imply the jump away from parity, provided that $|\gamma| > |\gamma_B|$. (The opposite inequality produces an exotic case of "overshooting": the jump crosses the price parity line, thus changing the direction of convergence since the break point. There are no such cases among estimates obtained except for insignificant γs.) Equation (7^*) is constructed so that the price jump is always parity-directed, in order to test whether r and s have become integrated since the date of the structural change. Given $\gamma_B > 0$, the crisis caused price-cutting in r; otherwise, it increased the relative price in the region. The hypotheses tested for (5^*) are the same as for (5) but H_2 which is substituted for H^*_2: $\gamma_B = 0$ (against $\gamma_B \neq 0$). For (7^*), a similar hypothesis denoted $H^{*\prime}_2$ is tested in addition to H'_1. Hypotheses H_1 and H'_1 are tested through the same procedure as above, however, using estimated empirical distributions of the unit-root test statistic for time series with breaks; see Appendix.

Thus, each time series $\{P_{rt}\}$ is analyzed as follows:

Step 1. Model (5^*) is estimated and tested. If hypotheses H_1, H^*_2, H_3 and are jointly rejected, regions r and s are deemed as tending to integration, $\{P_{rst}\}$ containing a structural break. Otherwise, if the structural break is rejected, the analysis comes to Step 2, and if it is not (and H_1 or/and H_3 is not rejected), the analysis continues from Step 3.

Step 2. Model (5) is estimated and tested. If hypotheses H_1, H_2, and H_3 are jointly rejected, r and s are deemed as tending to integration. Otherwise, the analysis comes to Step 3.

Step 3. Model (7^*) is estimated and tested. If there is no structural break (hypothesis $H^{*\prime}_2$ is not rejected), the analysis comes to Step 4. Otherwise, if the unit root is rejected, r and s are deemed as integrated (since the period of the break), and if it is not, they are deemed as non-integrated, $\{P_{rst}\}$ containing a structural break.

Step 4. Model (7) is estimated and tested. If the unit root is rejected, r and s are deemed as integrated; otherwise, they are deemed as non-integrated.

There are 75 series of regional prices for Russia, yielding 2775 region pairs. A standard way of reducing such a mass of pairwise comparisons in the literature on the law of one price and PPP is to take one of locations as a benchmark, as, e.g., in Parsley and Wei (1996), and Gardner and Brooks (1994), to name a few. This way is used in this paper as well. The national market as a whole is chosen as the benchmark (since, in the intra-national context, such a benchmark is believed to be natural and much more reasonable than an arbitrary region). Thus, integration of each region with the entire national market is analyzed, using only region-Russia pairs. That is, index s in the above relationships is fixed, and is set to $s = 0$, p_{0t} denoting the price in Russia as a whole. (This price is close to the mean of prices across all regions, however, does not coincide with it; see the next section. For brevity, nevertheless, it will be referred to as "average Russian price"). And so, s is omitted hereafter; i.e., P_{rt} denotes percentage difference in prices between region r and Russia as a whole: $P_{rt} \equiv \ln(p_{rt}/p_{0t})$.

Certainly, so reducing the set of pairs, the pattern becomes rougher and looses many details. However, it is believed to be in good agreement with the detailed pattern, based on Gluschenko (2002), where results of analysis across pairs of Russian economic territories are compared with those across the territory-Russia pairs. Theoretically, if two regions are integrated (or tending to integration) with the national market, then they should be integrated (tending to integration) with one another. Practically, this might fail, but only because of low power of unit root tests. There is a caveat though. There may be integration or long-run price convergence between two (and more) regions without integration with, or convergence to, the national market. 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, 1992). Using comparison with the benchmark rather than all pairwise comparisons, this issue remains open. It is to be clarified by additional analyses which is performed in Gluschenko (2004b, 2004c).

When there are both regions tending to integration and non-integrated regions, the resulting trend of the entire market is *a priori* unclear. Then the behavior of the entire cross-section over time can shed light on the issue. It is reasonable to believe that if it exhibits σ-convergence, then the market as a whole is moving towards integration. The occurrence of σ-convergence in the case when the existence of non-integrated regions has been detected is evidence that the trend to long-run convergence of prices prevails over the trend to divergence induced by those regions. To verify the separation of regions into three groups obtained through the time series analysis, σ-convergence is also analyzed for each group. The group of regions tending to integration is expected to display σ-convergence; and the group of integrated regions is expected to have near-constant σ. The group of non-integrated regions would show σ-divergence if non-integration is due to random walking or deterministic price divergence. However, if the reason of non-integration is constant persistent differences in prices, a near-constant σ is to be expected.

2.3. Data

The cost of the basket of 25 food goods (defined as the standard by the Russian statistical agency, Goskomstat, between January 1997 through June 2000) is used as a price representative for the analysis. 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; Goskomstat (1996) describes its composition. The costs of the basket (including retrospectively calculated for 1994-1996 and the second half of 2000) were obtained directly from Goskomstat.

The price information has been collected in capital cities of the Russian regions; 75 of the 89 regions of Russia are covered. The data are lacking for 10 autonomous *okrugs*, the Chechen Republic, and the Republic of Ingushetia. Besides that, two more regions are omitted. The city of Moscow is a "city-region", being a separate subject of the Russian Federation, and at the same time it is the capital city of the surrounding Moscow Oblast; the same holds for St. Petersburg and the Leningrad Oblast. Therefore only these "cities-regions" are present in the sample, while the relevant surrounding *oblasts* are not. The data are monthly, spanning January 1994 through December 2000. Thus, the number of the time observations equals 84.

Goskomstat calculates the cost of the basket for Russia as a whole as a weighed average of regional costs (using the ratio of region's population in the population of Russia as the regional weight). Thus, the average Russian price does not coincide with the average over regions, though they are rather close to one another. This implies that the mean of relative prices p_{rt}/p_{0t} can deviate – to some extent – from unity, and the mean of their logarithms can deviate from zero.

There are missing observations in the time series used. The most of them occur in 1994. For this year, there are 42 missing observations (4.7% of the yearly total) in 17 regional time series. The remainder of the data set has only 9 missing observations. To fill the gaps, the missing prices are approximated, using the food component of the regional monthly CPIs. The interpolated value of price p_{rt} is the arithmetic mean of the nearest known preceding price inflated to t, and the nearest known succeeding price deflated to t; see Gluschenko (2003). For example, if an observation for one month is missed, its restored value looks like $p_{rt} = (p_{r,t-1}\cdot\pi_{rt} + p_{r,t+1}/\pi_{r,t+1})/2$, where $\pi_{r\tau}$ is the food CPI for month τ in region r.

At last, a caveat with the data used should be mentioned. Retail prices embody region-specific distribution costs which may cause violation of the law of one price even if wholesale prices do obey the law. Two ways of dealing with the problem are suggested by Gluschenko (2003). The first is to produce proxies of wholesale prices from retail prices. However, given monthly price time series, this way is not proper here, since data on distribution costs and retail-wholesale margins are available only on a yearly basis. Thus, the second way is forced to follow, interpreting the spatial variation of distribution costs as an additional indication of poor integration. In fact, this means extending the notion of market integration, considering integration of the goods market as such in conjunction with integration of the related markets for distribution services and labor in retail trade.[3] (Indeed, organized crime responsible for a sufficient portion of inter-regional price dispersion in Russia acts both on the inter-regional level, forcing wholesale

[3] Such a component of distribution costs like rent does not fit in with this. However, rent does not play a noticeable role in costs of the Russian trade, coming to about 1% in retail prices of goods.

prices to rise, and on the local level, causing additional traders' expenses raising distribution costs.) On the other hand, basing on results reported by Gluschenko (2003), it may be believed that patterns for retail and proxied wholesale prices would not sufficiently deviate from each other.

3. EMPIRICAL RESULTS

Table 1 summarizes results on integration of each individual region with the entire national market, which are obtained with the use of models (5^*), (5), (7^*), and (7). For a given region, the table reports results for one of these models, depending on which of them is accepted as describing the price behavior in this region. Reporting all parameters – λ, γ, γ_B, and δ – means acceptance of model (5^*); reporting λ, γ, and δ implies that (5) is accepted; thus, the region is deemed as tending to integration. If there are only λ and γ_B in the table, model (7^*) is accepted; and the only parameter λ is reported for (7). In the last two cases, the region is deemed as integrated if the unit root is rejected (the *p*-value of the unit root test is less than, or equal to, 0.1); otherwise the region is deemed as non-integrated. (The full set of estimates, i.e., results for each model, is provided in Gluschenko (2004b), Appendix B.)

In the table, standard deviations are in parentheses; ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively; *p*-values of the unit root test exceeding 10% are marked with bold italics. The horizontal borders separate the economic territories (*ekonomicheskiy rayon*) from one another. The composition of these territories and their names can be seen from the map in Figure 2 below. Regions are arranged geographically in the table, accordingly to their traditional ordering in Goskomstat's publications until July 2000 (except for the Kaliningrad Oblast which is added to the Northwestern Territory).

Of all the 75 regions, 27, or 36%, are deemed as integrated with the national market; and there are 15 (20%) non-integrated regions having no trend to integration. The minimal *p*-value of the unit root test among regions for which the unit root is not rejected in model (7) or (7^*) equals 0.154. Thus, the results of testing can be believed as rather reliable in spite of low power of the unit root test.

Taking the structural break into account sufficiently increases the number of integrated regions: there are eight of them, for which the unit root being rejected in (7^*) is not rejected in (7). Recalling that the break dummy equals 1 before the period of break, and 0 since it, this implies that these regions became integrated since the break. Hence, the 1998 financial crisis facilitated price equalizing among Russian regions, so it improved the pattern of regional integration. There is the only opposite case, in Saint Petersburg City, where the unit root is rejected in (7), and is not in (7^*). The 1998 crisis caused persistent rise in prices there as compared to the average Russian price; thus it called forth non-integration with the national market.

Table 1. Summary of estimations and unit root tests

Region	Unit root test *p*-value	λ	γ	Structural break (γ_B)	δ
1. Rep. of Karelia	0.002	-0.423 (0.091)	0.186 (0.030)***		-0.011 (0.004)***
2. Rep. of Komi[d]	0.002	-0.439 (0.092)	0.005 (0.058)	0.227 (0.072)***	-0.017 (0.006)***
3. Arkhangelsk Obl.[d]	0.006	-0.428 (0.093)	0.195 (0.049)***	0.119 (0.039)***	-0.014 (0.003)***
4. Vologda Obl.	0.000	-0.347 (0.089)		-0.043 (0.010)***	
5. Murmansk Obl.	***0.154***	-0.013 (0.009)		-0.207 (0.036)***	
6. Saint Petersburg City	***0.299***	-0.028 (0.024)		-0.183 (0.036)***	
7. Novgorod Obl.	0.000	-0.677 (0.106)		-0.034 (0.007)***	
8. Pskov Obl.	0.015	-0.181 (0.069)		-0.088 (0.021)***	
9. Kaliningrad Obl.	0.009	-0.173 (0.063)		-0.125 (0.030)***	
10. Bryansk Obl.[a]	0.066	-0.274 (0.083)	-0.385 (0.108)***	0.147 (0.088)*	-0.018 (0.004)***
11. Vladimir Obl.	0.017	-0.175 (0.067)		-0.122 (0.018)***	
12. Ivanovo Obl.	0.001	-0.301 (0.084)		-0.090 (0.012)***	
13. Kaluga Obl.	0.035	-0.239 (0.073)	-0.236 (0.075)***		-0.042 (0.017)**
14. Kostroma Obl.	***0.300***	-0.078 (0.053)		-0.090 (0.028)***	
15. Moscow City[a]	***0.667***	-0.003 (0.013)		-0.070 (0.028)**	
16. Oryol Obl.	0.015	-0.328 (0.085)	-0.313 (0.029)***		-0.017 (0.003)***
17. Ryazan Obl.	0.011	-0.153 (0.060)		-0.083 (0.019)***	
18. Smolensk Obl.	0.000	-0.534 (0.101)	-0.090 (0.036)**	-0.133 (0.032)***	-0.009 (0.004)**
19. Tver Obl.	0.000	-0.344 (0.082)		-0.118 (0.013)***	
20. Tula Obl.	0.009	-0.299 (0.072)	-0.145 (0.053)***	-0.082 (0.044)*	-0.016 (0.005)***
21. Yaroslavl Obl.	0.000	-0.388 (0.088)		-0.077 (0.009)***	
22. Rep. of Mariy El	***0.330***	-0.014 (0.015)			
23. Rep. of Mordovia	***0.190***	-0.015 (0.014)		0.125 (0.039)***	
24. Chuvash Rep.[b]	***0.520***	-0.012 (0.018)		-0.070 (0.027)**	
25. Kirov Obl.	***0.271***	-0.050 (0.040)		-0.125 (0.030)***	
26. Nizhni Novgorod Obl.[c]	0.051	-0.129 (0.057)		-0.099 (0.024)***	
27. Belgorod Obl.	0.000	-0.470 (0.095)	-0.261 (0.027)***		-0.012 (0.003)***
28. Voronezh Obl.[a]	0.000	-0.524 (0.098)	-0.646 (0.142)***	0.249 (0.129)*	-0.029 (0.003)***
29. Kursk Obl.	0.000	-0.471 (0.097)	-0.245 (0.025)***		-0.015 (0.003)***
30. Lipetsk Obl.	0.002	-0.468 (0.095)	-0.391 (0.071)***	0.134 (0.059)**	-0.015 (0.003)***
31. Tambov Obl.[b]	0.004	-0.362 (0.082)	-0.176 (0.046)***	-0.068 (0.033)**	-0.007 (0.003)**
32. Rep. of Kalmykia[b]	0.000	-0.548 (0.103)	-0.045 (0.038)	-0.117 (0.037)***	-0.012 (0.005)**
33. Rep. of Tatarstan	0.000	-0.614 (0.101)	-0.363 (0.058)***	0.077 (0.045)*	-0.008 (0.002)***
34. Astrakhan Obl.	0.000	-0.701 (0.106)	-0.181 (0.020)***		-0.025 (0.005)***
35. Volgograd Obl.[d]	0.000	-0.354 (0.084)		-0.099 (0.015)***	
36. Penza Obl.	0.026	-0.279 (0.078)	-0.227 (0.027)***		-0.010 (0.003)**
37. Samara Obl.	0.000	-0.376 (0.087)			
38. Saratov Obl.	0.014	-0.316 (0.082)	-0.178 (0.035)***		-0.010 (0.005)**
39. Ulyanovsk Obl.	0.000	-0.577 (0.098)	-0.600 (0.068)***	0.152 (0.057)***	-0.013 (0.002)***
40. Rep. of Adygeya	0.000	-0.772 (0.108)	-0.366 (0.068)***	0.118 (0.059)**	-0.018 (0.003)***
41. Rep. of Dagestan	0.000	-0.574 (0.101)	-0.122 (0.023)***		-0.012 (0.005)**
42. Kabardian-Balkar Rep.	0.000	-0.231 (0.040)	-0.828 (0.079)***		-0.093 (0.017)***
43. Karachaev-Cirkassian Rep.	***0.158***	-0.080 (0.044)			
44. Rep. of Northern Ossetia	0.002	-0.445 (0.093)	-0.243 (0.032)***		-0.025 (0.005)***
45. Krasnodar Krai	0.000	-0.619 (0.105)	-0.430 (0.157)***	0.234 (0.140)*	-0.020 (0.005)***
46. Stavropol Krai	0.000	-0.554 (0.100)	-0.165 (0.016)***		-0.009 (0.003)***
47. Rostov Obl.	0.000	-0.679 (0.106)	-0.185 (0.012)***		-0.007 (0.002)***
48. Rep. of Bashkortostan[d]	0.003	-0.240 (0.073)		-0.126 (0.024)***	
49. Udmurt Rep.[c]	0.009	-0.185 (0.064)		-0.129 (0.022)***	
50. Kurgan Obl.[c]	0.004	-0.131 (0.042)		-0.099 (0.031)***	
51. Orenburg Obl.[b]	0.011	-0.167 (0.060)		-0.110 (0.040)***	
52. Perm Obl.	0.003	-0.372 (0.082)	0.160 (0.074)**		-0.084 (0.039)**
53. Sverdlovsk Obl.	0.020	-0.292 (0.081)	0.119 (0.044)***		-0.021 (0.012)*
54. Chelyabinsk Obl.	0.000	-0.698 (0.105)			

Table 1 (Continued)

Region	Unit root test *p*-value	λ	γ	Structural break (γ_B)	δ
55. Rep. of Altai	0.000	-0.401 (0.088)			
56. Altai Krai	***0.371***	-0.023 (0.024)		0.077 (0.039)*	
57. Kemerovo Obl.[e]	0.000	-0.310 (0.069)		0.038 (0.015)**	
58. Novosibirsk Obl.[e]	0.000	-0.306 (0.070)		0.033 (0.013)**	
59. Omsk Obl.[e]	0.000	-0.578 (0.101)	-0.910 (0.296)***	0.667 (0.282)**	-0.034 (0.005)***
60. Tomsk Obl.	0.000	-0.252 (0.071)			
61. Tyumen Obl.	0.019	-0.138 (0.056)		0.068 (0.024)***	
62. Rep. of Buryatia	0.003	-0.232 (0.073)		0.118 (0.022)***	
63. Rep. of Tuva	***0.228***	-0.073 (0.046)		0.118 (0.044)***	
64. Rep. of Khakasia[e]	0.010	-0.200 (0.068)		0.038 (0.018)**	
65. Krasnoyarsk Krai	0.008	-0.196 (0.066)		0.070 (0.026)***	
66. Irkutsk Obl.[f]	0.000	-0.342 (0.085)		0.147 (0.026)***	
67. Chita Obl.	0.001	-0.450 (0.091)	0.298 (0.076)***	0.106 (0.054)*	-0.012 (0.003)***
68. Rep. of Sakha (Yakutia)	***0.513***	-0.007 (0.013)			
69. Jewish Autonomous Obl.[f]	0.003	-0.422 (0.091)	0.183 (0.045)***	0.148 (0.035)***	-0.010 (0.003)***
70. Primorsky Krai	0.040	-0.282 (0.081)	0.545 (0.060)***		-0.008 (0.002)***
71. Khabarovsk Krai[d]	0.000	-0.571 (0.104)	0.298 (0.048)***	0.143 (0.034)***	-0.007 (0.002)***
72. Amur Obl.[c]	0.003	-0.216 (0.063)		0.170 (0.028)***	
73. Kamchatka Obl.[d]	***0.670***	-0.005 (0.014)		0.179 (0.063)***	
74. Magadan Obl.[d]	***0.347***	-0.008 (0.010)		0.155 (0.051)***	
75. Sakhalin Obl.[d]	***0.398***	-0.010 (0.014)		0.137 (0.055)**	

[a] Break in 1998:08; [b] Break in 1998:10; [c] Break in 1998:11; [d] Break in 1998:12; [e] Break in 1999:01; [f] Break in 1999:02. Not marked breaks are in 1998:09.

The structural break is not rejected for 23 of 27 integrated regions. Of them, 15 regions have an upward break, i.e., the crisis forced rise in relative prices in these regions. All of them are from the European part of Russia. For eight regions, all from the Asian part of Russia (Siberia and the Far East), the break is downward, implying decline in relative prices. The same pattern is valid for non-integrated regions (of which, the structural break is rejected only for three), with the only exception of the Republic of Mordovia. Thus, a consequence of the 1998 crises was coming prices in the Asian and European parts of Russia together, since prices in the former had been, as a rule, higher than in the latter before the crisis.

The number of regions deemed as tending to integration with the national market is 33, or 44% of the total. For the most part (24 regions of 33, or 73%), convergence is "upward", i.e., catching-up the average Russian level by regions with low prices. The lowest starting price level, 0.17 ($=1 + \gamma + \gamma_B$), among them has the Kabardino-Balkar Republic; the highest, 0.88, have the Republic of Dagestan. There are nine regions (or 27% of 33 regions) with "downward" convergence from the starting values of 1.12 in the Sverdlovsk Oblast and 1.54 in the Primorsky Krai as the low and high ends. All these are regions from the Northern Territory, Ural, Siberia, and the Far East. The only region with "upward" convergence on these territories is the Omsk Oblast (Western Siberia). The convergence speed expressed as a percentage (i.e., $|e^{\delta} - 1|$) varies from 0.7% (in the Tambov Oblast, Rostov Oblast, and Khabarovsk Krai) to 8.9% (in the Kabardino-

Balkar Republic) per month. Both values occur in regions with "upward" convergence; the range for "downward" convergence is 0.7% to 8.1%. There is strong positive correlation between the starting price gap, $|\gamma + \gamma_B|$, and the convergence speed in the case of upward convergence: the correlation coefficient equals 0.79. However, the pattern is reverse for the downward convergence: the greater the gap, the slower convergence; the correlation coefficient equals –0.52.

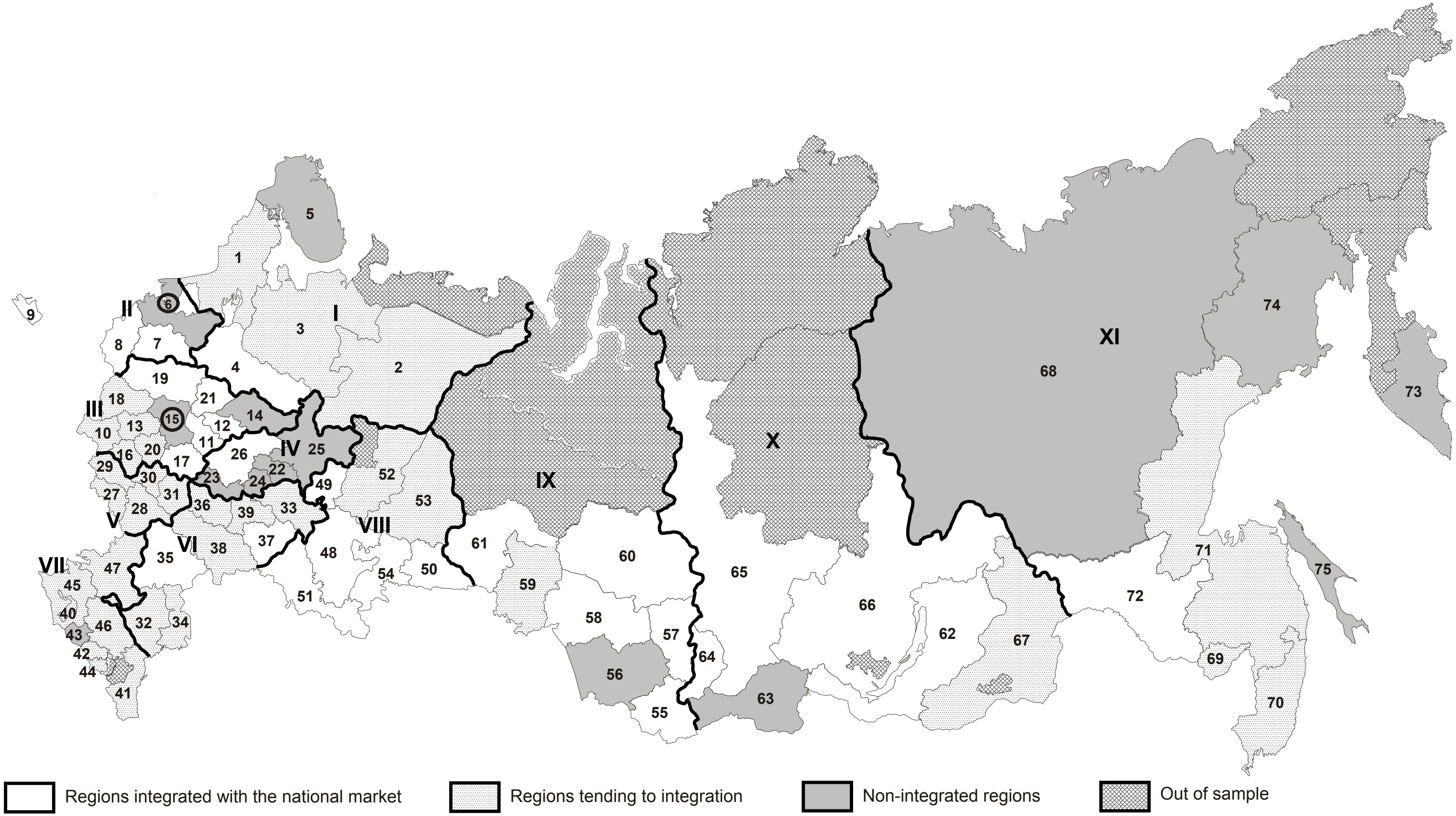
The structural break is rejected for about a half of regions tending to integration, namely, for 16, and is not for 17. The latter, in turn, are divided almost in half into those nine in which the break accelerated convergence (γ and γ_B have the same signs), having pushed prices towards the Russian average, and into eight regions where the break pushed prices away from the average Russian price (γ and γ_B with opposite signs), thus slowing convergence down. There are two regions, the republics of Komi and Kalmykia, with statistically insignificant γ, implying that prices there became near to the average Russian price since the break point on. Thus, these regions might be equally well classed as integrated.

Neglecting the structural break would markedly distort the pattern. There are 12 cases, where the break is spuriously treated as a trend in (5). Then the relevant regions would be deemed as tending to integration while they are, in fact, either integrated or non-integrated without a trend towards integration.

At last, there are 15, or 20% of the total, non-integrated regions having no trend to integration with the national market. While using models (7) and (7^*) augmented for the constant term, the unit root is not rejected only in two of these time series, namely, in those for the Magadan Oblast and the Sakhalin Oblast. This suggests that the reason of non-integration almost entirely is a constant nonzero difference of prices in a relevant region from the average Russian price rather than deterministic or stochastic price divergence. However, as discussed in Section 2.1, the existence of such a difference is taken as an indication of non-integration, since there is no way – in the context of the current analysis – to part irremovable price differences from removable ones caused by transitory impediments to integration.

Overall, the 1998 crisis strongly affected across-region price dynamics. Nevertheless, the behavior of prices remained intact in a number of regions; the break is rejected for 23 regions (31% of all the 75). In these regions, the crisis caused a price spike, after which relative prices returned to the previous trajectory.

The spatial pattern of market integration is presented in Figure 2.



For numerical designations of regions, see Table 1.

Thick lines are borders of economic territories, Roman numerals labelling the territories:

I Northern Territory	IV Volga-Vyatka Territory	VII North-Caucasian Territory	X Eastern-Siberian Territory
II Northwestern Territory	V Central Black-Earth Territory	VIII Ural Territory	XI Far-Eastern Territory
III Central Territory	VI Volga Region Territory	IX Western-Siberian Territory	

Figure 2. Geographical pattern of market integration

From this figure, about a half of non-integrated regions are seen to concentrate in Central Russia. (In particular, non-integrated are all but one regions of the Volga-Vyatka Territory.) The pattern is rather surprising, as these are small regions with relatively short distances between them; besides that, this part of the country has developed transport infrastructure. It can be surmised that it is the atomistic administrative-territorial division of Central Russia that causes market segmentation: the more regional borders and governors, the more possibilities to impede inter-regional trade and to diversify price policy across space. Curiously, the Ulyanovsk Oblast which maintained price regulations and subsidizing as long as up to the beginning of 2001 turns out to be tending to integration with the national market. The time series of Moscow prices has an "almost confident" unit root with its $\lambda = -0.003$. No correlation was found between non-integration and belonging to the "Red Belt" reported by Berkowitz and DeJong (1999), even in the European part of Russia.

On the other hand, non-integrated regions are few in number in Siberia and the Far East. This corroborates a finding by Gluschenko (2003) that the Asian part of Russia excluding difficult-to-access regions is more integrated than European Russia. Another evidence seen in Figure 2 is the fact that all difficult-to-access regions (the Murmansk, Magadan, Sakhalin, and Kamchatka *oblasts*, and the Republic of Yakutia) are not integrated with the national market, a result that could be expected. It also supports findings by Gluschenko (2003, 2004a) that these regions markedly contribute to the overall disconnectedness of regional markets.

In the full set of estimates, the unit root in (7) or/and (7^*) is rejected for 20 regions recognized as tending to integration. Thus, if the traditional approach to the time series analysis of integration were used, 47 regions, or 63%, would be classed as integrated with the national market, and 28 regions (37%) would fall into non-integrated ones.

Among all the 75 estimates of model (5), there are 13 non-subsiding trends ($\delta > 0$) implying divergence of prices, of which 10 have statistically insignificant δ, and two have insignificant factor γ. The only significant non-subsiding trend has Moscow. Taking account of the structural break, the number of positive estimates of δ increases to 20 in model (5^*), seven of them being for the same regions as in (5). Of these 20, 13 are insignificant, two are accompanied with non-rejection of the unit root in the model, and one is with insignificant factor $\gamma + \gamma_B$. This time, δ for Moscow turns out insignificant, but instead, there are four significant non-subsiding trends for other regions. For two of relevant regions, the unit root is rejected in (7^*), and then only two cases of price divergence remain. This pattern gives grounds to believe that the trend to convergence of prices is predominant in the Russian market.

Such a belief is supported by the dynamics of price dispersion plotted in Figure 3. The price dispersion is measured as σ_t, the standard deviation of prices normalized to the Russian average. The trajectory of σ_t demonstrates that price dispersion over all regions has been almost permanently decreasing, at least till the middle of 1999. This is a clear evidence of σ-convergence in 1994-2000, suggesting that the Russian market is moving towards integration.

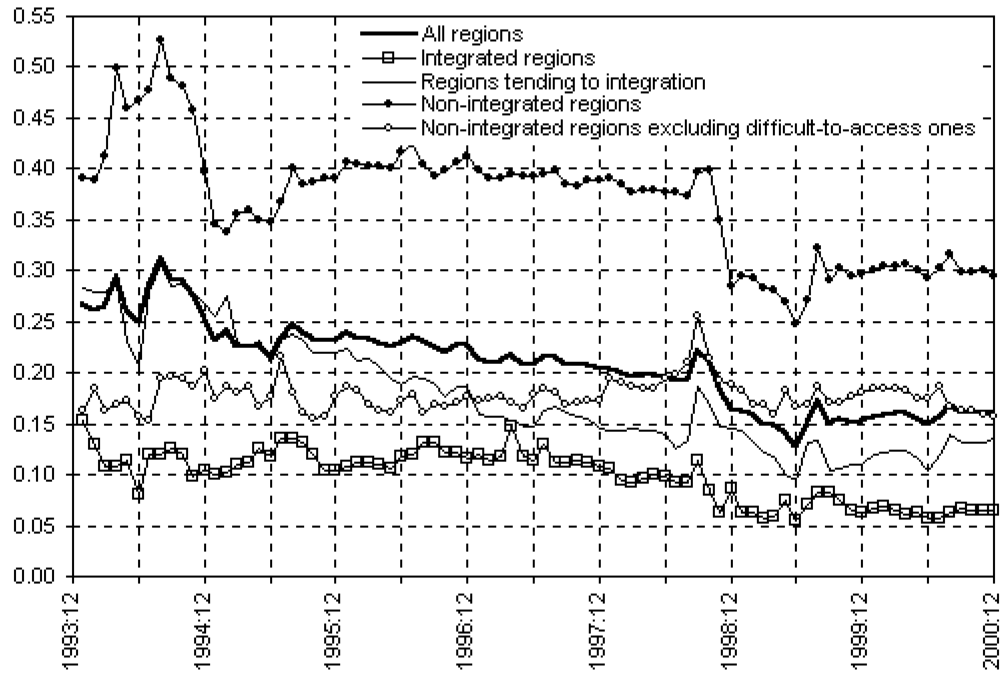


Figure 3. Standard deviations of the log relative cost of the 25-food basket

Additional trajectories for region groups provide insight into the pattern of changes in price dispersion. For comparability, standard deviations for region groups are computed with the use of the mean over all regions rather than that over a given group, i.e., price dispersion is measured relative whole of country; hence, it is not a within-group dispersion. With this, price dispersion over all Russian regions is a weighted average of group dispersions, $\sigma_t = (R_1/R)\sigma_{t1} + (R_2/R)\sigma_{t2} + (R_3/R)\sigma_{t3}$, the weight being the share of the group in the total number of regions (σ_{ti} denotes standard deviation of prices in region group i). The share of integrated regions is 0.36, that of non-integrated regions is 0.20, and that of regions tending to integration is 0.44.

The structural break caused by the August 1998 financial crisis is pronounced on the trajectories of σ. Its evident effect is reducing price dispersion. As expected, the main contribution to the decrease of price dispersion is due to regions tending to integration. Starting with σ roughly equaling that for the whole of the country in the beginning of the period, the gap between them quickly widens over time. For integrated regions, price dispersion is the lowest and is near-constant, fluctuating around the level of 0.11 before the 1998 crisis, and around the level of 0.07 since January 1999.

The most price dispersion is inherent in non-integrated regions. The trajectory for this group has the most pronounced structural break reducing the group σ by about a quarter. However, the main contribution to this is due to difficult-to-access regions. Being computed for non-integrated regions excluding difficult-to-access ones, the trajectory of σ appears to have no break. Contrary to the theoretical expectations this subgroup does not exhibit increasing price dispersion. The reason is the fact that there is almost no price divergence in the Russian market (indeed, the full set of estimates provide only two clear evidences of price divergence). Regions deemed as non-integrated are for the most part those having a persistent difference from the average Russian price, as mentioned above.

4. CONCLUSIONS

Using the cost of the basket of 25 basic food goods as the price representative, the spatial pattern and trends of market integration in Russia in 1994-2000 have been analyzed. The results obtained evidence poor market integration: with the strict law of one price as the benchmark, only about one third of Russian regions can be deemed as integrated with the national market. Nevertheless, encouraging evidence is found of trends towards more integration. About a half of Russian regions are classed with those tending to integration. Besides that, it is inconceivable that the obtained pattern of integration overstates shortcomings of the Russian market, ignoring such an irremovable market friction as spatial separation of regions.

Overall, the results unambiguously suggest that the Russian market has been moving towards integration. (An exception is the group of the difficult-to-access regions, which is hardly involved in this movement. However, the difficult access is one more 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.) More exactly, it moved until about the end of 1999. Then why it stopped? It seems that by that time price convergence in Russia completed, having reached a "natural" limit of market integration.

Reasoning from the *theoretical benchmark* of complete integration, the situation is not brilliant, as one fifth of regions neither are integrated nor tend to become such. But let us compare it with an actual benchmark: the United States, whose market is deemed to be the most integrated. Figure 4 provides such a comparison.

In this figure, the data on the 25-item basket are supplemented with the data on a new, 33-item basket, introduced since June 2000; the source of the data is Goskomstat (2000-2003). The costs of the baskets are normalized to the cost for Russia as a whole. Judging from the second half of 2000, for which data on both baskets are available, standard deviations of their costs, calculated over Russia without difficult-to-access regions, are close to one another. ACCRA (1994-2002) data on the relative (to the US average) costs of the 27-item grocery basket across about 300 US cities with quarterly frequency are used as a US price representative (see the source for the composition of the basket).

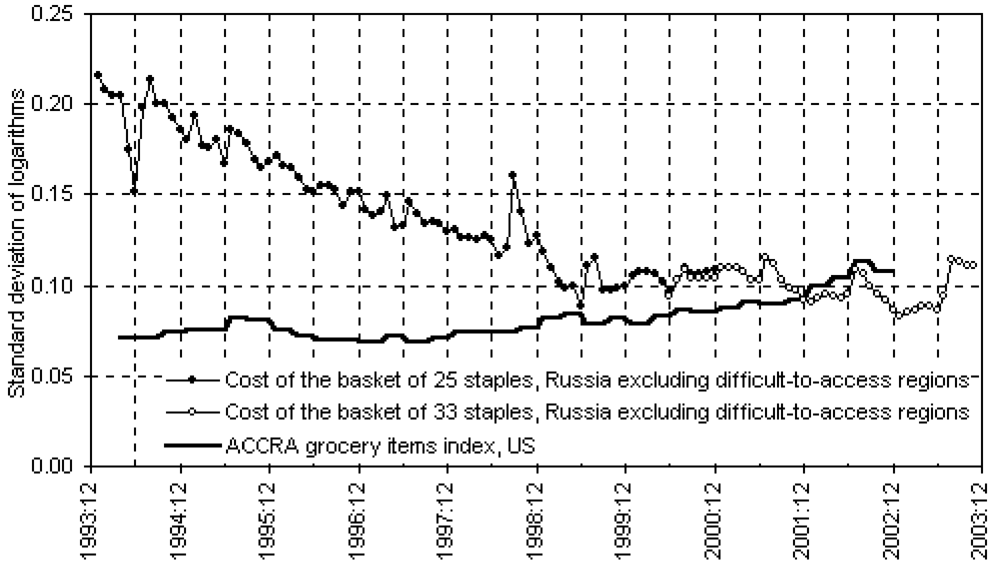


Figure 4. Price dispersion across Russia and the US

Firstly, the figure confirms the conclusion that price convergence in Russia is near to be completed: in recent years, price dispersion remains rather stable, fluctuating about the level of 0.1. And secondly – what is the most important thing – price dispersion across Russia in the last years is comparable with that across US.

This finding corroborates Shleifer and Treisman (2003) who conclude that by the late 1990s Russia has become a typical middle-income capitalist country. (As they write, “Russia’s economic and political systems remain far from perfect. However, their defects are typical of countries at its level of economic development”.) Moreover, regarding market integration, the behavior of the contemporary Russian economy is not far from that of the US economy.

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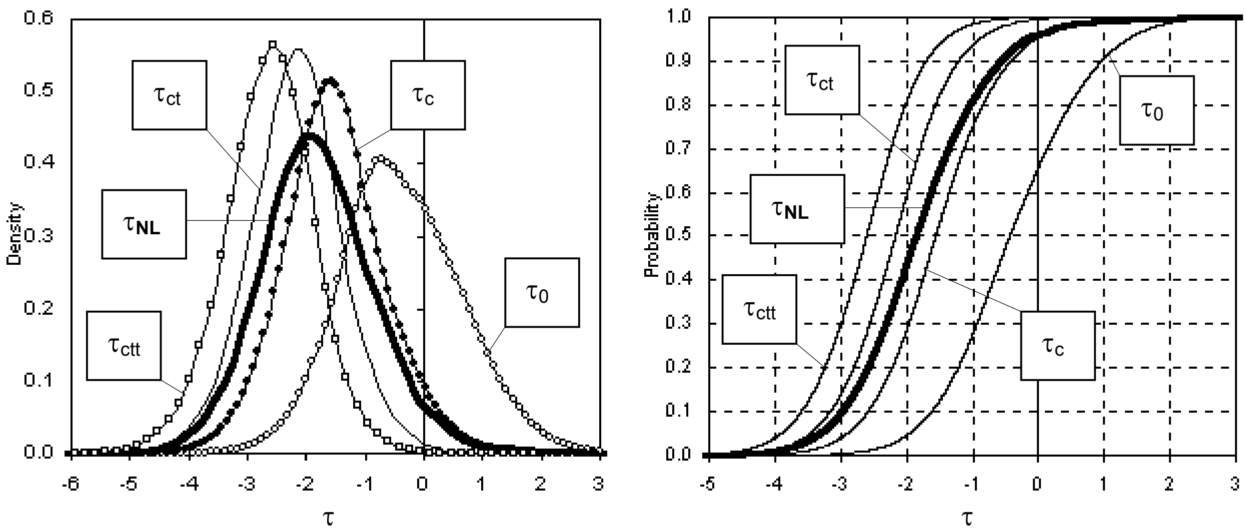
APPENDIX

Unit root test statistics for models with nonlinear trend and/or break

To obtain *p*-values of the *t*-ratio of λ that is used in the unit root test for Equation (5), the equation has been estimated over each of 500,000 simulated random walks with $t = 0,\ldots,83$, thus obtaining the empirical distribution of this *t*-ratio (referred to as τ_{NL}). Table A1 reports some critical values of these estimated statistics. For comparison, MacKinnon's (1996) values for the Dickey-Fuller regressions with no constant term, with constant, with constant and trend, and with constant, trend and trend squared (τ_0, τ_c, τ_{ct}, and τ_{ctt} statistic, respectively) for the sample size of 83 are reported as well.

Table A1. Critical values of the unit root test τ-statistics

Significance level	τ_{NL}	τ_0	τ_c	τ_{ct}	τ_{ctt}
0.1%	-4.820	-3.363	-4.251	-4.808	-5.258
1%	-3.963	-2.593	-3.511	-4.072	-4.516
5%	-3.310	-1.945	-2.897	-3.465	-3.906
10%	-2.978	-1.614	-2.586	-3.159	-3.598
20%	-2.585	-1.228	-2.223	-2.804	-3.242



(a) Probability densities (b) Cumulative distributions

Fig. A1. Distributions of τ-statistics

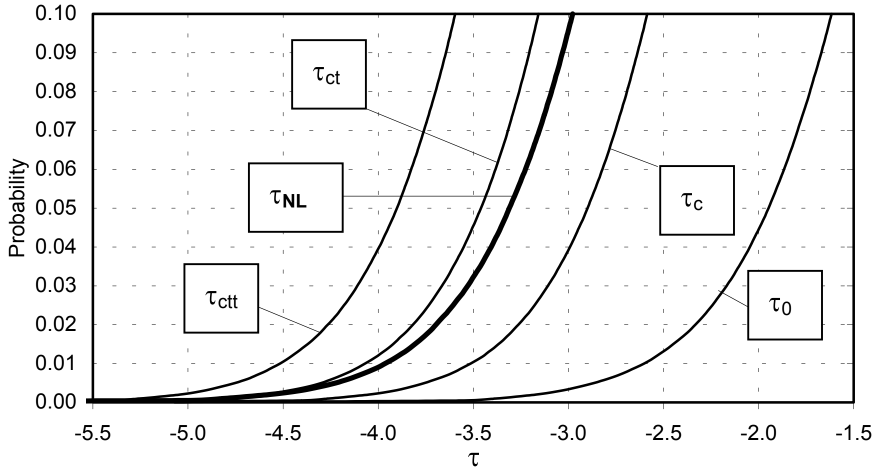


Fig. A2. Left-hand tails of cumulative distributions of τ-statistics

Empirical distributions for the case of structural break in time series have been computed in a similar way. Table A2 reports some critical values of these estimated statistics, denoted $\tau_{NL}(\theta)$ and $\tau_0(\theta)$, and Figure A3 demonstrates the left-hand tails of the their cumulative distributions. For comparison, selected τ-statistics from the above table are included.

Table A2. Critical values of the unit root test τ-statistics for models with structural break

Model with nonlinear tend and break (5*)									
Significance level	τ_{NL}	**$\tau_{NL}(\theta)$ with θ =**							τ_{ct}
		1998:08	**1998:09**	**1998:10**	**1998:11**	**1998:12**	**1999:01**	**1999:02**	
0.1%	-4.820	-4.853	-4.861	-4.875	-4.889	-4.882	-4.872	-4.872	-4.808
1%	-3.963	-4.034	-4.045	-4.052	-4.055	-4.064	-4.058	-4.065	-4.072
5%	-3.310	-3.357	-3.369	-3.372	-3.376	-3.379	-3.378	-3.381	-3.465
10%	-2.978	-3.017	-3.027	-3.030	-3.035	-3.036	-3.038	-3.039	-3.159
20%	-2.585	-2.622	-2.630	-2.633	-2.635	-2.638	-2.640	-2.641	-2.804
Model without trend and with break (7*)									
Significance level	τ_0	**$\tau_0(\theta)$ with θ =**							τ_c
		1998:08	**1998:09**	**1998:10**	**1998:11**	**1998:12**	**1999:01**	**1999:02**	
0.1%	-3.363	-3.639	-3.644	-3.644	-3.661	-3.655	-3.645	-3.673	-4.251
1%	-2.593	-2.720	-2.717	-2.728	-2.723	-2.732	-2.729	-2.742	-3.511
5%	-1.945	-1.976	-1.979	-1.979	-1.980	-1.982	-1.983	-1.986	-2.897
10%	-1.614	-1.621	-1.624	-1.624	-1.624	-1.627	-1.627	-1.628	-2.586
20%	-1.228	-1.221	-1.221	-1.222	-1.222	-1.223	-1.223	-1.222	-2.223

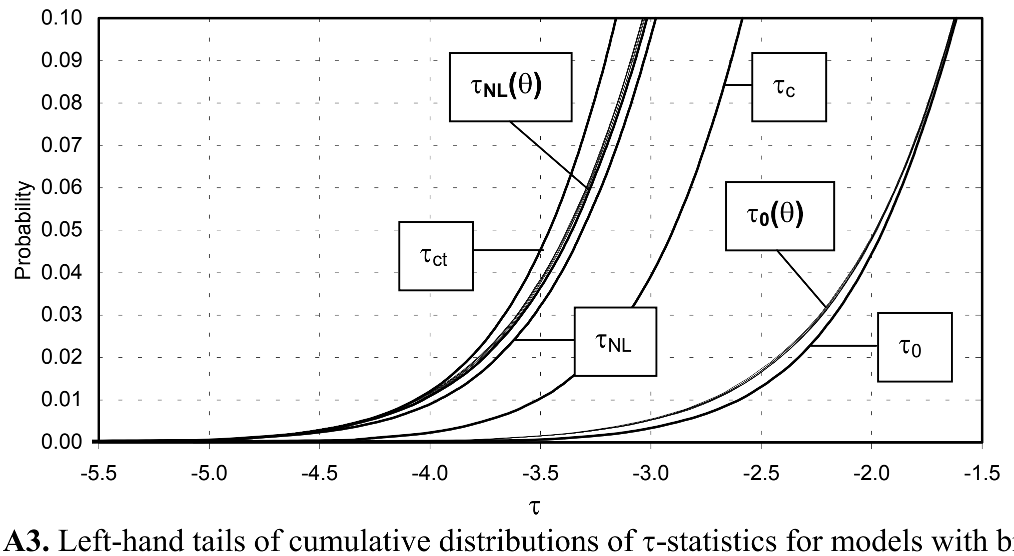


Fig. A3. Left-hand tails of cumulative distributions of τ-statistics for models with break

As could be expected, the cumulative distributions of τ for the model with break and without trend lie between those for the linear models without and with the constant term. With this, they are close the Dickey-Fuller distribution of τ_0. The distributions for the model with nonlinear trend and break lie to the left of that for the relevant model without break. They are rather close to the latter, and lie to the right of the distribution for the model with linear trend, except for low p-values (0.015 and lesser). In both cases, distributions for different break dates θ are very close to one another, and are hardly distinguishable in the figure.