Spatial pattern of Russia's market integration

Gluschenko, Konstantin

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

21 February 2017

Spatial pattern of Russia’s market integration

Konstantin Gluschenko
Novosibirsk State University;
Institute of Economics and Industrial Engineering of the Siberian Branch of the Russian Academy of Sciences,
pr. Lavrentieva 17, 630090 Novosibirsk, Russia.
Email: glu@nsu.ru

First version: February 2017
This version: August 2020

ABSTRACT
This paper studies integration of regional goods markets in Russia over 2001–2019, analyzing the law of one price. The analysis involves all pairs of country’s regions, which provides a comprehensive spatial pattern of market integration. The region pairs are classified as belonging to one of four groups: integrated, conditionally integrated, not integrated but tending towards integration (converging) and neither integrated nor tending towards integration (among these, diverging). On average, a region is found to be perfectly and conditionally integrated with 48.7% of other regions and tending towards integration with 3.3% of them. Non-integration is due to random walking (41.2%) and deterministic divergence (6.8%). Geographical reasons explain the pattern obtained only partially. Apparently, idiosyncratic features of regional markets play a main role in non-integration.

KEYWORDS
regional product market; law of one price; price convergence; nonlinear trend

JEL L81, R15, R19

INTRODUCTION

This study aims at obtaining a comprehensive pattern of integration of regional markets in Russia. Such a pattern reveals the role of every region of the country in integration, showing its relationship with each of other regions. Studies of this kind are very rare in the literature. In the case of Russia, the spatial pattern of integration is especially interesting, taking account of its vast territory (with the average distance between regions of 3,600 km, reaching circa 15,000 km between the extreme regions), diverse natural conditions of regions (from near-subtropical in the South-West to Arctic in the North), and poor transport accessibility of a number of regions (in the North-East of the country).

To be more specific, a definition of spatial market integration exploited in this study should be provided, since there is no generally accepted definition (Fackler & Goodwin, 2001; Barrett, 2008). Intuitively, a set of regional markets for a (tradable) good is integrated if there are no barriers to trade between regions, except for 'natural', geographically determined barriers, i.e. disconnectedness of regions (commonly quantified by transportation costs). In the integrated market, goods arbitrage results in spatial equilibrium that manifests itself in the law of one price. In its strict form, when transportation costs may be neglected (e.g., if they are very small as compared to the price of the good), the law states that the price of the same good should be equal across all regions. A weak version of the law takes account of 'natural' barriers to trade, allowing the price of the good to differ between two regions by no more than transportation costs. Thus, the law of one price can be applied as the criterion of market integration (which is a widespread methodology in studies of market integration). It is worth noting that direct trade between two regions is not necessary for them to be integrated; regional prices can interact indirectly through a trading network of regions (Fackler & Goodwin, 2001).

To obtain the comprehensive spatial pattern of integration, the law of one price is analyzed for every pair of Russian regions. Time series of regional prices for an aggregated good (staples basket) over 2001–2019 serve as empirical material. The analysis distinguishes among different 'grades' of market integration, classifying the region pairs as belonging to one of four groups.

The first one consists of perfectly integrated pairs, i.e. those where the strict law of one price holds. The second group comprises conditionally integrated pairs, where the weak law of one price holds. The regions in a pair could be acknowledged as integrated on condition that the difference in prices between them is due to transportation costs only. However, it can include also effects or ‘artificial’ impediments to integration, such as regional protectionism, local price regulations, organized crime, etc. Therefore, according to the above definition of market integration, the term ‘conditional integration’ is applied. The third group relates to a case that is intermediate between integration and non-integration. It includes region pairs tending towards integration. They are those where the law of one price does not hold (in either version), but regional prices converge to each other in the long run, eventually eliminating the price disparity. Note that this concept of convergence implies catching-up of prices, and not dying out of random deviations from the price parity, as not infrequently is meant in the literature. The movement towards integration is modelled by a nonlinear asymptotically decaying trend of price disparity. At last, the fourth group consists of neither integrated nor tending-towards-integration region pairs (among these, pairs with random walking and deterministic divergence are distinguished).

The results obtained suggest that 20.5% of region pairs are perfectly integrated, 28.2% of them are conditionally integrated, and 3.3% of pairs are tending towards integration. Non-integration is due to random walking (41.2%) and deterministic divergence (6.8%). These figures can be related to an average region, showing a proportion of other regions with which it is perfectly or conditionally integrated and so on. Further analysis reveals that although the role of distance in conditional integration prevails, ‘artificial’ impediments to integration (quantified by differences in markups) are not negligible, contributing on average 7.4% to the price differential in conditionally integrated pairs and decreasing the probability of perfect integration. However, the distance explains non-integration partially, in some subsamples of region pairs only. This leads to a conclusion that the reasons for non-integration are for the most part idiosyncratic.

Numerous publications analyze integration of intra-national product markets (not infrequently, represented by a set of cities rather than regions) by testing for the law of one price. However, as mentioned above, they very rarely deal with interaction of each region/city with other ones. The most probable reason is the dimensionality problem. To obtain a comprehensive spatial pattern of market integration, the law of one price should be tested for each pair of regions. The number of the pairs rises quadratically with the number of regions, N, equaling $N(N-1)/2$, which makes the analysis overly cumbersome.

One way to reduce dimensionality applied in the literature is the use of panel data analysis. Such an approach is exploited, e.g., by Parsley & Wei (1996) for the U.S., by Esaka (2003) for Japan, and by Horvath & Vidovic (2005) for Slovakia. They pool time series of the price for a given product across all regions into a data panel. This yields only a characterization of the country's market (for every product under consideration) as a whole with no spatial dimension.

Another way is to use some region/city as a benchmark, so reducing the number of pairs to $N - 1$. This method is applied, e.g., by Ceglowski (2003) for Canada, by Gluschenko (2011) for Russia, and by Iregui & Otero (2011) for Colombia. Such a method does provide a spatial pattern of market integration. However, it is only partial. It shows integration of the benchmark region with each of other regions, but is silent as to integration of these other regions with one another. A consequence is that the pattern obtained crucially depends on the choice of the benchmark (see, e.g., Chmelarova & Nath, 2010). A different version of this method exists, where the benchmark is the whole national market. In this case, the national price (weighted or unweighted average of regional prices) serves as the numeraire. This way is used, e.g., by Fan & Wei (2006) and Ritola (2008) for China, and by Akhmedjonov & Lau (2012) for Russia. Here, the results are difficult to interpret. Indeed, what is the intuitive sense of integration of a region with the whole national market?

A rare exception is an analysis performed by Yazgan & Yilmazkuday (2011), who analyze the law of one price for each pair of U.S. cities from their sample. Unfortunately, their results are reported in an overly summarized form, so that the spatial pattern is not seen in them.

This study contributes to the above literature in three aspects. First, it obtains a comprehensive pattern of intra-country market integration. Second, it considers, in addition to integration as such, convergence to integration, analyzing it in a straightforward way. Third, it tries to find factors responsible for the pattern obtained. The study also relates to work by Yilmazkuday (2018), analyzing the role of retail margins, albeit in a different way.

The rest of the paper proceeds as follows. The next section presents models exploited in the analysis and econometric strategy. The third section describes empirical data to be analyzed. The fourth section reports and discusses the results of the analysis. The fifth section compares results obtained with those for 1994–2000. The sixths section summarizes the study.

METHODOLOGY

Models

Let p_{rt} and p_{st} be prices for a tradable good in regions r and s (r, s = 1,…, N) at period t, $P_{rst} = \ln(p_{rt}/p_{st})$ being the price differential. It is worth noting that the use of the relative number as the price variable eliminates common factors from it (in particular, countrywide inflation).

The economic model of the strict law of one price looks like $p_{rt}/p_{st} = 1$ or $P_{rst} = 0$ for $t = 0,\ldots, T$ and a region pair (r, s). The law can hold only statistically in reality, accurate to random shocks ν_t supposed to be autocorrelated (to economize notation, the region indices for disturbances and model parameters are suppressed). Then the econometric model of the strict law of one price has the form $P_{rst} = \nu_t$, $\nu_t = (\lambda + 1)\nu_{t-1} + \varepsilon_t$, where $\lambda + 1 = \rho$ is the autoregression coefficient, and ε_t is the Gaussian white noise. Substituting the second equation into the first one gives the conventional AR(1) model with no constant:

$$\Delta P_{rst} = \lambda P_{rs,t-1} + \varepsilon_t, \quad (1)$$

where Δ is the first difference operator. The law of one price holds if time series P_{rst} is stationary (contains no unit root). In this case, regions r and s are deemed perfectly integrated with each other.

The weak law of one price can be modelled as $p_{rt}/p_{st} = 1 + c_{rs}$ or $P_{rst} = C_{rs} \equiv \ln(1 + c_{rs})$, where c_{rs} represents time-invariant arbitrage transaction costs (in percentage terms).[1] Based on the same considerations as above, we get from our model $P_{rst} = C_{rs}$ the conventional AR(1) model with constant $\gamma = -\lambda C_{rs}$:

$$\Delta P_{rst} = \gamma + \lambda P_{rs,t-1} + \varepsilon_t. \quad (2)$$

The weak law of one price holds if time series P_{rst} is stationary about a nonzero constant. In such an event, regions r and s are deemed conditionally integrated with each other. As noted in the introduction, they could be acknowledged as integrated on condition that the price disparity C_{rs} is due to transportation costs only. In the framework of time series analysis, it is impossible to reveal the nature of C_{rs}. (A cross-sectional analysis of estimates of C_{rs} in the fourth section confirms that not only transportation costs contribute to them.) As a rule, conventional definitions of market integration – sometimes, implicit – based of the law of one price do not limit barriers to trade to 'natural' barriers only (so differing from the definition stated in the introduction). Thus, there is no room for conditional integration under such definitions.

The movement towards integration implies convergence of prices (catching-up) between regions r and s. Following Gluschenko (2011), an asymptotically decaying trend $c_{rs}(t)$

[1] This is not a sole way to model the weak law of one price. An alternative version of the model is $\ln(1 - c_{rs}) \le P_{rst} \le \ln(1 + c_{rs})$ or, assuming the 'iceberg' representation of transaction costs, $-C_{rs} \le P_{rst} \le C_{rs}$. Econometrically, this leads to threshold autoregression models. For instance, O'Connell & Wei (2002) use two kinds of such models.

models convergence: $p_{rt}/p_{st} = 1 + c_{rs}(t)$ or $P_{rst} = C_{rs}(t) \equiv \ln(1 + c_{rs}(t))$, where $c_{rs}(t) \to 0$ as $t \to \infty$, and $d|c_{rs}(t)|/dt < 0$. This relationship is close to the definition of convergence suggested by Bernard & Durlauf (1995). However, such a concept of price convergence differs from that not infrequently used with regard to the law of one price. The concept adopted considers an actual convergence process as a superposition of two processes that can be called long-run, or deterministic, convergence and short-run, or stochastic, convergence. Long-run convergence is a deterministic path of the price disparity, $C_{rs}(t)$, that tends to zero over time. Short-run convergence is an autocorrelated stochastic process containing no unit root (i.e., a stationary process), $\nu_t = (\lambda + 1)\nu_{t-1} + \varepsilon_t$. Intuitively, short-run convergence characterizes the behavior of transient random shocks. A unit shock deflects the price disparity from its long-run path, dying out over time with half-life $\theta = \ln(0.5)/\ln(\lambda + 1)$, so that the price disparity eventually returns to its long-run path. The superposition of these two processes gives a process that is stationary around an asymptotically subsiding trend $C_{rs}(t)$. That is, albeit random shocks force the process to deviate from the trend, it permanently tends to return to the trend, thus satisfying the above condition ($C_{rs}(t) \to 0$ as $t \to \infty$). The following econometric model describes the superposition of the long-run and short-run convergences:

$$\Delta P_{rst} = C_{rs}(t) - (\lambda + 1)\cdot C_{rs}(t - 1) + \lambda P_{rs,t-1} + \varepsilon_t. \qquad (3)$$

It should be noted that Models (1) and (2) in fact also describe the superposition of a long-run path of the price differential and fluctuations around it. The difference is that the long-run paths are time-invariant: $C_{rs}(t) = 0$ in Model (1) and $C_{rs}(t) = -\gamma/\lambda$ in Model (2). Therefore, only short-run properties of adjustment towards the long-run path are of interest, hence the terms ‘convergence to the law of one price’ or simply ‘price convergence’ applied to such processes (e.g., Das & Bhattacharya, 2008, and Goldberg & Verboven, 2005, to name a few). The difference between such a concept of convergence and the concept exploited here is clearly seen from examples in the fourth section, comparing Figure 3(a)/(b) with Figure 3(c).

This study uses three modes of the convergence trend (as opposed to Gluschenko, 2011, where only the log-exponential trend is exploited). The first one is the log-exponential trend $C(t) = \ln(1 + \gamma e^{\delta t})$, $\delta < 0$; the second is the exponential trend $C(t) = \gamma e^{\delta t}$, $\delta < 0$; and the third is the fractional trend $C(t) = \gamma/(1 + \delta t)$, $\delta > 0$. The respective nonlinear econometric models have the forms:

$$P_{rst} = \ln(1 + \gamma e^{\delta t}) - (\lambda + 1)\cdot\ln(1 + \gamma e^{\delta(t-1)}) + \lambda P_{rs,t-1} + \varepsilon_t; \qquad (3a)$$

$$\Delta P_{rst} = \gamma e^{\delta t} - (\lambda + 1)\gamma e^{\delta(t-1)} + \lambda P_{rs,t-1} + \varepsilon_t; \qquad (3b)$$

$$\Delta P_{rst} = \frac{\gamma}{1+\delta t} - (\lambda+1)\frac{\gamma}{1+\delta(t-1)} + \lambda P_{rs,t-1} + \varepsilon_t \quad (3c)$$

Price convergence takes place if time series P_{rst} is stationary about one or more of these trends and parameter δ has the expected (for the given trend) sign. Then regions in the pair (r, s) are deemed to move towards integration with each other.

Similarly to the half-life time of random deviations from the long-run path, the semi-convergence time of the deterministic price disparity, Θ, can be defined as the time the disparity takes to halve. For the log-exponential trend, $\Theta = \ln(0.5)/\delta$; for the exponential trend, $\Theta = \frac{1}{\delta}\ln(\frac{\ln(0.5(e^{\gamma}+1))}{\gamma})$; and for the fractional trend, $\Theta = \frac{1}{\delta}(\frac{\gamma}{\ln(0.5(e^{\gamma}+1))} - 1)$. The initial (at $t = 0$) price disparity in real terms, $p_{r0}/p_{s0} - 1$, is γ in the log-exponential trend, and $e^{\gamma} - 1$ in the exponential and fractional trends.

The same models with 'wrong' signs of δ ($\delta > 0$ in the log-exponential and exponential trends, and $\delta < 0$ in fractional trend) characterize deterministic divergence. Its rate can be defined as the time the disparity takes to double; for example, it equals $\ln(2)/\delta$ for the log-exponential trend with $\delta > 0$.

If no one of Models (1)–(3) describes the behaviour of prices in region pair (r, s), the case at hand is a random walk. Such regions as well as diverging regions are deemed neither integrated nor tending towards integration with each other (hereafter, simply non-integrated regions for brevity).

With the econometric models in hand, it becomes possible to give a more evolved explanation of why the benchmark approach is not able to provide a comprehensive spatial pattern of market integration. In fact, only $N - 1$ of all region pairs are independent. From their time series, it is possible to generate the time series for any other region pair. Let r be a benchmark region. From P_{rst} and P_{rqt}, we can get P_{qst} as $P_{rst} - P_{rqt}$. Then, seemingly, the fact that regions s and q are perfectly integrated with the benchmark region – i.e. both P_{rst} and P_{rqt} satisfy Equation (1) – gives grounds to conclude that regions q and s are also perfectly integrated with each other. However, this is not the case, since autocorrelation of time series leads to non-transitivity of statistical inference. It is easily seen that subtraction of Equation (1) for P_{rqt} from that for P_{rst} does not yield a model of the form (1) for P_{qst} (unless estimates of λ for both P_{rst} and P_{rqt} are equal). Therefore, P_{qst} may satisfy any one of the above models or even no one. And vice versa, be P_{rst} and P_{rqt} unit root processes (random walks), P_{qst} might nonetheless manifest regularity of some form described by Models (1)–(3). The fourth section gives an actual example of non-transitivity.

Strategy of estimating and testing

If a time series P_{rst} satisfies more than one model from their set (1)–(3), the 'most proper' model is to be selected. Two approaches are possible, namely from general to specific and from specific to general. The general model in the set is Model (3). It encompasses the rest of models: imposing restriction $\delta = 0$ in $C(t)$, we get Equation (2), and $\gamma = 0$ produces Equation (1). Then the analysis of a time series goes from the general Equation (3) to Equation (2) and then to Equation (1), accepting the first significant model in this sequence.

Albeit the general-to-specific approach seems attractive from the theoretical point of view, the further analysis applies the specific-to-general approach, based on the following intuitive considerations. If a time series satisfies both Equations (1) and (2), it is reasonable to assume that although constant γ in Equation (2) is statistically significant, it is small and is caused by some accidental reasons (being a statistical artefact) rather than by properties of the process itself. Hence, it is logical to accept Model (1). Similarly, when a time series satisfies both Equations (2) and (3), the reason is a very weak trend, maybe, incidentally manifesting itself in the data. Hence, the model without trend, Model (2), should be accepted. A random inspection of some such cases has confirmed these assumptions. All three versions of Equation (3) are estimated for each region pair, selecting a version that provides the best fit (the minimal sum of squared residuals) if they turn out to be completive. The test for statistical significance of parameters γ and δ applies 10% as the critical level.

To test the unit root hypothesis, H_0: $\lambda = 0$ (against $\lambda < 0$), the augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test are applied. The hypothesis of non-stationarity H_0 is deemed rejected if both tests reject it at the level of 10%. The procedure of testing is as follows.

The ADF test uses an auxiliary regression with additional lags of the dependent variable: $\Delta P_{rst} = h(t) - (\lambda_0 + 1) \cdot h(t-1) + \lambda_0 P_{rs,t-1} + \sum_{m=1}^{M} \lambda_m \Delta P_{rs,t-m} + \varepsilon_t$, where $h(\cdot)$ is zero for Equation (1), a constant for Equation (2), and a trend $C(\cdot)$ for Equation (3). The choice criterion of optimal lag length $M = M^*$ is a modified Bayesian (Schwarz) information criterion with a sample-dependent penalty factor. This modification is due to Ng & Perron (2001), who find that the standard information criteria tend to select lag lengths that are generally too small for unit root tests to have good sizes. Besides, the effective number of observations is held fixed when estimating the auxiliary regression with different M (according to Ng & Perron, 2005).

Note that the auxiliary regression is merely technical: it serves only for obtaining the adjusted value of the test statistic. The estimates of λ and other regression parameters should be taken from the original regression. The literature on the law of one price (as well as on purchasing power parity) sometimes reports parameter estimates from the auxiliary regression. There are two arguments against this. First, it is the original regression, e.g., (1) or (2), that models the phenomena under consideration, and not the auxiliary regression. Second, parameter estimates should not depend on a test applied. Otherwise, we would have different values of them depending on whether the ADF test or, say, the PP test has been used.

The PP test applied exploits the OLS autoregressive spectral method (in doing so, the lag length selection is the same as described above for the ADF test). As Perron & Ng (1996) find, this make it possible to avoid size distortions that arise because of the use of kernel-based spectral density estimators.

The above testing procedure is more severe in rejecting the unit root hypothesis than commonly used procedures. First, the both applied tests should agree to the rejection.[2] Second, the use of the sample-adjusted information criterion in the ADF test leads to less frequent rejection of nonstationarity than in the case of the standard information criteria. Third, the application of the autoregressive spectral density estimator in the PP test, as opposed to kernel-based estimators commonly used, also gives less frequent rejection of nonstationarity. Gluschenko (2011) applies simultaneous rejection of the unit root hypothesis by the ADF and PP tests, however, exploiting the standard Schwarz criterion in the former and the Bartlett spectral kernel in the latter.

DATA

The Russian Federation consists of constituent units (republics, *oblasts*, one autonomous *oblast*, *krais*, autonomous *okrugs*, and federal cities) termed federal subjects. Despite different designations, all these are equal in legal terms. In this study, a federal subject (including federal cities of Moscow and Saint Petersburg) is meant by a region, 'composite' federal subjects (that include autonomous *okrugs*) being considered as single regions. The spatial

[2] Yazgan & Yilmazkuday (2011) use even seven unit root tests; however, they do not require them to be in agreement, separately reporting summarized results of applying each test.

sample covers 79 regions, all Russia's regions – as of 2001 – but the Chechen Republic that lacks full time series. They generate 3081 region pairs.

The empirical data to be analyzed relate to an aggregated good, a staples basket comprising 33 basic foods. This basket was introduced by the Russian statistical agency as the standard since June 2000. The monthly cost of the staples basket by region is used as a price representative. Table 1 reports the composition of the basket.

Table 1. Composition of the staples basket.

Good	Unit of measure	Quantity
Bread, white and rye-wheat	kg	9.583
White bread	kg	6.250
Wheat flour	kg	1.667
Rice	kg	0.417
Millet	kg	0.500
Peas and beans	kg	0.608
Vermicelli	kg	0.500
Potatoes	kg	12.500
White cabbages	kg	2.917
Cucumbers	kg	0.150
Carrots	kg	2.917
Onions	kg	1.667
Apples	kg	1.550
Sugar	kg	1.667
Candies	kg	0.058
Cookies	kg	0.058
Beef	kg	1.250
Mutton	kg	0.150
Pork	kg	0.333
Chicken	kg	1.167
Frozen fish	kg	1.167
Salted herring and the like	kg	0.058
Milk	litre	9.167
Sour cream	kg	0.150
Butter	kg	0.150
Cottage cheese	kg	0.833
Cheese	kg	0.208
Eggs	piece	15
Margarine	kg	0.500
Sunflower oil	kg	0.583
Salt	kg	0.304
Black tea	kg	0.042
Black pepper	kg	0.061

Source: Rosstat (2006, p. 161)

The price data cover January 2001 to December 2019 (228 time observations); their source is EMISS (2020a). Quantities in the staples basket are uniform across regions and invariant in time. This makes the cost of the basket to be comparable across regions and over time.[3] A similar basket (of 25 foods, though) was also used, e.g., by Berkowitz & DeJong (2001, 2005) for analyzing marker integration in Russia in the 1990s.

Figure 1 reports summary statistics – the mean $\overline{P}_t$ and standard deviation σ_t – of the price differentials over the time span under consideration. As the sign of the price differential depends on the (arbitrary) order of regions in their pair, the summary statistics are computed with the absolute values of the price differentials: $\overline{P}_t = \frac{2}{N(N-1)} \sum_{r=1}^{N-1} \sum_{s=r+1}^{N} |P_{rst}|$,

$$\sigma_t = \left(\frac{2}{N(N-1)} \sum_{r=1}^{N-1} \sum_{s=r+1}^{N} (|P_{rst}| - \overline{P}_t)^2 \right)^{1/2} .$$

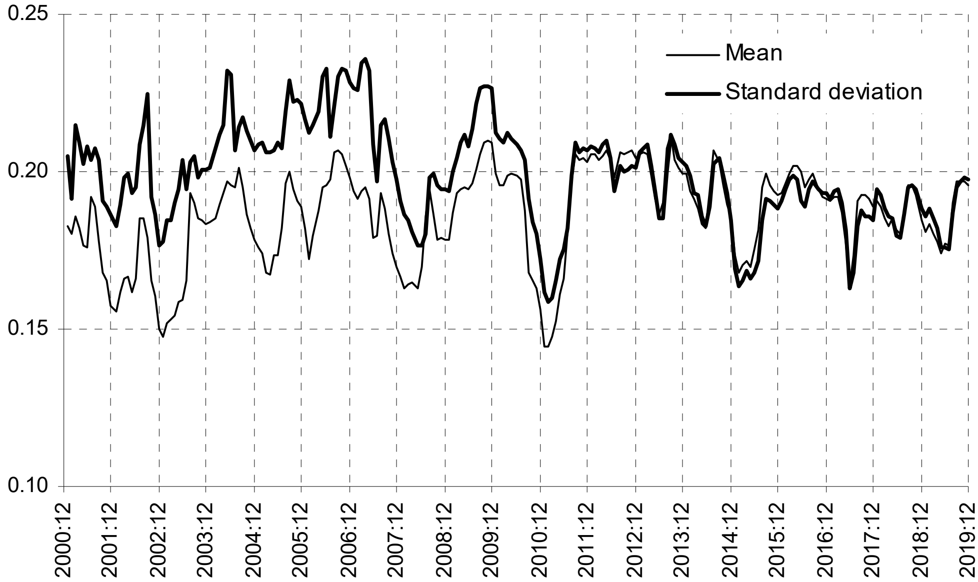


Figure 1. Summary statistics of absolute price differentials.

The statistics depicted in Figure 1 give an idea of price dispersion in the Russian

[3] This is not the case for a different kind of aggregated good, namely, baskets for computing regional consumer price indices (CPI), that are employed by some authors for analyzing the law of one price (to name a few, Cecchetti *et al.*, 2002, use CPIs across U.S. cities, Liu *et al.*, 2018, use CPIs across Chinese provinces, and Das & Bhattacharta, 2008, use CPIs across Indian cities). The point is that the CPI weighting schemes may vary across regions (so making commodity baskets to be region-specific) and change from time to time (e.g., the weights in the Russian regional CPIs change yearly).

spatial market. As it is seen, the price dispersion is highly volatile with dramatic fluctuations; the maximum to minimum ratio equals almost 1.5 for both mean and standard deviation. This was due to relatively high inflation that greatly varied across regions. In December 2019, the national average cost of the staples basket became 418.7% higher than in January 2001; the rise in the regional costs ranged from 227.5% to 437.6%. Over time, the mean of the absolute price differential tends to increase, while its standard deviation tends to decrease. Assuming a linear trend, the former rises by 0.48% per year, and the latter falls by 0.60% per year.

Price distributions give one more summary view on the data. Figure 2 shows distribution of the basket cost relative to the national average (p_{rt}/p_{0t}, where 0 stands for Russia as a whole) for the initial and final years of the time span under consideration. The costs are the averages over the respective years.

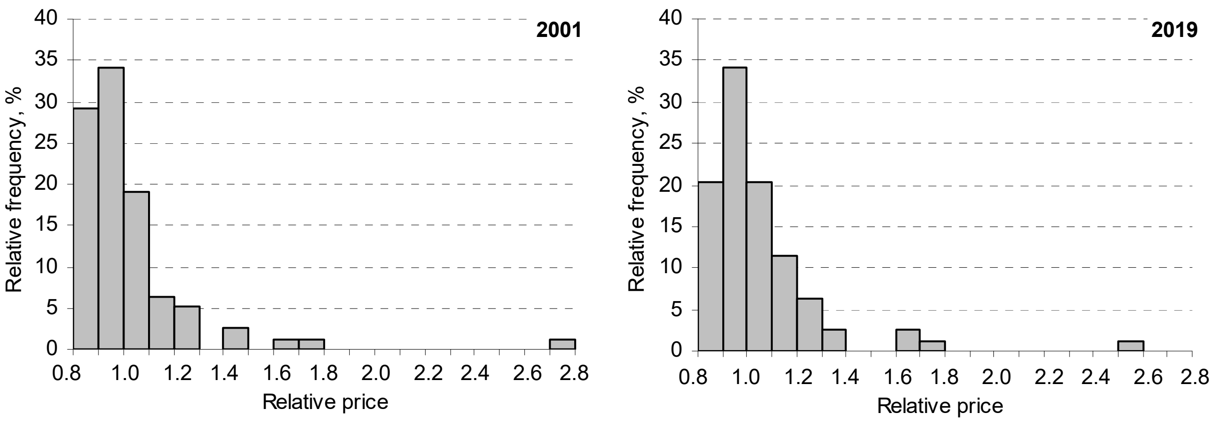


Figure 2. Distribution of the cost of staples basket.

Both realizations of the distribution evidence the absence of convergence clubs. A test for multimodality (Fischer, Mammen & Marron, 1994) corroborates this impression, rejecting the hypothesis of more than one mode with confidence for every out of 19 years. The right-hand tail of the distribution – starting from relative price 1.3 – is due to some regions from the Russian Far East (the rightmost histogram bar represents the Chukotka Autonomous Okrug, the most remote region of the country). Isolated histogram bars in this part of the distribution are a kind of outliers rather than modes.

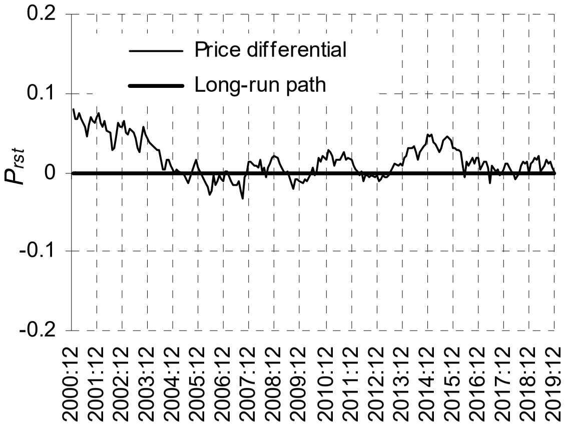
Comparing 2001 and 2019, the change in the shape of the price distribution is moderate; the mean increases from 1.025 to 1.051, while the standard deviation decreases from 0.261 to 0.247 (note that these statistics relate to prices themselves, and not to price differentials as in Figure 1). The largest change occurred among the ‘cheapest’ regions (with the relative price below 0.9): 7 regions left this group. However, the neighborhood of the national average, 0.9–1.1 changed only slightly, increased by one region. The most increase, 4 regions, occurred in the group 1.1–1.2. Hence, a prevailing tendency was that of rise in relative prices. Some decline in relative prices took place as well, though, e.g., the most expensive region, Chukotka, shifted by two positions in the direction of lower prices. Thus, it is possible that price convergence and divergence take place in some spatial parts of the Russian market. This makes analyzing only the state of integration with Models (1) and (2) insufficient, which motivates the use of modelling transitional processes.

EMPIRICAL RESULTS

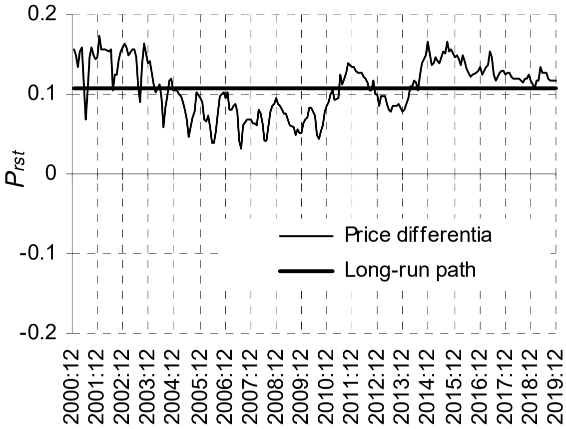
Before presenting the full results, it is instructive to look at examples of specific region pairs belonging to each of four groups: perfectly integrated, conditionally integrated, tending towards integration, and non-integrated. Figure 3 illustrates these, depicting the actual evolutions of the price differential vs. their theoretical long-run paths.

Figure 3 clarifies econometric considerations from the second section. Figure 3(a) relates to regions that are perfectly integrated with each other. Model (1) holds for this pair; the price differential fluctuates around the price parity. Deviations from the parity have the half-life time θ = 11.2 months. Figure 3(b) shows a conditionally integrated pair that satisfies Model (2). Here, the price differential fluctuates around constant disparity of 11.2% (in real terms) with θ = 6.9 months. Regions in Figure 3(c) are moving towards integration with each other. This pair satisfies Model (3c) with $C(t) = 0.321/(1 + 0.012t)$. The price differential fluctuates around this long-run path with θ = 4.2 months and diminishes, halving deterministically every 6 years (Θ = 71.9 months).

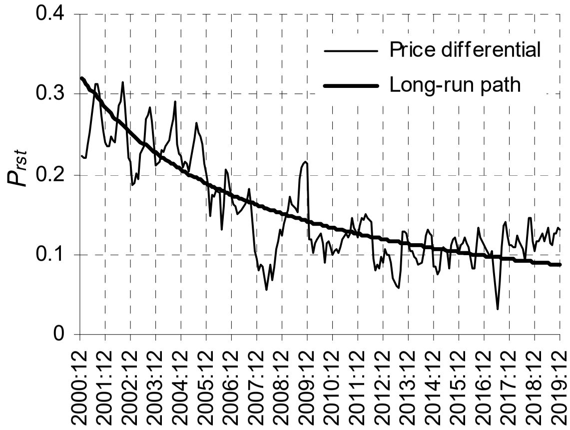
The lower panel of Figure 3 illustrates two cases of non-integration. No one model describes the behaviour of the price differential in Figure 3(d); it has no long-run path, being a random walk. Non-integration of the region pair in Figure 3(e) is due to deterministic price divergence. Model (3a) with $C(t) = 0.072e^{0.002t}$ describes the long-run behaviour of the price differential. The differential fluctuates around this rising trend with θ = 2.7 months; its deterministic part doubles every 26 years (314.4 months). Albeit there are more impressive examples of price divergence, the region pair in Figure 3(e) is selected to show the case of non-transitivity. This pair involves the same regions as in Figures 3(a) and 3(b), being the difference of region pairs in these figures. Then, seemingly, it would have to satisfy Model (2); however, it does not, actually obeying to Model (3) with a diverging trend.



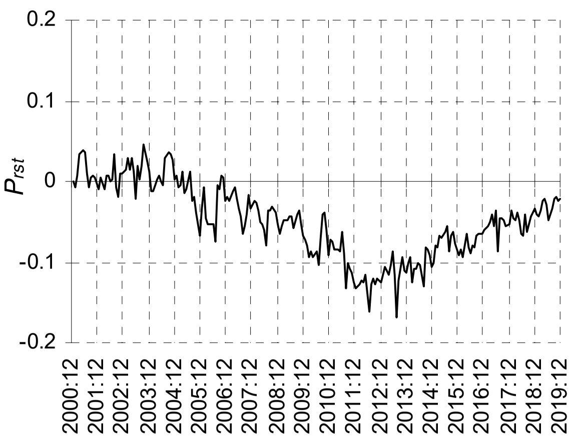
(a) Perfect integration:
St. Petersburg City – Leningrad Oblast



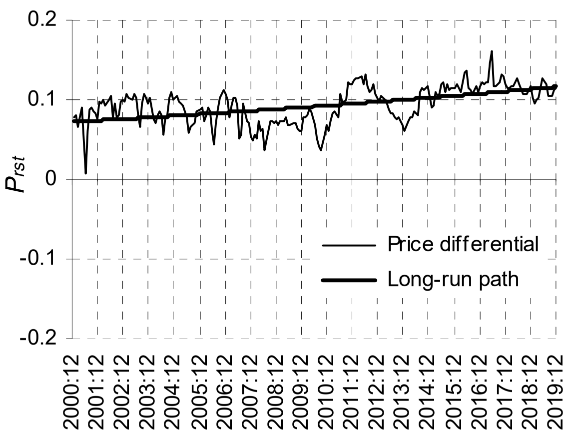
(b) Conditional integration:
St. Petersburg City – Novgorod Oblast



(c) The movement towards integration (convergence):
Tyumen Oblast – Novosibirsk Oblast



(d) Non-integration with random walking:
Omsk Oblast – Altai Krai



(e) Non-integration with divergence:
Leningrad Oblast – Novgorod Oblast

Figure 3. Examples of different types of region pairs.

Table 2 tabulates the results of the analysis across all region pairs in a summarized form

Table 2. Results of the analysis: the pattern of Russia's market integration, %.

Region	Perfect-integration rate	Conditional-integration rate	Convergence rate	Non-integration / Divergence rate
European part of Russia				
1. Rep. of Karelia	16.7	28.2	3.8	51.3 / 9.0
2. Rep. of Komi	14.1	37.2	2.6	46.2 / 2.6
3. Arkhangelsk Obl.	12.8	11.5	2.6	73.1 / 12.8
4. Vologda Obl.	16.7	26.9	2.6	53.8 / 1.3
5. Murmansk Obl.	11.5	28.2	2.6	57.7 / 5.1
6. St. Petersburg City	10.3	15.4	2.6	71.8 / 19.2
7. Leningrad Obl.	15.4	25.6	1.3	57.7 / 28.2
8. Novgorod Obl.	23.1	23.1	5.1	48.7 / 10.3
9. Pskov Obl.	20.5	7.7	2.6	69.2 / 6.4
10. Kaliningrad Obl.	15.4	35.9	0.0	48.7 / 7.7
11. Bryansk Obl.	25.6	12.8	3.8	57.7 / 1.3
12. Vladimir Obl.	28.2	17.9	1.3	52.6 / 2.6
13. Ivanovo Obl.	21.8	16.7	2.6	59.0 / 3.8
14. Kaluga Obl.	15.4	7.7	3.8	73.1 / 1.3
15. Kostroma Obl.	35.9	29.5	1.3	33.3 / 6.4
16. Moscow City	11.5	10.3	1.3	76.9 / 3.8
17. Moscow Obl.	25.6	21.8	1.3	51.3 / 2.6
18. Oryol Obl.	32.1	24.4	1.3	42.3 / 2.6
19. Ryazan Obl.	30.8	30.8	0.0	38.5 / 14.1
20. Smolensk Obl.	17.9	24.4	1.3	56.4 / 3.8
21. Tver Obl.	21.8	30.8	0.0	47.4 / 5.1
22. Tula Obl.	23.1	14.1	1.3	61.5 / 1.3
23. Yaroslavl Obl.	23.1	24.4	6.4	46.2 / 9.0
24. Rep. of Mariy El	26.9	39.7	0.0	33.3 / 2.6
25. Rep. of Mordovia	16.7	19.2	0.0	64.1 / 32.1
26. Chuvash Rep.	19.2	44.9	3.8	32.1 / 6.4
27. Kirov Obl.	24.4	21.8	1.3	52.6 / 20.5
28. Nizhni Novgorod Obl.	25.6	33.3	1.3	39.7 / 6.4
29. Belgorod Obl.	19.2	33.3	0.0	47.4 / 24.4
30. Voronezh Obl.	38.5	39.7	0.0	21.8 / 6.4
31. Kursk Obl.	10.3	5.1	0.0	84.6 / 10.3
32. Lipetsk Obl.	10.3	32.1	0.0	57.7 / 14.1
33. Tambov Obl.	16.7	34.6	2.6	46.2 / 0.0
34. Rep. of Kalmykia	15.4	6.4	6.4	71.8 / 0.0
35. Rep. of Tatarstan	17.9	20.5	2.6	59.0 / 3.8
36. Astrakhan Obl.	15.4	15.4	3.8	65.4 / 5.1
37. Volgograd Obl.	23.1	16.7	0.0	60.3 / 7.7
38. Penza Obl.	16.7	25.6	0.0	57.7 / 14.1
39. Samara Obl.	25.6	10.3	7.7	56.4 / 6.4
40. Saratov Obl.	12.8	9.0	0.0	78.2 / 10.3

Region	Perfect-integration rate	Conditional-integration rate	Convergence rate	Non-integration / Divergence rate
41. Ulyanovsk Obl.	21.8	17.9	2.6	57.7 / 1.3
42. Rep. of Adygeya	20.5	11.5	1.3	66.7 / 1.3
43. Rep. of Dagestan	20.5	7.7	5.1	66.7 / 1.3
44. Rep. of Ingushetia	57.7	17.9	1.3	23.1 / 9.0
45. Kabardian-Balkar Rep.	26.9	26.9	3.8	42.3 / 5.1
46. Karachaev-Cirkassian Rep.	24.4	23.1	3.8	48.7 / 1.3
47. Rep. of Northern Ossetia	16.7	17.9	2.6	62.8 / 1.3
48. Krasnodar Krai	20.5	19.2	1.3	59.0 / 12.8
49. Stavropol Krai	25.6	14.1	1.3	59.0 / 0.0
50. Rostov Obl.	25.6	20.5	1.3	52.6 / 1.3
51. Rep. of Bashkortostan	26.9	33.3	6.4	33.3 / 5.1
52. Udmurt Rep.	29.5	34.6	0.0	35.9 / 5.1
53. Kurgan Obl.	25.6	29.5	9.0	35.9 / 9.0
54. Orenburg Obl.	21.8	39.7	0.0	38.5 / 1.3
55. Perm Krai	26.9	29.5	0.0	43.6 / 7.7
56. Sverdlovsk Obl.	21.8	28.2	5.1	44.9 / 9.0
57. Chelyabinsk Obl.	37.2	33.3	0.0	29.5 / 6.4
Asian part of Russia				
Siberia				
58. Rep. of Altai	17.9	14.1	1.3	66.7 / 6.4
59. Altai Krai	34.6	20.5	7.7	37.2 / 2.6
60. Kemerovo Obl.	35.9	38.5	2.6	23.1 / 3.8
61. Novosibirsk Obl.	15.4	25.6	1.3	57.7 / 7.7
62. Omsk Obl.	29.5	44.9	0.0	25.6 / 2.6
63. Tomsk Obl.	24.4	47.4	1.3	26.9 / 6.4
64. Tyumen Obl.	10.3	29.5	20.5	39.7 / 2.6
65. Rep. of Buryatia	33.3	35.9	3.8	26.9 / 1.3
66. Rep. of Tuva	39.7	21.8	2.6	35.9 / 2.6
67. Rep. of Khakasia	19.2	41.0	1.3	38.5 / 3.8
68. Krasnoyarsk Krai	16.7	34.6	3.8	44.9 / 6.4
69. Irkutsk Obl.	34.6	51.3	3.8	10.3 / 1.3
70. Transbaikal Krai	21.8	55.1	3.8	19.2 / 9.0
Russian Far East				
61. Rep. of Sakha (Yakutia)	0.0	73.1	1.3	25.6 / 19.2
72. Jewish Autonomous Obl.	9.0	73.1	2.6	15.4 / 3.8
73. Chukotka AO	0.0	64.1	21.8	14.1 / 0.0
74. Primorsky Krai	3.8	26.9	1.3	67.9 / 5.1
75. Khabarovsk Krai	1.3	55.1	1.3	42.3 / 14.1
76. Amur Obl.	19.2	42.3	3.8	34.6 / 5.1
77. Kamchatka Krai	1.3	26.9	42.3	29.5 / 0.0
78. Magadan Obl.	1.3	64.1	0.0	34.6 / 23.1
79. Sakhalin Obl.	0.0	24.4	5.1	70.5 / 0.0
Total	20.5	28.2	3.3	48.0 / 6.8

Notes: Obl. stands for Oblast, Rep. stands for Republic, and AO stands for Autonomous Okrug. Percentages may not sum up to 100% due to rounding.

. For each region, Table 2 reports the percentages of the rest 78 regions with which this region is perfectly integrated, conditionally integrated, tending towards integration, and not integrated (referred to as respective rates). The non-integration rate is the total percentage of randomly walking and diverging regions; the percentage of the latter is also reported. The last line in the table reports the total percentages of region pairs (among all 3081 pairs); alternatively, they represent averages over all regions.

Among all region pairs, 48.7% are perfectly or conditionally integrated. Adding pairs tending towards integration, we get the total of 52.0%. Comparison of the first figure with results reported by Yazgan & Yilmazkuday (2011, Table 1) suggests that the degree of product market integration in Russia can be deemed fairly satisfactory, being comparable with that in the U.S. These authors analyze the law of one price across 1326 pairs of U.S. cities, applying a model of the form (2). In our terms, this means both perfect and conditional integration. They use seven unit root tests. Across these, the percentage of stationary price differentials for non-perishable goods is found to be 60% to 87.2% at the 10% significance level. Obviously, if the condition of simultaneously rejecting the unit root hypothesis by all tests were imposed (as it is done here), the resulting percentage would be surely less than 60%. On the other hand, as it is noted in the second section, the analysis performed bases on fairly 'tough' methods of unit root testing. Be 'softer' methods applied (even with the agreed-upon rejection of unit roots by the both tests), the share of perfectly and conditionally integrated region pairs in Russia would be found to equal 73.0% (see Table 8 in the fifth section).

Given long distances between many regions of Russia, price disparities should contain significant contributions of transportation costs. Hence, it is reasonable to expect conditional integration to prevail. This is, indeed, the case; the number of conditionally integrated region pairs is greater by the factor of circa 1.4 than the number of perfectly integrated ones. Figure 4 plots distributions of perfect-integration rates as well as the total of perfect- and conditional-integration rates.

The leftmost histogram bar in Figure 4(a) suggests that 8.9% of regions (7 regions out of 78) are perfectly integrated with less than 5% of other regions. Among them, three regions are perfectly integrated with none other region. The most frequent case is perfect integration with 15% to 20% of other regions; there are 25.3% of such cases. No one region is perfectly integrated with more that 60% (exactly, 57.7%) of other regions. Turning to the sum of perfectly and conditionally integrated regions, Figure 4(b), the 'worst' case is integration with 15% to 20% of other regions. Hence, there are no regions without conditional integration with other regions. The maximum is integration with 85.9% of regions. (Note that each region is herein taken twice, in pairs (*r, s*) and (*s*, *r*); that is why this value exceeds the total percentage of perfectly and conditionally integrated pairs in Table 2.) The most frequent case, 15.2%, is perfect and conditional integration with 35% to 40% of other regions. Specific regions that determine the leftmost and rightmost bars in these and next histograms will be specified below.

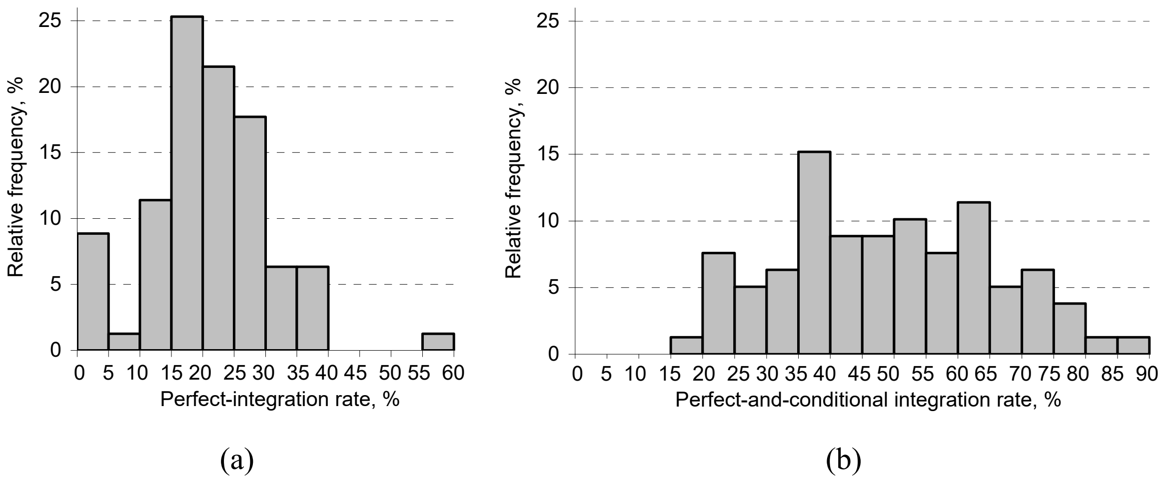


Figure 4. Distributions of the integration rates.

Processes of price convergence, i.e. the movement towards integration, do take place in the Russian market. However, they are rather rare, occurring only in 3.3% of all region pairs. Figure 5 plots the distribution of convergence rate. Most of cases concentrate in the interval of 0% to 5%, making up 83.5%. Out of them, 22.8% of regions do not move towards integration with other regions, and 27.8% of regions converge with a sole region.

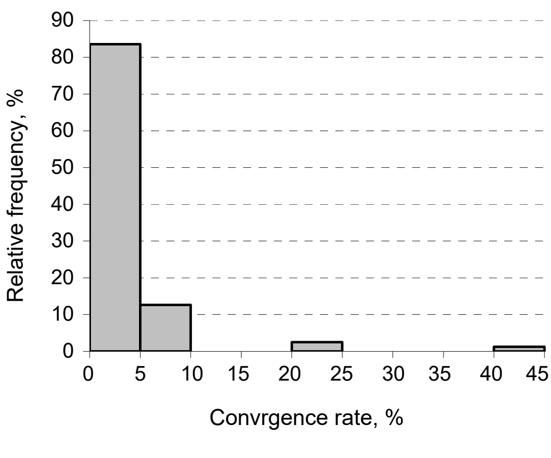


Figure 5. Distribution of convergence rate.

Figure 6(a) plots the distribution of non-integration rate (including divergence). It evidences that in the best case, a region is not integrated with 9 other regions (10.3%). The range of non-integration rate is very wide, amounting to 84.6%. The most frequent case, 16.5%, is non-integration with 55% to 60% of other regions.

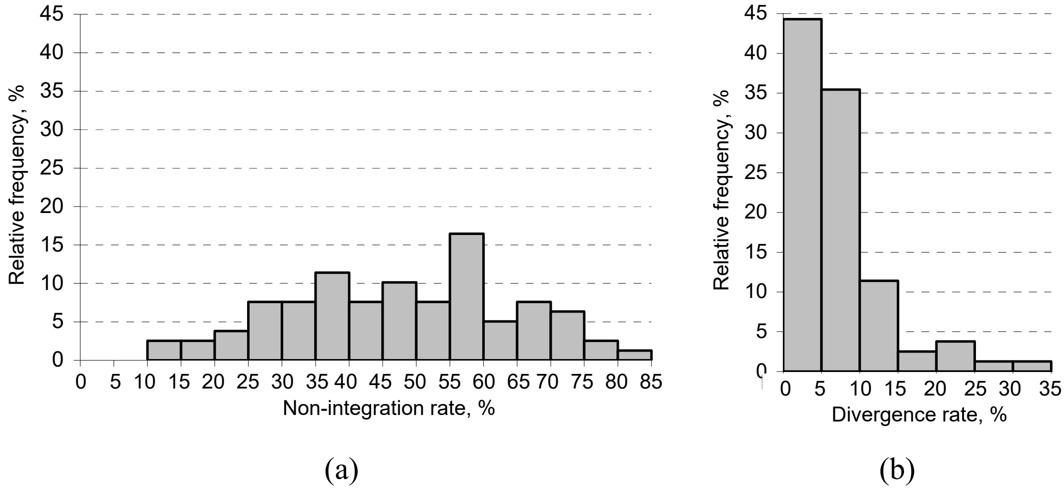


Figure 6. Distributions of non-integration and divergence rates.

An unpleasant aspect of non-integration is a significant proportion of price divergence, more than twice as much as that of convergence. Among all non-integrated region pairs, the proportion of diverging ones is 14.1%. Figure 6(b) plots the distribution of divergence rate. Only six regions diverge with no one other. Although, only two regions diverge with more than 25% of other ones. However, price divergence not always is a negative phenomenon. Imagine that the price paths in two regions are parallel. If the price in some third region catches up with one of them, then it inevitably diverges from the price in other region.

Figure 7 relates the results obtained to geography, mapping regional extents of integration, that is, the total percentage (as a range) of regions with which a given region is perfectly and conditionally integrated and tends towards integration. This indicator is reverse to the non-integration rate, equalling 100% minus non-integration rate.

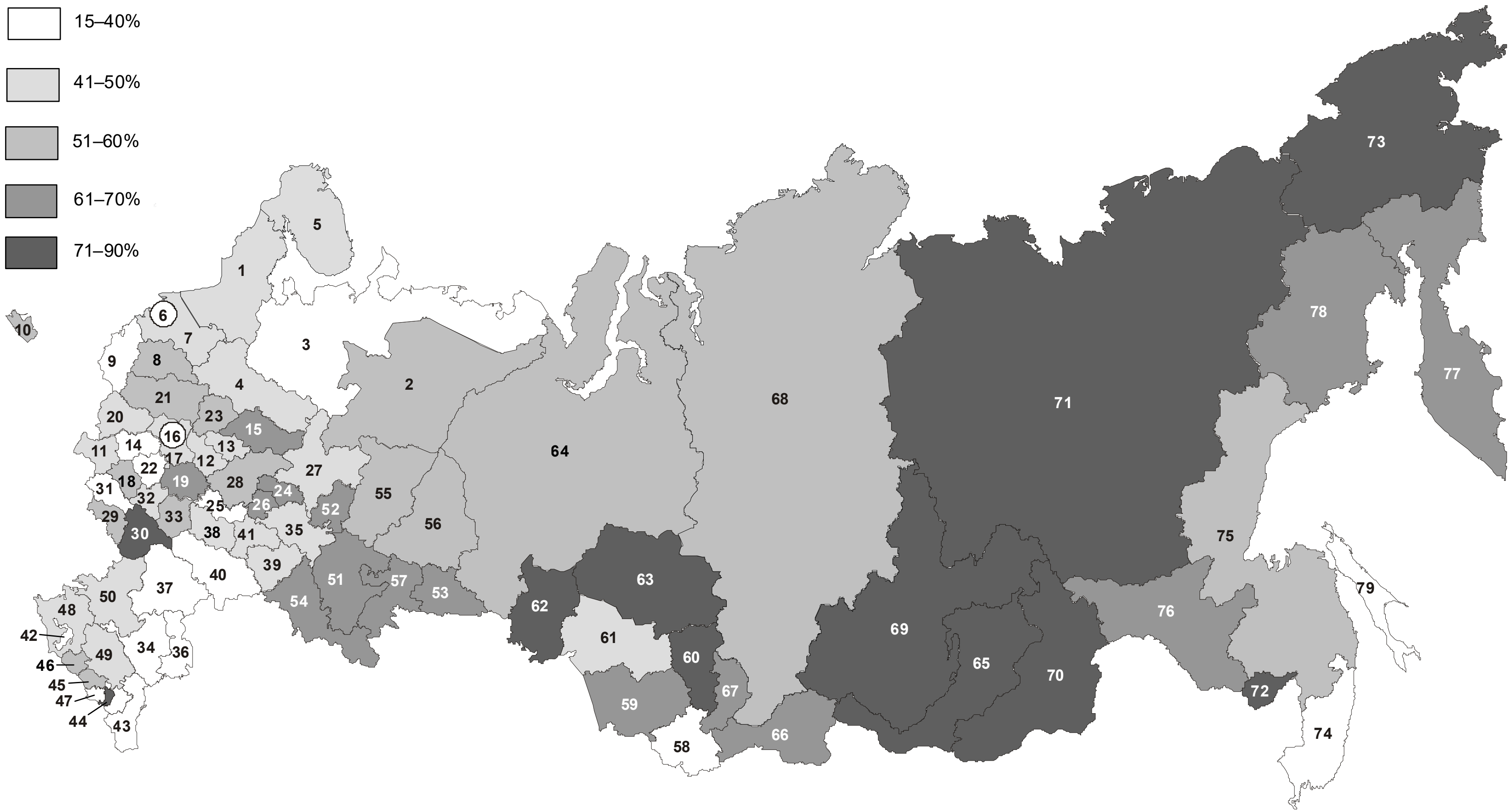


Figure 7. Geography of market integration in Russia: extent of integration by country's region.

Notes: See Table 2 for numerical designations of regions. Not numbered region (between 43 and 44) is the (out-of-sample) Chechen Republic.

Taking a look at the map, some unexpected features are seen. Given much shorter distances and more developed transport infrastructure in the European part of Russia than in its Asian part, one would a priory expect the former to be more strongly integrated than the latter. However, a significant number of poorly integrated regions are present in the European part. Except for the northern Arkhangelsk Oblast (region 3), the rest cases can be hardly explained by geographical reasons. At the same time, integration in Siberia is fairly strong. There is a sole region with the integration rate below 40% (the Republic of Altai, region 58). As the entire matrix of region pairs is very cumbersome, let us divide it into three aggregated blocks: pairs within European Russia, pairs within Asian Russia, and pairs 'between', i.e. with one region from European Russia and second from Asian Russia. There are 57 regions in European Russia (1596 pairs) with average distance between them equalling 1.4 thousand km; Asian Russia consists of 22 regions (231 pairs) with average distance of 4.2 thousand km. The average distance between regions belonging to European and Asian Russia (1254 pairs) equals to 6.3 thousand km. Table 3 presents the results by block.

Table 3. The pattern of Russia's market integration by spatial block, %.

Block of region pairs	Perfect-integration rate	Conditional-integration rate	Convergence rate	Non-integration / Divergence rate
Within European Russia	23.6	16.0	1.2	51.7 / 7.5
Within Asian Russia	13.9	42.0	9.5	30.7 / 3.9
Between European and Asian Russia	17.9	41.1	4.8	29.7 / 6.5

From the geographical viewpoint, the correlation of perfect and conditional integration looks quite expectable: in European Russia, with its shorter distances, perfect integration prevails, while conditional integration prevails in Asian Russia and between European and Asian Russia, reflecting longer distances. However, the geography cannot explain greater non-integration rate in European Russia as well as lesser convergence rate, accompanied by greater divergence rate.

Further analysis of the results obtained can shed some light on this issue. At first, the role of different factors in conditional integration is to be analyzed. Consider a simple model of pricing. Let s be a region of origin of a good, and $p_{(w)s}$ be the wholesale price of the good there. With markup (retail margin) m_s, the retail price of the good in s is $p_{(w)s}(1 + m_s)$. In region r, the retail price is $p_{(w)s}(1 + \tau_{rs})(1 + m_r)$, where τ_{rs} is the cost of transportation from s to r in percentage terms, $(1 + \tau_{rs})(1 + m_r) - 1$ representing the distribution share (Yilmazkuday, 2018). Herefrom, the price differential takes the form $P_{rs} = \log(1 + \tau_{rs}) + \log((1 + m_r)/(1 + m_s)) \equiv \tau(L_{rs}) + M_{rs}$, a sum of some function of log distance, L_{rs}, and the markup differential. The markups can accumulate a considerable part of the effects of 'artificial' impediments to integration, such as regional protectionism, local price regulations, organized crime, etc. Gluschenko (2010) found the contribution of such factors to interregional price dispersion to be fairly significant in 1992–2000. Regional protectionism still poses a problem in Russia, as the Federal Antimonopoly Service of Russia documents in its annual reports (e.g., FAS Russia, 2020). Gousev (2016) considers this issue in detail concerning Russian retail trade. However, the markups not fully capture the effect of regional protectionism. For instance, it can prevent the use of arbitrage opportunities, forcing retailers to buy goods from local producers, despite $p_{(w)r} > p_{(w)s}(1 + \tau_{rs})$, which the above model does not describe. Differences in wages and rents across regions are also responsible in part for the dispersion of markups. In turn, this is due to imperfection of associated markets, labor market and real estate market.[4] (For example, high wages and rents in Moscow City is one of reasons for its weak integration with the rest of Russia.)

There are only rough proxies of the transportation costs and markups. Data on markups by region are available only for 2016–2019 (EMISS, 2020b). Therefore, the averages over these years are used to compute M_{rs}. The markups are those for socially-significant foods. Although a list of these foods is not provided in the data source, all they for sure have to be present in the staples basket. As regards the transportation costs, a linear function of log distance proxy them. The dependent variable is the estimate of time-invariant price differential $P_{rst} = C_{rs} = -\hat{\gamma}_{rs} / \hat{\lambda}_{rs}$ in Model (2). (Therefore, we may assume the markups to be approximately stable as well and use their static proxies.) The cross-sectional model to be estimated has the form:

$$C_{rs} = \alpha_0 + \alpha_1 L_{rs} + \alpha_2 M_{rs} + \varepsilon_{rs},\ (r, s) \in \{\text{conditionally-integrated pairs of regions}\}. \quad (4)$$

Table 4 presents the estimation results. The estimations are run for the whole set of conditionally-integrated pairs and by spatial block; N denotes the number of observations in a respective sample. The standard errors reported are the White heteroscedasticity-consistent errors. As the estimates are not comparable across samples, the contributions of independent variables to the dependent variable give the idea of their roles. Since $\overline{C} = \hat{\alpha}_0 + \hat{\alpha}_1 \overline{L} + \hat{\alpha}_2 \overline{M}$, the contribution of distance is $(\hat{\alpha}_0 + \hat{\alpha}_1 \overline{L}) / \overline{C}$ (taking into account that α_0 is a scale factor depending on the units of measure of distance), and the contribution of the markup differential is $\hat{\alpha}_2 \overline{M} / \overline{C}$.

[4] A reservation should be made that this is not always the case. In northern regions, higher wages are due to compensating wage differentials that compensate unfavorable natural conditions in these territories.

Table 4. Results of estimation of Equation (4).

Variable	Coefficient	Standard error	P-value	Contribution, %
		Russia as a whole (N = 869)		
Constant	–1.051	0.056	0.000	
Distance	0.160	0.007	0.000	92.6
Markup differential	1.059	0.195	0.000	7.4
		Within European Russia (N = 256)		
Constant	–0.158	0.047	0.001	
Distance	0.041	0.007	0.000	90.0
Markup differential	0.723	0.144	0.000	10.0
		Within Asian Russia (N = 97)		
Constant	–1.183	0.190	0.000	
Distance	0.183	0.023	0.000	96.0
Markup differential	1.237	0.705	0.082	4.0
		Between European and Asian Russia (N = 516)		
Constant	–2.452	0.131	0.000	
Distance	0.317	0.015	0.000	90.9
Markup differential	1.469	0.244	0.000	9.1

The results suggest that albeit the role of the ‘natural’ impediment to integration, the distance, is predominant, it is not exhaustive (which justifies the term ‘conditional integration’). The most pronounced influence of other impediments captured by the markup differential is within European Russia, where it contributes 10% to the average price differential. Contrastingly, its contribution within Asian Russia is 2.5 times lesser, despite this part of the country includes the majority of northern regions where the wage compensation differentials are applied. Comparing the results for the whole of Russia with those for pairs with European and Asian regions, we may conclude that the difference between markups in European and Asian Russia plays a greater role there than in the whole country. By and large the results from Table 4 give grounds to suppose that ‘artificial’ impediments to integration are more abundant in European Russia, causing its weaker integration.

In what follows, the analysis exploits probit models. Denote Prob(·) the probability, $\Phi(\cdot)$ standard normal distribution, and $\boldsymbol{\alpha}$ and $\mathbf{x}$ vectors of coefficients and variables. Dependent variable y possesses the value 1 on a certain set of region pairs and equals 0 on some alternative set of pairs. Then the model has the following general form:

$$\text{Prob}(y = 1) = \Phi(\mathbf{x}\boldsymbol{\alpha}'). \qquad (5)$$

The marginal effects of variables are $\partial\text{Prob}(y = 1|\mathbf{x})/\partial\mathbf{x} = \varphi(\mathbf{x}\hat{\boldsymbol{\alpha}}')\hat{\boldsymbol{\alpha}}$, where $\varphi(\cdot)$ is the standard normal density. Tables 5 and 6 report the marginal effects computed as the averages of individual effects over all $N_1 + N_0$ observations; N_1 and N_0 denote the numbers of observations with $y_{rs} = 1$ and $y_{rs} = 0$, respectively. The standard errors reported are the Huber/White errors.

Let us consider, in addition to the previous results, whether distances and markups prevent integration to be perfect. Then $y_{rs} = 1$ if P_{rst} satisfies Model (1), and $y_{rs} = 0$ if P_{rst} satisfies Model (2). Table 5 reports the results of estimating the respective probit model that has the form:

$$\text{Prob}(y_{rs} = 1) = \Phi(\alpha_0 + \alpha_1 L_{rs} + \alpha_2 M_{rs}),$$
$$(r, s) \in \{\text{perfectly integrated pairs}\} \cup \{\text{conditionally integrated pairs}\}. \tag{5a}$$

Table 5. Perfect vs. conditional integration

Variable	Coefficient	Standard error	*P*-value	Marginal effect
Russia as a whole ($N_1 = 633$, $N_0 = 869$)				
Constant	4.072	0.293	0.000	
Distance	–0.513	0.037	0.000	–0.181
Markup differential	–4.237	1.489	0.004	–1.445
Within European Russia ($N_1 = 377$, $N_0 = 256$)				
Constant	2.556	0.551	0.000	
Distance	–0.305	0.077	0.000	–0.115
Markup differential	–7.014	2.401	0.003	–2.633
Within Asian Russia ($N_1 = 32$, $N_0 = 97$)				
Constant	4.440	1.207	0.000	
Distance	–0.656	0.148	0.000	–0.173
Markup differential	1.518	7.899	0.848	0.401
Between European and Asian Russia ($N_1 = 224$, $N_0 = 516$)				
Constant	7.026	0.797	0.000	
Distance	–0.878	0.094	0.000	–0.270
Markup differential	–2.571	1.952	0.188	–0.790

The results in Table 5 suggest that the greater the distance and difference in markups between regions in the pair, the lesser probability of perfect integration, as both variables have the negative sign. An exception is Asia Russia with a positive coefficient of the markup differential; however, this estimate is surely insignificant. This implies a predominant role of distance in time-invariant price differentials in Asian Russia, which corroborates a result from Table 4 regarding a small contribution of the markup differential (4%) here. As for other spatial blocks, an interesting result is that the marginal effect of the markup differential is much stronger than that of distance. For instance, an infinitesimal rise in distance lowers the probability of perfect integration by 11.5%, while such rise in markup differential lowers it by 263.3%. (The role of the markup differential may seem questionable in 'mixed' pairs because of relatively high p-value of its estimate.) By and large, the results from Tables 4 and 5 are in good agreement with economic and geographical considerations.

Let us turn to non-integration. The markup differential is not applicable for analysis of its reasons. It may be that it is the dynamics of the price differential that causes random walk or deterministic divergence. However, static proxy M_{rs} (as well as a static model at all) cannot capture this effect. Thus, only distance remains as an explanatory variable. Based on theoretical considerations (e.g., Fackler & Goodwin, 2001), one can expect that the longer distance between regions, the more likely loosening price transmission between them (the more so if the good passes through a trading network of regions). As the distance increases, the dynamics of prices in a region pair eventually becomes independent, generating a random walk of their price differential or, maybe, divergence of prices. Hence, the probability of random walk and divergence should rise with increase in distance. The model used takes the following form:

$$\text{Prob}(y_{rs} = 1) = \Phi(\alpha_0 + \alpha_1 L_{rs}). \quad (5b)$$

Table 6 reports results for random walks: $y_{rs} = 1$ if P_{rst} is a random walk, and $y_{rs} = 0$ if P_{rst} satisfies Model (1) or (2).

Table 6. Random walks vs. perfect and conditional integration

Variable	Coefficient	Standard error	*P*-value	Marginal effect
	Russia as a whole (N_1 = 1269, N_0 = 1502)			
Constant	1.473	0.196	0.000	
Distance	–0.204	0.025	0.000	–0.079
	Within European Russia (N_1 = 825, N_0 = 633)			
Constant	–0.890	0.366	0.015	
Distance	0.149	0.052	0.004	0.058
	Within Asian Russia (N_1 = 71, N_0 = 129)			
Constant	0.372	0.838	0.657	–0.035
Distance	–0.093	0.104	0.372	
	Between European and Asian Russia (N_1 = 373, N_0 = 740)			
Constant	0.223	0.588	0.704	–0.076
Distance	–0.076	0.068	0.269	

We can accept the hypothesis that longer distances are associated with random walking for European Russia only. Here, an infinitesimal change of distance increases the probability that a random walk takes place by 5.8%. For Asian Russia and the 'mixed' pairs, Model (5b) is inappropriate, having high *p*-values of both estimates and the model statistic (log-likelihood ratio). Nonetheless, the model works for the whole of country, but yields a paradoxical result: an infinitesimal change of distance lowers the probability of random walking by 7.9%. Indeed, the average distance in region pairs with random walks is shorter than the average distance in integrated pairs everywhere except for European Russia.

Results of a similar analysis of divergence with $y_{rs} = 1$ if P_{rst} satisfies Model (3) with a 'wrong' sign of δ, and $y_{rs} = 0$ otherwise are tabulated in Table 7. (Different alternative sets of region pairs have been tried as well, yielding qualitatively similar results.)

Table 7. Divergence vs. the rest.

Variable	Coefficient	Standard error	*P*-value	Marginal effect
Russia as a whole ($N_1 = 209$, $N_0 = 2872$)				
Constant	–1.652	0.282	0.000	
Distance	0.021	0.036	0.571	0.003
Within European Russia ($N_1 = 119$, $N_0 = 1477$)				
Constant	–2.172	0.563	0.000	
Distance	0.103	0.079	0.193	0.014
Within Asian Russia ($N_1 = 9$, $N_0 = 222$)				
Constant	–1.292	1.202	0.283	–0.005
Distance	–0.059	0.150	0.694	
Between European and Asian Russia ($N_1 = 81$, $N_0 = 1254$)				
Constant	–3.770	0.886	0.000	0.032
Distance	0.260	0.102	0.011	

These results are also rather poor. The validity of Model (5b) can be accepted only for pairs with regions from European and Asian Russia. The marginal effect of distance is minor, suggesting a 3.2% rise in probability of divergence with an infinitesimal increase in distance.

Thus, it can be concluded that geography explains the pattern of non-integration only partially. The mains reasons for non-integration seem idiosyncratic features of regional markets. The analysis performed is not able to reveal them; however, it may be suspected that regional protectionism significantly contributes to non-integration.

At last, let us take a look at concrete regions that are in opposite ends of the 'integration spectrum'. Table 8 lists the 'best' and 'worst' regions (which rank first to fifth from the top and bottom, respectively) with respect to different indicators of market integration. Values are expressed as the percentage of 78 regions.

Table 8. Ranking of regions by different indicators of market integration, %.

Panel A			
The most perfectly-integrated region	Perfect-integration rate	The least perfectly-integrated region	Perfect-integration rate
Rep. of Ingushetia (44)	57.7	Rep. of Sakha (Yakutia) (61), Chukotka A.O. (73), Sakhalin Obl. (79)	0
Rep. of Tuva (66)	39.7	Khabarovsk Krai (75), Kamchatka Krai (77), Magadan Obl. (78)	1.3
Voronezh Obl. (30)	38.5	Primorsky Krai (74)	3.8
Chelyabinsk Obl. (57)	37.2	Jewish Autonomous Obl. (72)	9.0
Kostroma Obl. (15), Kemerovo Obl. (60)	35.9	St. Petersburg City (6), Kursk Obl. (31), Lipetsk Obl. (32), Tyumen Obl. (64)	10.3
Panel B			
The most perfectly-and-conditionally integrated region	Integration rate	The least perfectly-and-conditionally integrated region	Integration rate
Irkutsk Obl. (69)	85.9	Kursk Obl. (31)	15.4
Jewish Autonomous Obl. (72)	82.1	Moscow City (16), Rep. of Kalmykia (34), Saratov Obl. (40)	21.8
Voronezh Obl. (30)	78.2	Kaluga Obl. (14)	23.4
Transbaikal Krai (70)	76.9	Arkhangelsk Obl. (3), Sakhalin Obl. (79)	24.4
Rep. of Ingushetia (44)	75.6	St. Petersburg City (6)	25.6
Panel C			
Region with the greatest extent of integration	Extent of integration	Region with the least extent of integration	Extent of integration
Irkutsk Obl. (69)	89.7	Kursk Obl. (31)	15.4
Chukotka A.O.	85.9	Saratov Obl. (40)	21.8
Jewish Autonomous Obl. (72)	84.6	Moscow City (16)	23.1
Transbaikal Krai (70)	80.8	Kaluga Obl. (75), Arkhangelsk Obl. (3)	26.9
Voronezh Obl. (30)	78.2	St. Petersburg City (6), Rep. of Kalmykia (34)	28.2

Notes: Numerical designations of regions are in parentheses. Obl. stands for Oblast, Rep. stands for Republic, and A.O. stands for Autonomous Okrug.

The data in panel A of Table 8 look fairly reasonable from the geographical viewpoint. Regarding its left part, the most perfectly-integrated regions are from the European Russia, except for the Republic of Tuva and Kemerovo Oblast from Siberia. The rightmost histogram bar in Figure 4(a) is due to Ingushetia; the next five regions form the preceding nonzero bar. As for the least perfectly-integrated regions, all regions ranked from first to fourth are remote Far Eastern regions.

Therefore, perfect integration can rarely occur there. It is these eight regions (out of all ten constituting the Russian Far East) that form the leftmost and next histogram bars in Figure 4(a). However, only one region among regions ranked as fifth is from Siberia, the rest three are from the European Russia.

Regions in the left part of panel B of Table 8 form three rightmost histogram bars in Figure 4(b). More than a half of regions (three out of five) that are perfectly or conditionally integrated with the most number of other regions are from Asian Russia. Turning to the right part of this panel, there is a sole Far Eastern region (the Sakhalin Oblast). Rest seven regions here are from European Russia, among them the 'worst' in Russia, the Kursk Oblast (the leftmost histogram bar in Figure 4(b) is due solely to it). The presence of the Archangelsk Oblast, a northern remote region of European Russia, among poorly integrated regions is explainable. As for the Moscow City, the reason for its poor integration is clear, as the Moscow market is known for many and varied impediments to access to it, at least in the early 2000s.

Panel C of Table 8 differs from Panel B in that the convergence rate is added. Since the cases of the movement towards integration are not widespread in the pattern obtained, the lists in these two panels overlap heavily. Chukotka, because of its high convergence rate, replaces the Republic of Ingushetia in the left part of Panel C as compared to panel B. This region and the Tyumen Oblast form the last but one nonzero histogram bar in Figure 5 (the last one is due to the Kamchatka Krai). The 'worst' regions in the right part of Panel C of Table 8 are the same as in Panel B, except for the Sakhalin Oblast which leaves the list because of convergence with 5.1% of other regions. No one case of price convergence with other regions is observed in the Kursk and Saratov *oblasts*. The rest regions converge to 1 to 3 other regions; only the Republic of Kalmykia moves towards integration with 5 regions. Contrastingly, price divergence is widespread among these regions; four of them diverge with 10.3% to 19.2% of other regions.

In general, the above considerations confirm the results of the regression analysis, suggesting that distance is not a main reason for non-integration. Idiosyncratic features of regional markets seem to prevail in the European part of the country.

2001–2019 VS. 1994–2000

As it is mentioned in the introduction, Gluschenko (2011) analyzes market integration in Russia over 1994–2000 relative to a benchmark region, choosing the 'best' benchmark among all possible ones. Thus, he previously obtains a comprehensive pattern of integration, Gluschenko (2011, Table A2) reporting it. It would be interesting to compare that pattern with the pattern for 2001–2019.

However, these two analyses are not fully comparable.

First, they differ in the data used. For 1994–2000, the cost of a staples basket consisting of 25 foods has been analyzed, while the 33-food basket is used here. The difference is not only the number of goods, but also their quantities across the baskets; see Gluschenko (2009) for comparison of these baskets. Besides, the price data for 1994–2000 are those collected in the capital cities of regions, whereas the data for 2001–2019 are the regional averages. At last, the 1994–2000 analysis covers 75 regions (2775 region pairs); it does not include the Moscow and Leningrad *oblasts*, Ingushetia, and Chukotka.

Second, the analyses differ in methodology. The analysis for 1994–2000 exploits the general-to-specific approach and classes conditionally integrated region pairs as non-integrated (since the most part of price disparities in that time were so great that surely could not be assigned to transportation costs). Besides, different methods of testing for unit roots are applied in Gluschenko (2011); the difference is pointed out in the second section. Those methods make it possible to reject unit roots more frequently than the methods exploited in this study.

While the difference in the data is irremovable, the results of both analyses can be made methodologically compatible. On the one hand, benefiting from unpublished intermediate results of the 1994–2000 analysis, it is possible to distinguish conditionally integrated region pairs and restore results corresponding to the specific-to-general approach. On the other hand, results for 2001–2019 can be reestimated with the use of the same methods of unit root testing as in Gluschenko (2011). Table 9 reports so obtained methodologically compatible results, comparing summarized patterns for 1994–2000 and 2001–2019 within the framework of both specific-to-general and general-to-specific approaches.

Table 9. Comparison of integration patterns for 1994–2000 and 2001–2019, %

Group of region pairs	Specific-to-general approach		General-to-specific approach	
	1994–2000	2001–2019	1994–2000	2001–2019
Perfectly integrated	54.7	25.2 (20.5)	25.8	8.4 (11.8)
Conditionally integrated	29.2	47.8 (28.2)	32.6	30.9 (20.6)
Tending towards integration	11.3	3.3 (3.3)	34.3	17.3 (10.0)
Extent of integration	**95.2**	**76.3 (52.0)**	**92.7**	**56.6 (42.4)**
Non-integrated	4.8	23.7 (48.0)	7.3	43.4 (57.6)
Out of these, diverging	1.1	7.7 (6.8)	3.6	27.5 (16.4)

Notes: The data are proportions of all region pairs. Results for 2001–2019 obtained with the use of unit root testing described in the second section are in parentheses (under the specific-to-general approach, they are from Table 2).

There is a great difference between 1994–2000 and 2001–2019. Prior to 1992, most of consumer prices in Russia were centrally-fixed. In January 1992, they were decontrolled. However, no market institutions existed by that time; the wholesale trade and the most part of retail trade were state-owned. Such institutions were emerging during the early 1990s due to mass privatization and market self-organization. As a result, spatial arbitrage came into play since about 1994. Beginning in that year, the improvement in integration of Russia's regional markets was observed. The period of 1994–2000 was that of further transition from centrally-planned to market economy; 'artificial' barriers to interregional trade were progressively lowering over time (Gluschenko, 2010). In 2001–2019, by contrast, the Russian economy was functioning as a market one. At least, there were no fundamental differences in the functioning of markets for consumer goods in Russia and long-standing market economies.

Figure 8 gives an idea of processes in the market in a generalized form, plotting distribution of the basket cost relative to the national average price for 1994 and 2000. (Convergence clubs are detected in no one year of 1994–2000.) Comparing this figure with Figure 2, we can see that the shape of the distribution changed by the final year much more than in 2001–2019. The standard deviation almost halved, from 0.343 in 1994 to 0.184 in 2000. Note that the most expensive region, Chukotka, is absent in Figure 8 because of the lack of full data. In 2000, the cost of its 25-food basket averaged over 7 last months of the year equalled 316% of the national average. The same figure for the 33-fod basket equalled 297%, reflecting the difference of two baskets. The same reason is responsible for uneven distributions in 2001 and 2000 in Figures 2 and 8 rather than for a change over one year. It is clearly seen from Figure 8 that convergence processes occurred intensively in 1994–2000 in the directions of both increase and decrease of relative prices.

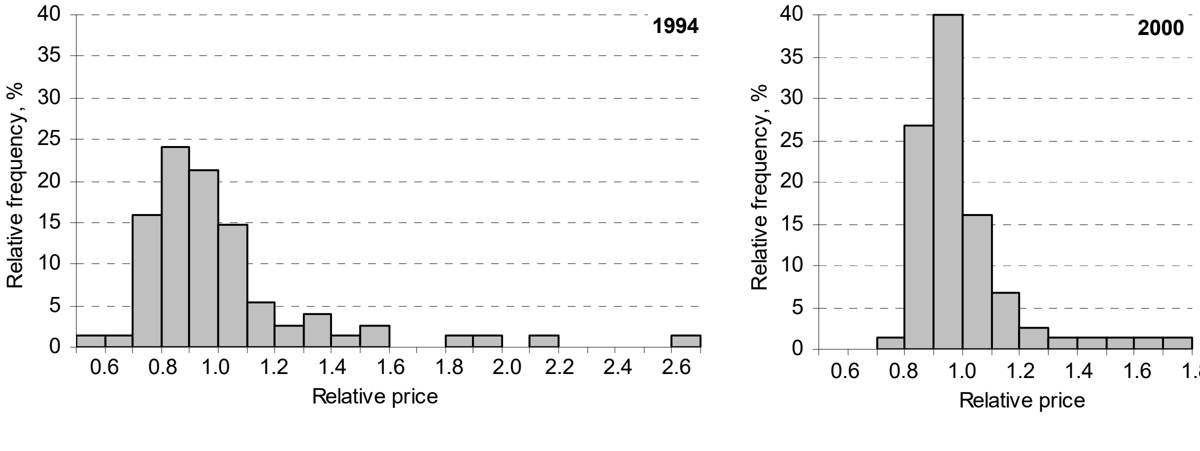


Figure 8. Distribution of the cost of the 25-food basket.

Based on the aforesaid, one would expect integration in 1994–2000 to be poorer – with a greater number of converging region pairs – than in 2001–2019. Surprisingly, this is not the case. The extent of integration in 1994–2000 is significantly higher, exceeding 90% under both approaches. The use of the general-to-specific approach decreases it by merely 2.5 percent points. If this approach were applied to obtain the 2001–2019 pattern, the extent of integration would drop by 18.5 percent points. As expected, the convergence rate is greater in 1994–2000. However, this is not the reason for higher extent of integration. The share of perfectly and conditionally integrated pairs is also greater in 1994–2000: 86.6% as compared to 73.0% in 2001–2019 (58.4% vs. 39.3%, respectively, under the general-to-specific approach). The most unexpected feature is widespread perfect integration in 1994–2000. The share of perfectly integrated pairs in that period is twice (or even three times) as much as in 2001–2019. The cases of price divergence were rare in 1994–2000. In the next period, their number dramatically increased, up to almost one third, if additional region pairs exhibiting weak divergence trends (revealed by the general-to-specific approach) were taken into consideration.

Possibly, unexpected features in the difference between the 1994–2000 and 2001–2015 patterns can be partially explained by the difference in the data. If the cost of the staples basket with a wider coverage of goods and cities were used for 1994–2000, the integration pattern would become worse. Gluschenko (2009, Figures 5 and 6) provides an indirect confirmation of this hypothesis. The degree of market segmentation estimated with the use of the 33-staples basket is higher than that estimated with the use of the 25-staples basket.

One more hypothetical reason is the shorter time span (7 years vs. 19 years), which sometimes does not make it possible to reveal actual long-run properties of price dynamics. Possible effects of time span can be seen in Figure 3. If the time series in Figure 3(a) were analyzed over the initial 7 years, it would be recognized as converging. The same analysis of time series in Figure 3(d) would suggest perfect integration instead of random walk.[5] Besides, many time series for 1994–2000 include structural breaks caused by the 1998 financial crisis in Russia. The breaks were distributed across region pairs from August 1998 to January 1999. Thus, the after-break time span is rather short, containing 22 to 29 months. This would have prevented revealing actual behaviour of price differentials after the break (that differed significantly from the 'pre-break' behaviour).

Thus, it can be concluded that the extent of integration in 1994–2000 is significantly

[5] One more example relates to the current study. Initially, it covered 15 years, 2001–2015. After expanding the time span to 19 years, the proportion of perfectly and conditionally integrated pairs has decreased by 1.8 percent points, and that of converging pairs dropped by 0.9 points.

overstated. Nonetheless, this does not provide a full explanation. This relates specifically to the divergence stretching over 7.7% of region pairs in 2001–2019. More detailed and deeper study is needed to find reasons for this phenomenon.

CONCLUSION

Using the cost of the basket of 33 basic food goods as the price representative and analyzing behaviour of its differential in all pairs of country's regions over 2001–2019, this article obtains a comprehensive spatial pattern of market integration in Russia. That is, distinguishing among different 'grades' of integration, this pattern shows how many regions are perfectly integrated, conditionally integrated, moving towards integration (converging), and non-integrated (diverging among these) with each region of the country.

Perfectly and conditionally integrated region pairs have been found to amount to 48.7% of all pairs. Taking account of more severe unit root tests (than those in common use) exploited, this figure is comparable with that for the U.S.: be commonly used tests applied, it would run to 73.0%. Thus, there is no a fundamental difference in the extent of product market integration between modern Russia and long-standing market economies. The pattern obtained is not static. Processes of its improvement have been found as well: 3.3% of region pairs are converging. This should eventually lead to integration between regions in these pairs. At the same time, 6.8% of the pairs are diverging, deteriorating market integration in the country.[6] Contrary to expectations, the European part of Russia proves to be less integrated than the Asian part, despite more favourable prerequisites for market integration in European Russia

Further analysis reveals that although the role of distance in conditional integration prevails, 'artificial' impediments to integration (quantified by the difference in markups) are not negligible, contributing on average 7.4% to the price differential in conditionally integrated regions and decreasing the probability of perfect integration. However, the distance explains non-integration partially, in some subsamples of region pairs only. This leads to a conclusion that the reasons for non-integration are for the most part idiosyncratic. It is highly likely that it is regional protectionism that prevents integration of a number of regions, especially in European Russia. It is worth noting that this is not a peculiar feature of the Russian market. As Herrmann-Pillath, Libman & Yu (2014) note, local protectionism plays a substantial role in many federations and decentralized states.

Intuitive considerations suggest that market integration in Russia in 2001–2019 should be

[6] Ritola (2008) also finds both processes in China.

stronger than in 1994–2000, when transition from centrally-planed to market economy was in progress. Surprisingly, the comparison does not confirm the expectation. This can be partially referred to the fact that the extent of integration in 1994–2000 is overstated because of shorter time span. However, some differences between the patterns remain unexplained.

ACKNOWLEDGEMENTS

Helpful comments of participants at the conference “Spatial Analysis of Socio-Economic Systems: History and the Current State” (Novosibirsk, 2016) and the Third Russian Economic Congress (Moscow, 2016) are gratefully acknowledged.

REFERENCES

Akhmedjonov, A. & Lau, C.K. (2012). Do energy prices converge across Russian regions? *Economic Modelling*, *29*, 1623–1631. doi:10.1016/j.econmod.2012.05.023

Barrett, C.B. (2008). Spatial market integration. In L.E. Blume & S.N. Durlauf (Eds.), *New Palgrave Dictionary of Economics Online*. Palgrave Macmillan. doi:10.1057/9780230226203.1584.

Berkowitz, D. & DeJong, D.N. (2001). The evolution of market integration in Russia. *Economics of Transit*ion, 9, 87–104. doi:10.1111/1468-0351.00068

Berkowitz, D. & DeJong, D.N. (2005). Economic fragmentation in Russia: The Influence of international trade and initial conditions. *Economics of Governance*, 6, 253–268. doi:10.1007/s10101-004-0092-8

Bernard, A.B. & Durlauf, S.N. (1995). Convergence in international output. *Journal of Applied Econometrics*, *10*, 97–108. doi:10.1002/jae.3950100202

Cecchetti, S.G., Mark, N.C. & Sonora, R.J. (2002). Price index convergence among United States cities. *International Economic Review*, *43*, 1081–1099. doi:10.1111/1468-2354.t01-1-00049

Ceglowski, J. (2003). The law of one price: intranational evidence for Canada. *Canadian Journal of Economics*, *36*, 373–400. doi:10.1111/1540-5982.t01-1-00005

Chmelarova, V. & Nath, H.K. (2010). Relative price convergence among US cities: Does the choice of numeraire city matter? *Journal of Macroeconomics*, *32*, 405–414. doi:10.1016/j.jmacro.2009.09.006

Das, S. & Bhattacharya, K. (2008). Price convergence across regions in India. *Empirical Economics*, *34*, 299–313. doi:10.1007/s00181-007-0123-8

EMISS (2020a). *The Cost of the Simulated (Minimal) Food Basket* [Database, Integrated

Interagency Informational and Statistical System of Russia (EMISS)]. Retrieved May 12, 2020, from https://www.fedstat.ru/indicator/31481.do [In Russian.]

EMISS (2020b). *The Estimate of Average Level of Markup in Retail Outlets* [Database, Integrated Interagency Informational and Statistical System of Russia (EMISS)]. Retrieved July 1, 2020, from https://www.fedstat.ru/indicator/33958.do [In Russian.]

Esaka, T. (2003). Panel unit root tests of purchasing power parity between Japanese cities, 1960–1998: disaggregated price data. *Japan and World Economy*, *15*, 233–244. doi:10.1016/S0922-1425(01)00087-1

Fackler, P.L. & Goodwin, B.K. (2001). Spatial price analysis. In B. Gardner & G. Rausser (Eds.), *Handbook of Agricultural Economics* (Vol. *1B*, pp. 971–1024). Amsterdam: Elsevier.

Fan, C. S. & Wei, X. (2006). The law of one price: Evidence from the transitional economy of China. *Review of Economics and Statistics*, *88*, 682–697. doi:10.1162/rest.88.4.682

FAS Russia. (2020). *Report on the State of Competition in the Russia Federation for 2019*. Moscow: Federal Antimonopoly Service of the Russian Federation. [In Russian.]

Fischer, N. I., Mammen, E. & Marron, J. S. (1994). Testing for multimodality. *Computational Statistics and Data Analysis, 18*. 499–512. doi:10.1016/0167-9473(94)90080-9

Gluschenko, K. (2009). Goods market integration in Russia during the economic upturn. *Post-Communist Economies*, *21*, 125–142. doi:10.1080/14631370902778443

Gluschenko, K. (2010). Anatomy of Russia's market segmentation. *Economics of Transition*, *18*, 27–58. doi:10.1111/j.1468-0351.2009.00363.x

Gluschenko, K. (2011). Price convergence and market integration in Russia. *Regional Science and Urban Economics*, *41*, 160–172. doi:10.1016/j.regsciurbeco.2010.12.003

Goldberg, P.K., & Verboven, F. (2005). Market integration and convergence to the law of one price: Evidence from the European car market. *Journal of International Economics*, *65*, 49–73. doi:10.1016/j.jinteco.2003.12.002

Gousev, A. (2016) Regional protectionism in retail trade. *Society and Economy, No. 1*, 49–68. [In Russian.]

Herrmann-Pillath, C., Libman, A. & Yu, X. (2014). Economic integration in China: Politics and culture. *Journal of Comparative Economics*, *42*, 470–492. doi: 10.1016/j.jce.2013.10.003

Horvath, J. & Vidovic, S. (2005). The law of one price: Evidence from a small transition economy. *Jahrbuch für Wirtschaftswissenschaften / Review of Economics*, *56*, 257–284.

Iregui, A.M. & Otero, J. (2011). Testing the law of one price in food markets: evidence for Colombia using disaggregated data. *Empirical Economics*, *40*, 269–284. doi:10.1007/s00181-

010-0358-7

Liu, T.-Y., Su, C.-W., Chang, H.-L. & Xiong, D.-P. (2018). Does the law of one price hold? A cross-regional study of China. *Economic Research – Ekonomska Istraživanja*, *31*, 592–606. doi:10.1080/1331677X.2018.1429294

Ng, S. & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, *69*, 1519–1554. doi:10.1111/1468-0262.00256

Ng, S. & Perron, P. (2005). A note on the selection of time series models, *Oxford Bulletin of Economics and Statistics*, *67*, 115–134. doi:10.1111/j.1468-0084.2005.00113.x

O'Connell, P.G.J. & Wei, S.-J. (2002). "The bigger they are, the harder they fall": Retail price differences across U.S. cities. *Journal of International Economics*, *56*, 21–53. doi:10.1016/S0022-1996(01)00111-8

Parsley, D.C. & Wei, S.-J. (1996). Convergence to the law of one price without trade barriers or currency fluctuations. *Quarterly Journal of Economics*, *111*, 1211–1236. doi:10.2307/2946713

Perron, P. & Ng, S. (1996). Useful modifications to some unit root tests with dependent errors and their local asymptotic properties. *Review of Economic Studies*, *63*, 435–463. doi:10.2307/2297890

Ritola, M. (2008). Price convergence and geographic pattern of market integration: Evidence from China, BOFIT Discussion Paper 13/2008, Helsinki. https://helda.helsinki.fi/bof/bitstream/handle/123456789/8169/159255.pdf

Rosstat (2006). *Methodological Regulations on Observations of Prices for Consumer Goods and Services, and Calculation of Consumer Price Indexes*, (Moscow). [In Russian.]

Yazgan, M.E. & Yilmazkuday, H. (2011). Price-level convergence: New evidence from U.S. cities. *Economics Letters*, *110*, 76–78. doi:10.1016/j.econlet.2010.10.013

Yilmazkuday, H. (2018). Spatial dispersion of retail margins: evidence from Turkish agricultural prices. *Agricultural Economics*, *49*, 455–462. doi: 10.1111/agec.12428