# Spatial pattern of Russia's market integration

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## Abstract

This paper studies integration of regional goods markets in Russia over 2001–2015 with the use of time series analysis, based on the law of one price as the criterion of market integration. The cost of a staples basket is used as a price representative. The analysis involves all pairs of country's regions, thus providing a comprehensive 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, and neither integrated nor tending towards integration. The results suggest that less than a half of region pairs fall into the fourth category.



**Keywords:** regional goods markets, Russian regions, law of one price, price convergence

**JEL classifications:** L81, R12, R15, R19

## 1. Introduction

Considering a product market of some country as a system of regional markets, the question arises as to how strong ties between elements of this system are. In economic terms, it sounds as how strongly regional markets are integrated with each other. Two forms of answer to this question are possible. The first is an aggregated characterization of the degree of spatial integration within the whole domestic market. The second is a characterization of spatial structure of integration which provides information on integration of each regional market with other ones. This makes it possible to reveal heterogeneity of regions from the viewpoint of market integration. This heterogeneity may be due to different extent of regional protectionism, remoteness of regions, and other factors. For example, Berkowitz and DeJong (1999) find a group of regions in Russia denoted as the Red Belt that has impeded market integration in the country in the 1990s because of antireform attitude of their governments. In China, it has come to interregional trade wars, as Young (2000) reports.

There is no uniform definition of spatial market integration (Fackler and Goodwin, 2001; Barrett, 2008). The following definition is exploited in this paper. A set of regional markets for a (tradable) good is deemed integrated if there are no barriers to trade between regions, except for 'natural,' geographically determined barriers, i.e. disconnectedness of regions (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 (if they are very small as compared to the price of the good or the price includes average transportation costs), 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 (per unit of the good). Thus, the law of one price can be applied as the criterion of market integration.

Testing for the law of one price in its strict or weak versions is a common exercise in studies of market integration. However, it overlooks an important transitional case. Despite the price differs between two regions, regional prices can converge to each other, eventually eliminating the price disparity. Thus, albeit this pair of regions is not integrated, it tends towards integration over time.

This paper analyzes time series of the cost of a staples basket over 2001–2015 with a monthly frequency across all pairs of Russian regions, thus providing a comprehensive pattern of market integration in the country. The region pairs are classified as belonging to one of four groups. The first one consists of integrated pairs, i.e. those where the strict law of one price holds (perfect integration). The second group comprises conditionally integrated pairs, where the weak law of one price holds (the next section explains why integration is deemed conditional in this case). The third group includes region pairs tending towards integration. Following a method put forward in Gluschenko (2011), the movement towards integration is modeled by a nonlinear asymptotically decaying trend of price disparity (however, unlike that paper, with the use of different modes of the trend). At last, the fourth group consists of neither integrated nor tending-towards-integration region pairs.

A number of papers investigate spatial pattern of market integration in Russia, using different product and location samples as well as time spans. Gardner and Brooks (1994) study market integration in Russia in 1992–1993, using data for six food commodities across 14 cities in the Volga economic area. They pool time series for all pairs of cities into a data panels (separately for each commodity). This allows including time invariant variables such as distance, price regulations, etc., but yields results averaged across city pairs, hence an overly aggregated pattern of market integration (so that its spatial dimension disappears). Berkowitz et al. (1998) analyze time series of prices for five foods across 13 to 25 cities from the European part of Russia in 1992–1995. They do not address directly to the issue of market integration, focusing on the relationship between the behavior of prices of similar goods across cities, which provides an indirect indications of integration. Goodwin et al. (1999) consider prices for four goods across five cities of Russia during 1993–1994, analyzing linkages of prices in each pair of cities with the use of cointegration, Granger causality, and impulse response techniques. They interpret the presence of the price linkages as evidence in favor of market integration. Gluschenko (2011) uses the cost of a staples basket relative to a benchmark region across almost all regions of Russia (represented by their capital cities) over 1994–2000. Using time series analysis, regions are broken down into three groups: integrated with the benchmark region, tending towards integration with it, and neither integrated nor tending towards integration. Akhmedjonov and Lau (2012) deal with prices for four energy products in all Russian regions relative to the national average prices during 2003–2010. They focus on convergence of prices, using a nonlinear trend (the argument of which is the lag of the relative price rather than time) to model it. A similar methodology is applied in Lau and Akhmedjonov (2012), where convergence of aggregated (relative) prices for outer clothing across 44 regions of Russia for 2002–2009 is explored. This paper contributes to the above literature, providing a spatial pattern of market integration in Russia that involves all pairs of country’s regions. (To my knowledge, such a work was not done as yet for any country with a significant number of regions.) In some respect, it supplements results of Gluschenko (2011), extending them to the 2000s.

The reminder of the paper is organized as follows. Section 2 expounds methodology applied.

In Section 3, empirical data used for the analysis are described .Section 4 reports and discusses the estimation results. Section 5 compares results obtained with those for 1994–2000. Section 6 concludes.

## 2. Methodology

Let $p_{rt}$ and $p_{st}$ be prices for a tradable good in regions $r$ and $s$ ($r, s = 1,\dots, N$) at period $t$, $P_{rst} = \log(p_{rt}/p_{st})$ being the price differential;. The economic model of the strict law of one price looks like $P_{rst} = 0$ for $t = 0,\dots, T$ and a region pair ($r$, $s$). Certainly, the law can hold only statistically in reality, accurate to random shocks $\nu_t$ (to economize notation, the region indices for disturbances and parameters are suppressed). It is natural to suppose the prices (hence, the price differential) to depend on their previous values, i.e. to be autocorrelated. 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 $\varepsilon_t$ is the Gaussian white noise. Substituting the second equation into the first gives the conventional AR(1) model with no constant ($\Delta P_{rst}$ stands for the first difference, $\Delta P_{rst} \equiv P_{rst} - P_{rs,t-1}$; hereafter, $t = 1,\dots,T$):

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

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 modeled as $P_{rst} = C_{rs}$, where $C_{rs}$ represents time-invariant arbitrage transaction costs. (Note that different versions of the model are possible, e.g. $C_{(-)rs} \le P_{rst} \le C_{(+)rs}$, leading to threshold econometric models). Based on the same considerations as above, we get the conventional AR(1) model with constant $\gamma = -\lambda C_{rs}$:

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

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. They could be acknowledged as integrated on condition that the price disparity $C_{rs}$ 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. In the framework of time series analysis, it is impossible to reveal the nature of $C_{rs}$; therefore the term ‘conditional integration’ is applied.

The movement towards integration (price convergence) can be modeled by an asymptotically decaying trend: $P_{rst} = C_{rs}(t)$, where $C_{rs}(t) \to 0$ as $t \to \infty$, and $\text{sign}(C_{rs}(0))\cdot dC_{rs}(t)/dt < 0$. This relationship is close to the definition of convergence suggested by Bernard and Durlauf (1995).

Taking account of autocorrelation, we get an AR(1) model of the form

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

This study uses three modes of the trend. The first is the log-exponential trend $C(t) = \log(1 + \gamma e^{\delta t})$, $\delta < 0$; the second is the exponential trend $C(t) = \gamma e^{\delta t}$, $\delta < 0$; and the third is the fractional trend $C(t) = \frac{\gamma}{1+\delta t}$, $\delta > 0$. The respective nonlinear models have the forms

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

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

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

Price convergence takes place if time series $P_{rst}$ is stationary around one or more of these trends and parameter $\delta$ has the expected (for the given trend) sign. Then regions in the pair ($r$, $s$) are deemed to move towards integration with each other. Incorrect sign of $\delta$ implies price divergence, hence the respective region pair is deemed non-integrated (and diverging).

If no one of the Models (1)–(3) describes the behavior of prices in region pair ($r$, $s$), these regions are deemed neither integrated nor tending towards integration with each other (hereafter, simply non-integrated for brevity).

A problem in exploring spatial market integration is a great number of region pairs, equaling $N(N - 1)/2$. For instance, 79 Russian regions produce 3081 pairs. There are a few ways to reduce dimensionality. The first is to pool time series of all region pairs into a data panel, estimating only one panel regression, as, e.g., Gardner and Brooks (1994) do. However, this yields only a characterization of the whole country's market with no geographical dimension. Another way is to use some region as a benchmark, i.e. to fix some region index, say, $s$ in regressions (1)–(3), as, e.g., in Gluschenko (2011). Then the number of pairs reduces to $N - 1$. Seemingly, this way would provide a comprehensive spatial pattern of integration, since only $N - 1$ of all pairs are independent, making it possible to generate a time series for any other region pair, e.g., $P_{qrt} = P_{qst} - P_{rst} = \log(p_{qt}) - \log(p_{st}) - (\log(p_{rt}) - \log(p_{st}))$. But, unfortunately, autocorrelation of time series leads to non-transitivity of statistical inference. For instance, if region pairs ($q$, $s$) and ($r$, $s$) are integrated, i.e. each satisfy Equation (1), this does not imply that pair ($q$, $r$) is also integrated. And vice versa, despite $P_{qst}$ and $P_{rst}$ are unit root processes (random walks), $P_{qrt}$ may manifest regularity of form (1)–(3). Thus, we have only a partial spatial pattern, which shows the state of integration with the benchmark region, but is silent as to integration of other region pairs. A consequence is that the pattern obtained crucially depends on the choice of benchmark region. One more way is to use the national market as the benchmark. In this case, the national price (a weighted average of regional prices) serves as the numeraire, like, e.g., in Akhmedjonov and Lau (2012). Here, the same problem of non-transitivity as above arises. Besides, this way is questionable from the econometrical viewpoint, since price differentials involve a mixture of all regional prices. Some of them could be unit root processes, spoiling the whole pattern of market integration.

Thus, the existing ways of reducing the number of pairs do not provide a comprehensive pattern of market integration. Therefore regressions (1)–(3) are estimated and tested separately for each region pair ($r$, $s$).

To test for a unit root (i.e. to test the hypothesis $\lambda = 0$ against $\lambda < 0$), the augmented Dickey-Fuller test and Plillips-Perron test are applied. The hypothesis of non-stationarity is deemed rejected if both tests reject it at the level of 10%. (For technical details of testing, see Appendix). The 10% significance level is also applied to parameters $\gamma$ and $\delta$. All three versions of Model (3) are estimated for each region pair. If they turn out to be completive, the model providing the best fit – namely, the minimal sum of squared residuals – is accepted.

Not infrequently, a time series $P_{rst}$ satisfies more than one model from their set (1)–(3). Then the ‘most proper’ model is to be selected. Two approaches are possible, general to specific and specific to general. The general model in this set is Model (3). It encompasses the rest models: imposing restriction $\delta = 0$ on $C(t)$, 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 (1), accepting the first significant model in this sequence.

Albeit the general-to-specific approach seems attractive from the theoretical point of view, this study applies the specific-to-general approach (which implies the reverse sequence), based on the following intuitive considerations. If a time series satisfies both Equations (1) and (2), it is reasonable to assume that although constant $\gamma$ in Equation (2) is statistically significant, it is small and is caused by some accidental reasons (being a statistical artifact) 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, Equation (2), should be accepted. A random inspection of some such cases has confirmed these assumptions.

## 3. 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. There is a curious feature of the political division of Russia, 'composite' federal subjects, namely, *oblasts* or *krais* that include one or more other federal subjects, autonomous *okrugs*. (The Chukchi Autonomous Okrug is the only one that is not a part of another federal subject.) Within the time span under consideration, the autonomous *okrugs* have been merging with the *oblasts*/*krais* that include them, ceasing to be separate federal subjects (by now, only two 'composite' federal subjects remain).

In this study, by a region is meant a federal subject (including federal cities of Moscow and Saint Petersburg); however, the composite federal subjects are considered as single regions (namely, the Arkhangelsk, Tyumen, and Irkutsk *oblasts*, and the Transbaikal and Kamchatke *krais*). The spatial sample for the analysis covers 79 regions, all Russia's regions but the Chechen Republic, where full data on prices are lacking. They generate 3081 region pairs.

An aggregated market for 33 basic foods (staples) is considered, using the cost of a basket of these goods as a price representative for the analysis. Rosstat (2005, Appendix 6)[1] reports the composition of the basket. The analysis covers January 2001 through December 2015 with a monthly frequency (180 time observations). The price data are drawn from the Integrated Interagency Informational and Statistical System of Russia (EMISS), https://www.fedstat.ru/indicator/31481.do.

Figure 1 reports summary statistics – the mean and standard deviation – of the price differentials over the time span under consideration. The sign of the price differential depends on the order of regions in their pair; therefore a rearrangement of region indexes can change the summary statistics. To avoid this effect, the summary statistics are computed for the absolute values of the price differentials, $|P_{rst}|$.

[1] Available on http://www.gks.ru/free_doc/new_site/prices/potr/PRIL6.DOC

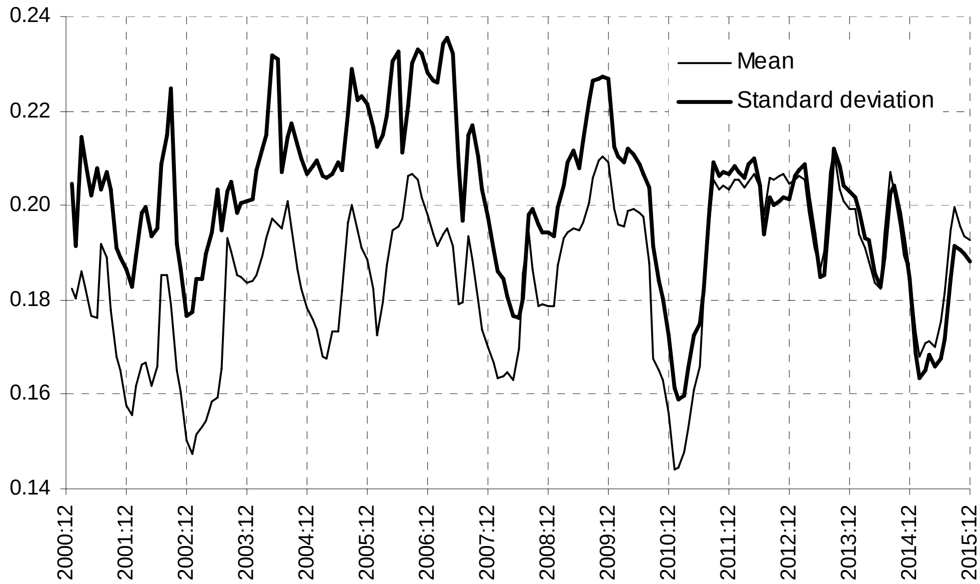
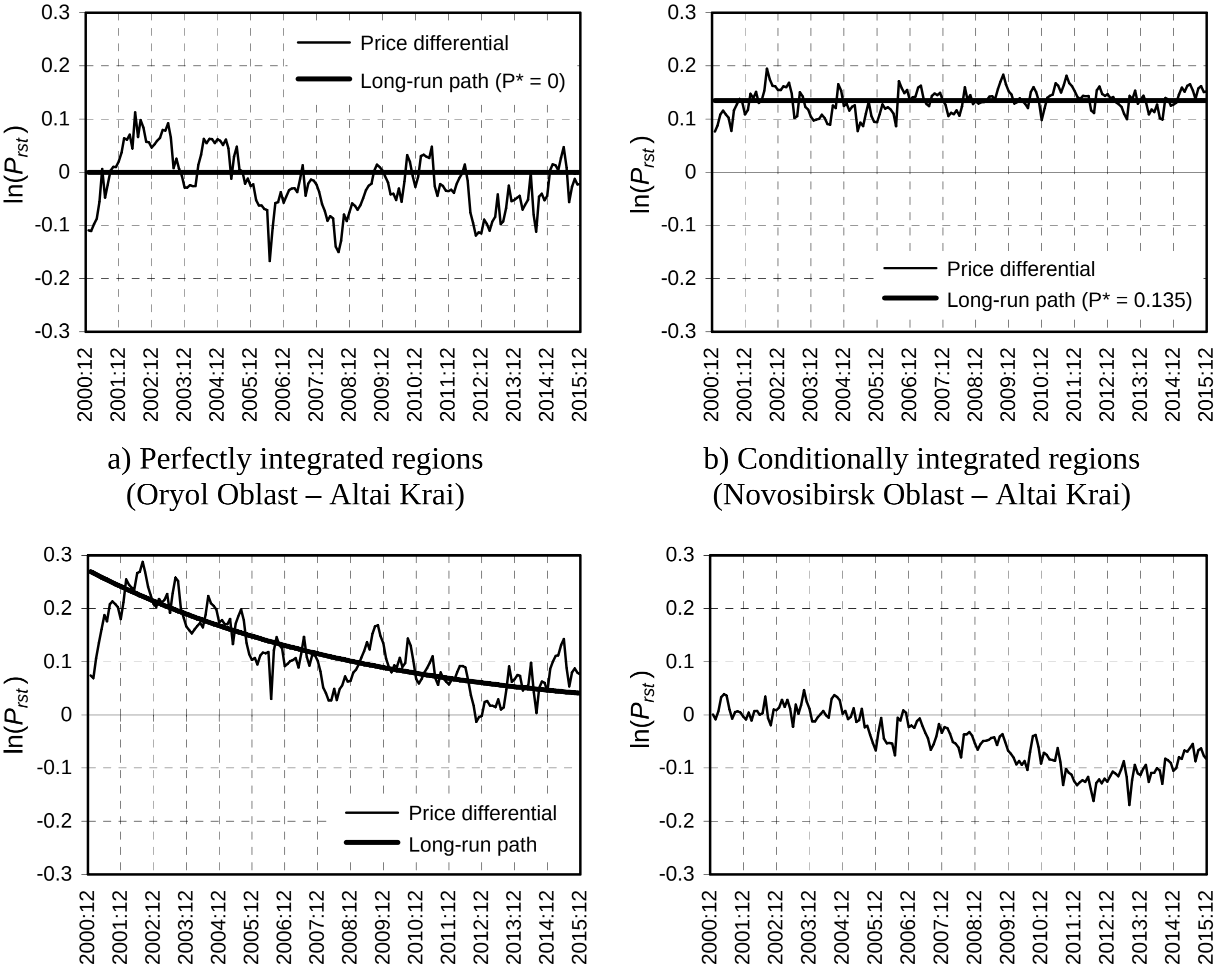



**Figure 1.** Summary statistics of absolute price differentials.

Statistics depicted in Figure 1 give an idea of price dispersion in the Russian spatial market. As it is seen, the price dispersion is highly volatile with dramatic fluctuations; the maximum to minimum ratio equals about 1.5 for both mean and standard deviation. This is due to relatively high inflation that greatly differs across regions. On average, monthly inflation rate over 2001–2015 was 0.85% (10.7% per year), varying across regions from 0.71% to 0.96% (8.9% to 12.1% per year). 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 0.8% per year, and the latter falls by 0.6% per year. Thus, it can be concluded that the process of spatial market integration in Russia is not completed. It is still in transition; both price convergence and divergence are going on in some spatial parts of the market. This makes analyzing only the state of integration with models of the form (1) or/and (2) insufficient, which motivates the use of modeling the movement to integration.

## 4. Empirical results

Before presenting full results, it is instructive to look at an example of specific region pairs belonging to each of four groups: perfectly integrated, conditionally integrated, tending towards integration, and non-integrated. Figure 2 illustrates these, depicting the actual evolution of the price differentials vs. their theoretical long-run paths. No long-run path exists for the non-integrated pair, Figure 2d.




a) Perfectly integrated regions (Oryol Oblast – Altai Krai)

b) Conditionally integrated regions (Novosibirsk Oblast – Altai Krai)

c) Regions tending towards integration (Moskow Oblast – Altai Krai)

d) Non-integrated regions (Omsk Oblast – Altai Krai)

**Figure 2.** Examples of four types of region pairs.

Figure 2 clarifies econometric considerations in the previous section. Equation (1) holds for the pair of integrated regions, Figure 2a. The price differential fluctuates around the price parity line $P^* = 0$; that is, prices in these regions continually tend to equalize with each other. The conditionally integrated pair in Figure 2b satisfies Equation (2). Here, the price differential fluctuates around some nonzero constant. This means that prices in these regions tend to maintain a constant price disparity, 14.4% (on average) in real terms. Regions in Figure 2c are moving to integration with each other. This pair satisfies Equation (3b) with trend $C(t) = 0.273e^{-0.01t}$. Over time, the price differential diminishes, approaching the parity. Certainly, this does not imply that it necessarily will reach the parity. It is possible that beyond the time span under consideration the price differential will come to some equilibrium disparity. At last, no one model describes the behavior of price differential in

Figure 2d. It is interestingly to note that while the Altai Krai is perfectly integrated with the Oryol Oblast and not integrated with the Omsk Oblast, the Oryol and Omsk *oblasts* are conditionally integrated with each other, having $P^* = 0.035$ that corresponds to a 3.6% price disparity in real terms.

Table 1 tabulates the results of analysis across all region pairs in a summarized form. For each region, it reports percentage of the rest 78 regions with which the given region is perfectly integrated, conditionally integrated, tending towards integration, and not integrated (and not tending towards integration). In the last case, non-integration can be caused by price divergence, which manifests itself in a positive trend factor in trends (3a) and (3b) or negative factor in trend (3c). The percentage of such cases is also reported. In fact, the actual cases of divergence may be greater, as trends of the form (3a)–(3c) cannot cross zero by construction. Therefore Equation (3) cannot detect divergence with a trend crossing zero. The last line in the table reports the total percentage of respective region pairs (among all 3081 pairs).

**Table 1.** Results of the analysis: the pattern of Russia's market integration (in percentage terms)

| Region | Integrated with | Conditionally integrated with | Tending towards integration with | Not integrated with | Diverging with |
|---|---|---|---|---|---|
| 1. Rep. of Karelia | 15.4 | 50.0 | 2.6 | 32.1 | 3.8 |
| 2. Rep. of Komi | 14.1 | 38.5 | 2.6 | 44.9 | 6.4 |
| 3. Arkhangelsk Obl. | 15.4 | 16.7 | 2.6 | 65.4 | 17.9 |
| 4. Vologda Obl. | 17.9 | 25.6 | 1.3 | 55.1 | 7.7 |
| 5. Murmansk Obl. | 7.7 | 35.9 | 5.1 | 51.3 | 1.3 |
| 6. St. Petersburg City | 12.8 | 30.8 | 3.8 | 52.6 | 9.0 |
| 7. Leningrad Obl. | 20.5 | 46.2 | 5.1 | 28.2 | 12.8 |
| 8. Novgorod Obl. | 28.2 | 34.6 | 1.3 | 35.9 | 6.4 |
| 9. Pskov Obl. | 19.2 | 9.0 | 9.0 | 62.8 | 29.5 |
| 10. Kaliningrad Obl. | 16.7 | 32.1 | 2.6 | 48.7 | 1.3 |
| 11. Bryansk Obl. | 25.6 | 23.1 | 2.6 | 48.7 | 5.1 |
| 12. Vladimir Obl. | 28.2 | 19.2 | 3.8 | 48.7 | 5.1 |
| 13. Ivanovo Obl. | 23.1 | 16.7 | 3.8 | 56.4 | 3.8 |
| 14. Kaluga Obl. | 20.5 | 14.1 | 7.7 | 57.7 | 11.5 |
| 15. Kostroma Obl. | 42.3 | 33.3 | 0.0 | 24.4 | 10.3 |
| 16. Moscow City | 10.3 | 10.3 | 16.7 | 62.8 | 1.3 |
| 17. Moscow Obl. | 19.2 | 25.6 | 7.7 | 47.4 | 5.1 |
| 18. Oryol Obl. | 34.6 | 28.2 | 5.1 | 32.1 | 6.4 |
| 19. Ryazan Obl. | 29.5 | 25.6 | 0.0 | 44.9 | 15.4 |
| 20. Smolensk Obl. | 20.5 | 30.8 | 2.6 | 46.2 | 10.3 |
| 21. Tver Obl. | 20.5 | 24.4 | 1.3 | 53.8 | 6.4 |
| 22. Tula Obl. | 25.6 | 19.2 | 3.8 | 51.3 | 7.7 |
| 23. Yaroslavl Obl. | 19.2 | 20.5 | 3.8 | 56.4 | 15.4 |
| 24. Rep. of Mariy El | 23.1 | 35.9 | 1.3 | 39.7 | 6.4 |
| 25. Rep. of Mordovia | 25.6 | 28.2 | 1.3 | 44.9 | 17.9 |
| 26. Chuvash Rep. | 17.9 | 39.7 | 2.6 | 39.7 | 5.1 |
| 27. Kirov Obl. | 29.5 | 24.4 | 1.3 | 44.9 | 15.4 |

| Region | Integrated with | Conditionally integrated with | Tending towards integration with | Not integrated with | Diverging with |
|---|---|---|---|---|---|
| 28. Nizhni Novgorod Obl. | 24.4 | 29.5 | 0.0 | 46.2 | 14.1 |
| 29. Belgorod Obl. | 24.4 | 30.8 | 1.3 | 43.6 | 17.9 |
| 30. Voronezh Obl. | 46.2 | 25.6 | 0.0 | 28.2 | 10.3 |
| 31. Kursk Obl. | 6.4 | 3.8 | 0.0 | 89.7 | 26.9 |
| 32. Lipetsk Obl. | 11.5 | 35.9 | 0.0 | 52.6 | 19.2 |
| 33. Tambov Obl. | 15.4 | 33.3 | 6.4 | 44.9 | 7.7 |
| 34. Rep. of Kalmykia | 17.9 | 11.5 | 7.7 | 62.8 | 0.0 |
| 35. Rep. of Tatarstan | 20.5 | 23.1 | 3.8 | 52.6 | 1.3 |
| 36. Astrakhan Obl. | 20.5 | 15.4 | 2.6 | 61.5 | 10.3 |
| 37. Volgograd Obl. | 25.6 | 26.9 | 2.6 | 44.9 | 7.7 |
| 38. Penza Obl. | 19.2 | 25.6 | 0.0 | 55.1 | 17.9 |
| 39. Samara Obl. | 20.5 | 11.5 | 10.3 | 57.7 | 6.4 |
| 40. Saratov Obl. | 15.4 | 7.7 | 0.0 | 76.9 | 7.7 |
| 41. Ulyanovsk Obl. | 21.8 | 24.4 | 0.0 | 53.8 | 9.0 |
| 42. Rep. of Adygeya | 26.9 | 14.1 | 1.3 | 57.7 | 7.7 |
| 43. Rep. of Dagestan | 12.8 | 10.3 | 9.0 | 67.9 | 7.7 |
| 44. Rep. of Ingushetia | 57.7 | 30.8 | 1.3 | 10.3 | 3.8 |
| 45. Kabardian-Balkar Rep. | 28.2 | 24.4 | 1.3 | 46.2 | 7.7 |
| 46. Karachaev-Cirkassian Rep. | 32.1 | 21.8 | 3.8 | 42.3 | 6.4 |
| 47. Rep. of Northern Ossetia | 17.9 | 16.7 | 6.4 | 59.0 | 5.1 |
| 48. Krasnodar Krai | 21.8 | 24.4 | 0.0 | 53.8 | 9.0 |
| 49. Stavropol Krai | 24.4 | 23.1 | 1.3 | 51.3 | 7.7 |
| 50. Rostov Obl. | 28.2 | 20.5 | 2.6 | 48.7 | 3.8 |
| 51. Rep. of Bashkortostan | 23.1 | 32.1 | 3.8 | 41.0 | 2.6 |
| 52. Udmurt Rep. | 33.3 | 28.2 | 1.3 | 37.2 | 5.1 |
| 53. Kurgan Obl. | 30.8 | 30.8 | 7.7 | 30.8 | 3.8 |
| 54. Orenburg Obl. | 23.1 | 33.3 | 1.3 | 42.3 | 3.8 |
| 55. Perm Krai | 32.1 | 41.0 | 2.6 | 24.4 | 2.6 |
| 56. Sverdlovsk Obl. | 20.5 | 33.3 | 3.8 | 42.3 | 9.0 |
| 57. Chelyabinsk Obl. | 39.7 | 35.9 | 5.1 | 19.2 | 3.8 |
| 58. Rep. of Altai | 15.4 | 19.2 | 3.8 | 61.5 | 21.8 |
| 59. Altai Krai | 34.6 | 30.8 | 14.1 | 20.5 | 1.3 |
| 60. Kemerovo Obl. | 44.9 | 28.2 | 3.8 | 23.1 | 6.4 |
| 61. Novosibirsk Obl. | 20.5 | 17.9 | 6.4 | 55.1 | 19.2 |
| 62. Omsk Obl. | 26.9 | 43.6 | 1.3 | 28.2 | 10.3 |
| 63. Tomsk Obl. | 29.5 | 33.3 | 2.6 | 34.6 | 10.3 |
| 64. Tyumen Obl. | 10.3 | 42.3 | 21.8 | 25.6 | 2.6 |
| 65. Rep. of Buryatia | 32.1 | 30.8 | 0.0 | 37.2 | 2.6 |
| 66. Rep. of Tuva | 33.3 | 42.3 | 3.8 | 20.5 | 1.3 |
| 67. Rep. of Khakasia | 33.3 | 29.5 | 3.8 | 33.3 | 6.4 |
| 68. Krasnoyarsk Krai | 17.9 | 41.0 | 3.8 | 37.2 | 2.6 |
| 69. Irkutsk Obl. | 34.6 | 50.0 | 2.6 | 12.8 | 9.0 |
| 70. Transbaikal Krai | 30.8 | 55.1 | 2.6 | 11.5 | 5.1 |
| 61. Rep. of Sakha (Yakutia) | 0.0 | 62.8 | 3.8 | 33.3 | 14.1 |
| 72. Jewish Autonomous Obl. | 9.0 | 41.0 | 3.8 | 46.2 | 7.7 |
| 73. Chukotka A.O. | 0.0 | 44.9 | 26.9 | 28.2 | 0.0 |
| 74. Primorsky Krai | 1.3 | 17.9 | 2.6 | 78.2 | 41.0 |
| 75. Khabarovsk Krai | 1.3 | 20.5 | 2.6 | 75.6 | 57.7 |
| 76. Amur Obl. | 14.1 | 23.1 | 1.3 | 61.5 | 24.4 |
| 77. Kamchatka Krai | 1.3 | 55.1 | 26.9 | 16.7 | 0.0 |
| 78. Magadan Obl. | 1.3 | 43.6 | 1.3 | 53.8 | 29.5 |
| 79. Sakhalin Obl. | 0.0 | 34.6 | 5.1 | 60.3 | 2.6 |
| **Total** | 21.7 | 28.8 | 4.2 | 45.3 | 9.7 |

Obl. = Oblast, Rep. = Republic, and A.O. = Autonomous Okrug.

Among all region pairs, 51% are integrated or conditionally integrated. Adding pairs tending towards integration, we get the total of 55%. Unfortunately, there is no possibility to immediately compare these results with other countries, since a similar analysis has not been performed so far for any country. An indirect comparison can be done with results in Ceglowski (2003), who applies a model of form (2) to analyze prices for 45 individual goods across 25 cities in Canada (using Ottawa as a benchmark city). Averaging results reported in Ceglowski (2003, Table 2) over all covered goods, the percentage of cities integrated and conditionally integrated with Ottawa equals 55%. Based on this figure, it seems that the state of spatial market integration in Russia can be deemed more or less satisfactory. There is one more consideration in favor of such a conclusion. This study uses a 'tough' strategy of unit root testing (see Appendix). Be a 'softer' strategy applied (like that in Ceglowski, 2003, or Gluschenko, 2011), the proportion of perfectly and conditionally integrated region pair would equal 71.4% (with pair tending towards integration, 76.2%; see the next section).

Given long distances between many regions of Russia and supposing that constant price disparities are due to transportation costs only, it is reasonable to expect that conditional integration would prevail. This is, indeed, the case; the number of conditionally integrated region pairs is greater by the factor of 1.3 than the number of perfectly integrated ones. Figure 3 plots distributions of the degree of perfect integration (left panel) and degree of both perfect and conditional integration in total (right panel) in the form of histograms. The degree of perfect integration and the like is the percentage of regions that are perfectly integrated (and the like) with a given one. Herefrom, $[x, y)$ is the interval within which a percentage, $Z$, lies: $x \leq Z < y$.

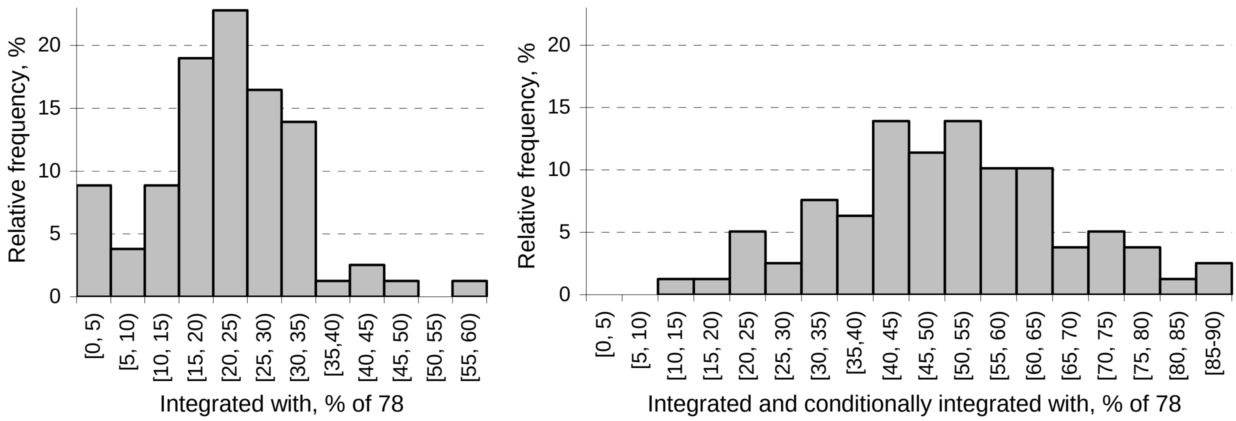



**Figure 3.** Distributions of the degree of perfect integration and degree of both perfect and conditional integration.

The histogram bar [0, 5) in the left panel of Figure 3 suggests that there are 8.9% of regions (7 regions of 78) 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 20% to 25% of other regions; there are 22.8% 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 (the right panel of Figure 3), the ‘worst’ case is 10% to 15%; hence there are no regions without conditional integration with other ones. The maximum is 88.5%. Note that each region is herein taken twice, in pairs (*r*, *s*) and (*s*, *r*). That is why this figure exceeds the total percentage of perfectly and conditionally integrated pairs in Table 1. Specific regions that determine the left-most and right-most bars in these and next histograms will be specified below.

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 4.2% of region pairs. Figure 4 plots distribution of the degree of tending towards integration. The most cases are concentrated in the range of 0 to 5%, making up 74.5%. Of them, cases of no convergence give14.1%; price convergence with one region gives 20.5%.

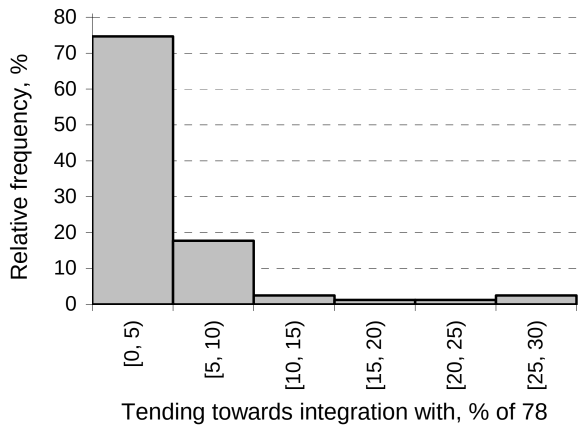



**Figure 4.** Distribution of the degree of tending towards integration.

The left panel of Figure 5 plots the distribution of the degree of non-integration. (Recall that non-integration means here that a region pair not only is not integrated, perfectly or conditionally, but also does not tend towards integration.) There are no regions with this degree less than 10%. The range of the degree of non-integration is very wide, running to 89.7%.

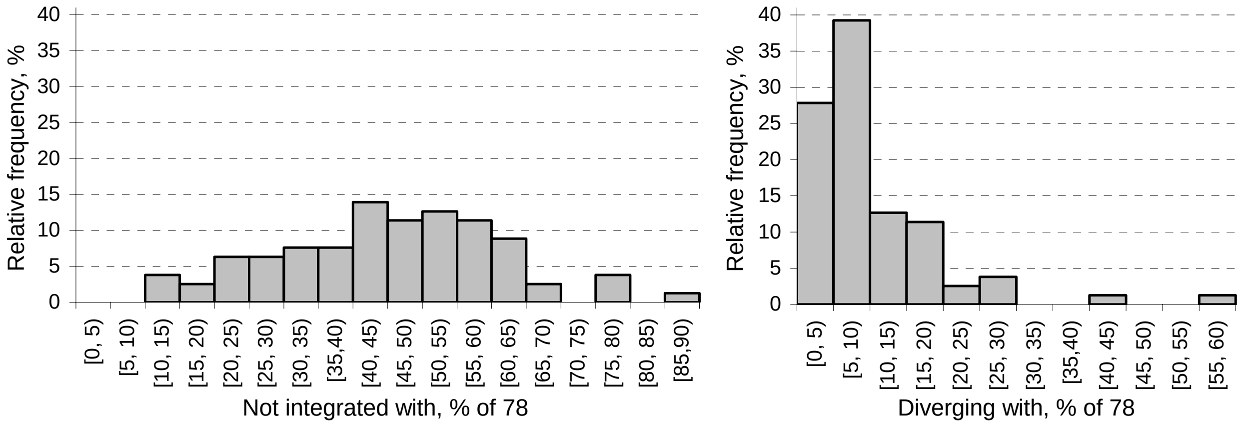



**Figure 5.** Distributions of the degree of non-integration and degree of divergence.

An unpleasant feature of non-integration is a significant proportion of price divergence. As mentioned above, the number of cases of divergence actually may be more, since only those are detected that satisfy Equation (3) with ‘incorrect’ sign of estimated parameter $\delta$. The cases of divergence are more than twice as much as the cases of convergence. Price divergence is responsible for 21.4% of non-integration. The right panel of Figure 5 plots the distribution of the degree of divergence. Only three regions diverge with no one other. The most frequent case is price divergence with 5% to 10% of regions; it occurs in 39.2% of regions. A third of regions (33%) diverge with a greater number of other regions, up to 57.7% of them. Although, only two regions diverge with more than 30% of other ones.

Figure 6 relates the results to geography, mapping ‘integration rates’ of regions, that is, the total percentage (as a range) of regions with which a given region is perfectly and conditionally integrated and tends towards integration. Note that the ‘integration rate’ is reverse to the degree of non-integration (column “Not integrated with” in Table 1 and the left panel of Figure 5), equaling 100% minus this degree.

The European part of Russia comprises 57 regions westward from the Tyumen Oblast (numbered as 64); the rest – 22 regions – is the Asian part of the country. In turn, it consists of Siberia and the Russian Far East. Siberia comprises regions from the Tyumen Oblast (including it) eastward up to the western border of Yakutia (region 71) and the Amur Oblast (region 76). Regions to the east of this border belong to the Russian Far East.

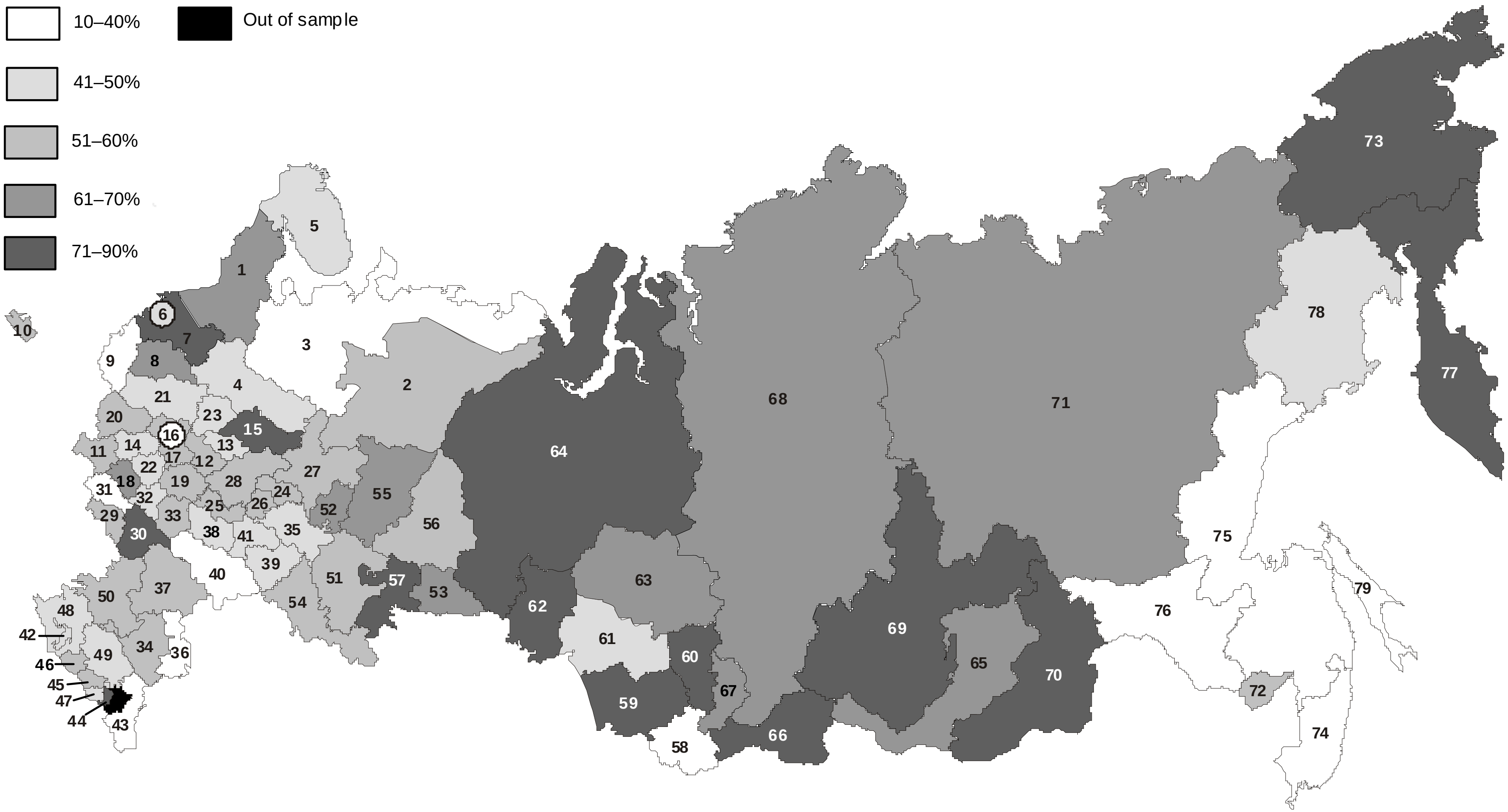



**Figure 6.** Geography of market integration in Russia: 'integration rates' of country's regions.

See Table 1 for numerical designations of regions.

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). The rest regions – except for the Novosibirsk Oblast (region 61) – range between 65.4% and 79.5%. Poor integration of Far Eastern regions is quite expectable. Surprisingly, one of the most remote and difficult-to-access regions, Kamchatka (region 77) has ‘integration rates’ of 83.3%.

Table 2 lists the ‘best’ and ‘worst’ regions with respect to different aspects of market integration. Values are expressed in percentage (of 78 regions).

**Table 2.** Ranking of regions by different indicators of market integration (percentages)

| The most integrated region | Perfectly integrated with | The least integrated region | Perfectly integrated with |
|---|---|---|---|
| 44. Rep. of Ingushetia | 57.7 | 61. Rep. of Sakha (Yakutia) | 0 |
| 30. Voronezh Obl. | 46.2 | 73. Chukotka A.O. | 0 |
| 60. Kemerovo Obl. | 44.9 | 79. Sakhalin Obl. | 0 |
| 15. Kostroma Obl. | 42.3 | 74. Primorsky Krai | 1.3 |
| 57. Chelyabinsk Obl. | 39.7 | 75. Khabarovsk Krai | 1.3 |
| | | 77. Kamchatka Krai | 1.3 |
| | | 78. Magadan Obl. | 1.3 |
| **The most integrated and conditionally-integrated region** | **Perfectly and conditionally integrated with** | **The least integrated and conditionally-integrated region** | **Perfectly and conditionally integrated with** |
| 44. Rep. of Ingushetia | 88.5 | 31. Kursk Obl. | 10.3 |
| 70. Transbaikal Krai | 85.9 | 74. Primorsky Krai | 19.2 |
| 69. Irkutsk Obl. | 84.6 | 16. Moscow City | 20.5 |
| 15. Kostroma Obl. | 75.6 | 75. Khabarovsk Krai | 21.8 |
| 57. Chelyabinsk Obl. | 75.6 | 40. Saratov Obl | 23.1 |
| 66. Rep. of Tuva | 75.6 | 43. Rep. of Dagestan | 23.1 |
| **The least non-integrated region** | **Not integrated with** | **The most non-integrated region** | **Not integrated with** |
| 44. Rep. of Ingushetia | 10.3 | 31. Kursk Obl. | 89.7 |
| 70. Transbaikal Krai | 11.5 | 74. Primorsky Krai | 78.2 |
| 69. Irkutsk Obl. | 12.8 | 40. Saratov Obl | 76.9 |
| 77. Kamchatka Krai | 16.7 | 75. Khabarovsk Krai | 75.6 |
| 57. Chelyabinsk Obl. | 19.2 | 43. Rep. of Dagestan | 67.9 |

Obl. = Oblast, Rep. = Republic, and A.O. = Autonomous Okrug.

The data in the upper panel of Table 2 look reasonable. Regarding its left part, the most integrated regions are from the European part of Russia, except for the Kemerovo Oblast from

Siberia. The rightmost histogram bar in the left panel of Figure 3 is due to Ingushetia; the next four regions form the three preceding bars. As for the least integrated regions, all they are remote Far Eastern regions; hence, perfect integration can hardly occur there. It is these seven regions that form the leftmost histogram bar in the left panel of Figure 3.

The first two regions in the left part of the middle panel of Table 2 form the rightmost histogram bar in the right panel of Figure 3. Interestingly, one of them (the Transbaikal Krai) is a Far Eastern region. There are also two Siberian regions in the list. Thus, a half of regions perfectly or conditionally integrated with the most number of other regions are from the Asian part of Russia. Turning to the right part of this panel, the presence of Far Eastern regions (the Primorsky and Khabarovsk *krais*) looks reasonable. However, four regions here are from the European part of the country. The 'worst' is the Kursk Oblast (the leftmost histogram bar in the right panel of Figure 3 is due to it only). As for the Moscow, its market is known for many and varied impediments to access to it, at least in the early 2000s.

The lower panel of Table 2 deals with the absence of perfect and conditional integration as well as the movement to integration, which is reverse to the 'integration rate.' The first three regions from this list form the leftmost histogram bar in the left panel of Figure 5. The 'worst' regions in the right part of the lower panel of Table 2 are the same as in its middle panel. Moscow is not present here because of convergence with 16.7% of regions. No one case of price convergence with other regions is observed in the Kursk and Saratov *oblasts* (it is the Kursk Oblast that forms the rightmost histogram bar in the left panel of Figure 5). Convergence with two regions occurs in the Khabarovsk and Primorsky *krais*. The Republic of Dagestan converges with seven regions. Contrastingly, price divergence is widespread among these regions; three of them diverge with 26.9% to 57.7% of other regions. The Khabarovsk Krai forms the rightmost histogram bar in the right panel of Figure 4, diverging with more than a half of regions.

## 5. 2001–2015 vs. 1994–2000

As it is mentioned in Introduction, Gluschenko (2011) reports a spatial pattern of market integration in Russia in 1994–2000 relative to a benchmark region. It would be interesting to compare this with the pattern obtained for 2001–2015. Unfortunately, these two analyses are not fully comparable.

First, they differ in 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 in the number of goods, but also in their quantities across the baskets. Besides, the price data for 1994–

2000 are those collected in capital cities of regions, whereas the data for 2001–2015 are regional averages (to be exact, averages over cities/towns where prices are being observed by the official statistics in a given region). 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 uses a benchmark region, exploits the general-to-specific approach, and classes conditionally integrated region pairs as non-integrated (since most price disparities were so great that could not be assigned to transportation costs only). However, Table A2 in Gluschenko (2011) reports results of estimation across all region pairs, using these to select the 'best' benchmark region.[2] Besides, 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.

Third, Gluschenko (2011) uses a different strategy of testing for unit roots (see Appendix for details). It makes it possible to reject unit roots more frequently than under the strategy applied in this study. For the sake of comparability, results for 2001–2015 have been reestimated with the use of the same unit root tests as in Gluschenko (2011).

Table 3 compares summarized patterns obtained for 1994–2000 and 2001–2015 within the framework of both specific-to-general and general-to-specific approaches. Results for 2001–2015 are those obtained under the same strategy of testing for unit roots as has been used for the 1994–2000 analysis (actual results from Table 1 are in parentheses).

**Table 3.** Comparison of integration patterns for 1994–2000 and 2001–2015, percentage of region pairs

| Group of region pairs | Specific to general | | General to specific | |
|---|---|---|---|---|
| | 1994–2000 | 2001–2015 | 1994–2000 | 2001–2015 |
| Perfectly integrated | 54.7 | 26.8 (21.7) | 25.8 | 8.6 (12.1) |
| Conditionally integrated | 29.2 | 44.6 (28.8) | 32.6 | 30.7 (22.9) |
| Tending towards integration | 11.3 | 4.7 (4.2 ) | 34.3 | 18.4 (11.0) |
| **Total** | **95.2** | **76.2 (54.7)** | **92.7** | **57.7 (46.0)** |
| Non-integrated | 4.8 | 23.8 (45.3) | 7.3 | 42.3 (54.0) |
| Out of these, diverging | 1.1 | 11.0 (9.7) | 3.6 | 29.5 (18.4) |

There is a great difference between the periods of 1994–2000 and 2001–2015. Prior to 1992, the overwhelming part of consumer prices in Russia was centrally-fixed; in January 1992, they were liberalized (decontrolled). However, no market institutions existed by that time; the wholesale trade

[2] It is worth noting that the Saratov Oblast was chosen, as it generated the greatest number of integrated region pairs. In 2001–2015, this region turns out to be the third 'worst.' This is one more argument against the benchmark approach.

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 goods arbitrage came into play since about 1994. Beginning in that year, improvement in integration of Russia's regional market was observed. The period of 1994–2000 was that of further transition from centrally-planned to market economy; 'artificial' barriers to inter-regional trade becoming progressively lowered (Gluschenko, 2010). In 2001–2015, 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.

Therefore, one would expect integration in 1994–2000 to be poorer than in 2001–2015 (with a greater number of region pairs tending towards integration). Surprisingly, this is not the case. The 'integration rate' in 1994–2000 is significantly higher, exceeding 90% under both approaches. The use of the general-to-specific approach decreases the 'integration rate' by only 2.5 percent points. If this approach would be applied to obtain the 2001–2015 pattern, the 'integration rate' dropped by 18.5 percent points, to 58%. As expected, the share of region pairs tending towards integration is greater in 1994–2000. However, this is not the reason for higher 'integration rate;' the share of perfectly and conditionally integrated pairs is also greater in 1994–2000: 86.6% as compared to 71.4% in 2001–2015 (58.4% vs. 39.3%, respectively, under the general-to-specific approach). The most unexpected feature is widespread perfect integration in 1994–2000. The percentage of perfectly integrated pairs in that period is twice (or even three times) as much as in 2001–2015. 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 18.5% of 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 effect of the 1998 financial crisis in Russia. It caused structural breaks in many time series of price differentials; the breaks were distributed over August 1998 through January 1999. Thus, the after-break time span is rather short, containing 22 to 29 points in time. This would have prevented revealing actual behavior of price differentials after the break that differed significantly from the 'pre-break' behavior, overstating the 'integration rate.'

However, these factors could provide only partial explanation. In general, reasons of poorer integration in 2001–2015 as compared with 1994–2000 are unclear. This relates specifically to the disintegration tendency stretching over more than a tenth of region pairs in 2001–2015. More detailed and deeper study is needed to explain reasons behind the obtained pattern of market integration.

## 6. Conclusion

Using the cost of the basket of 33 basic food goods as the price representative, the spatial pattern of market integration in Russia in 2001–2015 was analyzed. It was found that about 71% of region pairs in Russia could be deemed integrated or conditionally integrated, and about 5% could be classified as tending towards integration with each other. An unpleasant feature in the pattern obtained is a significant share (11%) of region pairs inclined to disintegration, i.e. exhibiting price divergence.

There are a number of poorly integrated regions in the European part of Russia. This seems strange from the viewpoint of their favorable geographical positions. Intuitive considerations suggest that market integration in Russia in 2001–2015 should be stronger than in 1994–2000, when transition from centrally-planed to market economy was in progress. Surprisingly, this has not been confirmed. Further research has to find explanation of this fact as well as reasons for incomprehensible features of the pattern obtained.

## Acknowledgements

The helpful comments of participants at the conference "Spatial Analysis of Socio-Economic Systems: History and Current State" (Novosibirsk, 2016) and the Third Russian Economic Congress (Moscow, 2016) are gratefully acknowledged. Thanks are also due to Natalia Budkina for research assistance.

## Appendix. Technical details of unit root testing

For testing the unit root hypotheses, $H_0$: $\lambda = 0$ (against $\lambda < 0$), the *t*-statistic of $\lambda$ is used, $\tau = \lambda/\sigma_\lambda$ (because of the nonstandard distributions, it is denoted $\tau$, and not *t*). Two tests employed take account of possible autocorrelation of a form other than AR(1), the augmented Dickey-Fuller (ADF) test and Phillips-Perron test.

The ADF test uses an auxiliary regression which includes additional lags of the dependent variable. A modified Bayesian (Schwarz) information criterion with a sample-dependent penalty factor serves for choosing the optimal lag length. This modification is due to Ng and Perron (2001), who note that the ‘ordinary’ information criteria tend to select lag lengths that are generally too small for unit root tests to have good sizes. The lag length varies in the auxiliary regressions from 0 to $K_{\max} = [12(T/100)^{1/4}]$, where $[\cdot]$ stands for integer part. At the same time, the number of effective observations is fixed (according to Ng and Perron, 2005), equaling $T - 1 - K_{\max}$. Then the reestimation of auxiliary regression with the optimal number of lags and actual number of observations yields the adjusted value of $\lambda$ and, in turn, $\tau$. Note that the auxiliary regression is merely technical: it is used only for obtaining adjusted value of $\tau$. The estimates of $\lambda$ and other regression parameters should be taken from the original regression.

In contrast to the ADF test, the Phillips-Perron test adjusts values of $\sigma_\lambda$ rather than $\lambda$. It is known that the Phillips-Perron test may suffer from size distortions. As Perron and Ng (1996) find, this may be avoided with the use of an autoregressive spectral density estimator instead of kernel-based estimators. Therefore, the OLS (not-detrended) autoregressive spectral method is applied in this study. In doing so, the lag length selection method is the same as described above for the ADF test.

Gluschenko (2011) uses a different strategy of testing for unit roots. First, he applies the ‘ordinary’ Bayesian (Schwarz) information criterion for selection of lag lengths in the ADF test. Second, he employs the Phillips-Perron test based on the Bartlett spectral kernel. Under such a strategy, the unit root tests more frequently reject nonstationarity than those used in this study.

Although distributions of the test statistic $\tau$ are nonstandard, they are documented in the literature (e.g., MacKinnon, 1996) for the cases of Equations (1) and (2) as well as for equations with linear and quadratic trends. These distributions (known as the Dickey-Fuller distributions) are a built-in tool of different econometric packages. As for Equation (3) with different nonlinear trends, there are no ready-to-use distributions. To derive them, the empirical distributions of $\tau$ under the null hypothesis of random walk have been estimated with the use of the Monte Carlo method with 1,000,000 replications. Table A1 reports selected critical values of the $\tau$-statistics for equations with trends, (3a)–(3c), and sample size $T = 180$. Figure A1 plots the 10-percent tails of the distributions, comparing them with the Dickey-Fuller distributions for the cases of linear and quadratic trends.

**Table A1.** Selected critical values of the unit root test $\tau$-statistics for Equation (3)

| Significance level | Log-exponential trend (8a) | Exponential trend (8b) | Fractional trend (8c) |
|---|---|---|---|
| 0.1% | –4.528 | –4.463 | –6.616 |
| 1% | –3.848 | –3.865 | –5.162 |
| 5% | –3.230 | –3.279 | –3.825 |
| 10% | –2.908 | –2.974 | –3.302 |
| 20% | –2.522 | –2.614 | –2.796 |

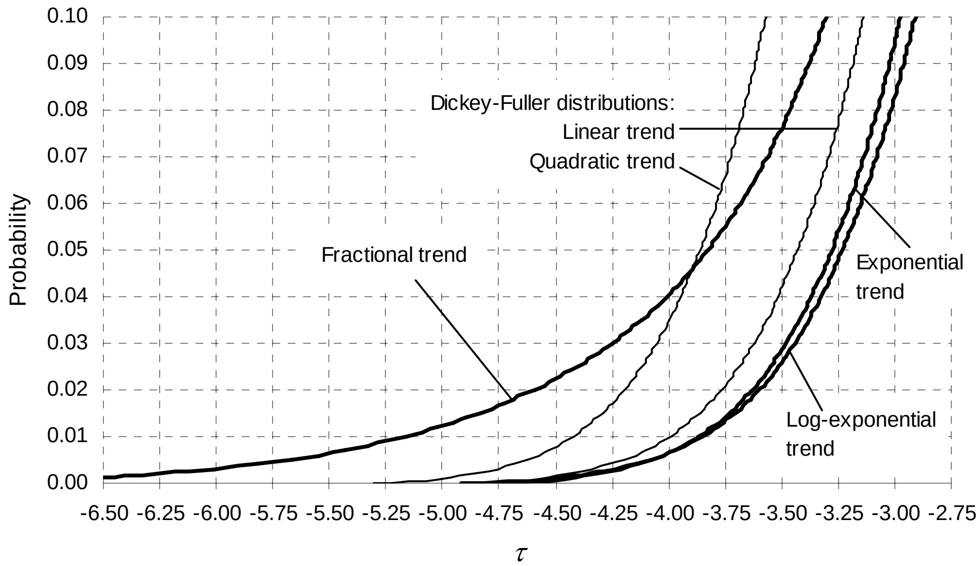



**Figure A1.** Distributions of $\tau$-statistics for Equation (3) and selected Dickey-Fuller distributions.

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