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The Moscow market in country's economic space

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This paper studies integration of the Moscow market for final goods with markets of all other Russian regions. It considers an aggregated market represented by a minimum food basket. The law of one price serves as a criterion of market integration. It is a base for constructing time series models of the regional costs of the staples basket over 2001–2015 relative to its cost in Moscow. Regional markets are divided into four groups: integrated with the Moscow market, conditionally integrated with it, not integrated but tending towards integration with the Moscow market, and neither integrated nor tending towards integration. Nonlinear time series models with asymptotically decaying trends describe the movement towards integration (price convergence).

Keywords: market integration, law of one price; price convergence; nonlinear trend; Russian regions.
JEL classification: C32, L81, P22, R15

1. Introduction

The question of whether the Russian economic space is single still keeps topicality. As Biyakov (2004) shows, there is no a uniform concept of the economic space and, all the more so, its unity. However, despite all differences in versions of the concept of ‘single economic space,’ it is obvious that it should be sure to imply the absence of barriers (except for ‘natural,’ geographically determined ones) to inter-regional trade, or, in other words, spatial integration of product markets. It may be said that spatial integration is the pivot of single economic space.

The Moscow market keeps aloof in the system of Russian regions. As it is known, prices in Moscow are significantly higher than in the neighboring regions, even than those in the Moscow Oblast.[1] Seemingly, this provides an excellent opportunity for profit earning through buying goods in regions where they are cheaper and selling them in Moscow. Goods arbitrage is a mechanism of the establishment and maintenance of 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, in the absence of impediments to inter-regional trade, the price of the same tradable good should be equal across all regions. (The tradable goods are those that can take part in inter-regional trade.) 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). But since prices in Moscow do not equalize with prices even in neighboring regions, this implies that there are considerable impediments to goods arbitrage in the Moscow market.[2]

It is interesting to find out in this connection the position of the Moscow market in the economic space of Russia, i.e., to perform analysis of its integration with other country’s regions. Taking a market for an aggregated good, a minimum food basket (staples basket), time series of differences in the cost of the basket in Moscow and other regions over 2001–2015 are analyzed. The law of one price serves as a criterion of market integration. Regional markets are divided into four groups. The first group consists of regional markets that are integrated with the Moscow market, i.e., where the law of one price holds in the strict form. The second group includes markets that are conditionally integrated with the Moscow market, i.e., where the weak law of one price holds (the next section explains why integration is deemed conditional

[1] It is worth noting that the Russian Statistical Agency, Rosstat, collects prices only in ordinary shops and markets, and not in ‘boutiques’ and other ‘elite’ outlets.

[2] The press provides a multitude of examples of such impediments: discriminatory policy of retail networks, policy of the Moscow government with respect to retail trade, activity of organized crime, etc. However, these are merely particular and odd examples; attempts to find a systematic study of features of the Moscow market for consumer goods in the literature have not met with success.

in this case). The third group is comprised of markets that are not integrated with the Moscow market but tending towards integration with it, i.e., where convergence of prices in Moscow and a given region takes place. Nonlinear time series models with asymptotically decaying trends describe the movement towards integration (price convergence). At last, the fourth group consists of markets that are neither integrated nor tending towards integration with the Moscow market.

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, applying a time series model with a nonlinear trend (the argument of which is the lag of the relative price rather than time). A similar methodology is used in Lau and Akhmedjonov (2012), where convergence of aggregated (relative) prices for outer clothing across 44 regions of Russia in 2002–2009 is explored.

This paper contributes to the above literature, analyzing for the first time integration of the Moscow market with markets of other country's regions (it is interesting to note that Moscow – along with a few other regions – is not infrequently excluded from the spatial sample in regional studies as an 'outlier'). The main findings are as follows:

– the Moscow market is very poorly integrated with markets of other regions (with a one fifth of them);

– at the same time, a trend to the improvement of integration is observed: prices in approximately 15% of the Russian regions converge with the Moscow prices.

2. Methodology

Let p_{rt} and p_{st} be prices for a tradable good in regions r and s, respectively, at time point t. The law of one price is formalized as $p_{rt}/p_{st} = 1$ for all $t = 0,\ldots, T$ and a region pair (r, s). Describe $P_{rst} = \ln(p_{rt}/p_{st})$ as the price differential (or price disparity, since $P_{rst} \approx p_{rt}/p_{st} - 1$). Then the law of one price takes the form $P_{rst} = 0$. In reality, if the law holds, prices in regions r and s coincide accurate to random shocks ν_t (to economize notation, the region indices for disturbances and model parameters are suppressed). It is reasonable to assume the prices, hence, their disparity, to depend on their previous values, i.e. to be autocorrelated. Then the econometric model of the law of one price is the autoregression model AR(1) $P_{rst} = \nu_t, \nu_t = (\lambda + 1)\nu_{t-1} + \varepsilon_t$, where $\lambda + 1 = \rho$ is the autoregression coefficient and ε_t is the Gaussian white noise. Substituting the second equation into the first one and denoting $\Delta P_{rst} \equiv P_{rst} - P_{rs,t-1}$, we get the canonical form of the AR(1) model with no constant (hereafter, $t = 1,\ldots,T$):

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

The law of one price holds if time series P_{rst} is stationary (contains no unit root). In this case, markets of regions r and s are deemed perfectly integrated with each other. It is worth noting that integration of spatially separated markets does not necessarily implies that there are trade flows between them; it is the *potential* possibility of unimpeded trade between these markets that is important.

The presence of transportation costs in prices of the goods can result in time-invariant price disparity. A weak version of the law of one price in the form $P_{rst} = C_{rs}$ describes this case (other versions are possible, e.g., $C_{(-)rs} \le P_{rst} \le C_{(+)rs}$, which leads to a threshold autoregression model). Based on the same considerations as above, we get the 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 (statistically significant) constant. In this case, markets of regions r and s are deemed conditionally integrated with each other. Disparity C_{rs} quantifies arbitrage transaction costs. However, in the framework of time series analysis, it is impossible to reveal the nature of C_{rs}. They can, indeed, reflect transportation costs only, but it can also include also effects due to 'artificial' or eliminable (in principle) impediments to integration. The former includes regional protectionism, local price regulations, organized crime,[3] etc. The latter is features of local markets that determine 'nontradable component' of retail prices. That is why the term 'conditional integration' is applied here: markets of regions r and s could be acknowledged as integrated on condition that the disparity is due to transportation costs *only*.

The 'nontradable component' of prices is worth a more detailed consideration. It is the distribution

[3] Gluschenko (2007) describes mechanisms of impact of organized crime on prices for consumer goods.

costs, the lion's share of which being costs of nontradable services. In turn, their most significant parts are labor in trade and the lease of places of business and storage rooms. Computations based on data from Rosstat (2015, pp. 109, 116) suggest that the share of these costs in the distribution costs – averaged over the country and all consumer goods – was equal to 57% in 2014 (out of it, wages with deductions for the social insurance funds gave 35.8%, and rent gave 21.2%). Their proportion of retail prices was 13.7% (as the distribution costs made up 24.1% of the prices). In other words, the labor costs and rent increase retail price by 18.6%. Thus, prices in local markets for labor and real estate significantly influence on retail prices for goods in the region.

If we would restrict our analysis to Models (1) and (2) only, we get a rather poor pattern that ignores transitional processes. Despite markets of regions r and s are not integrated with each other, either perfectly or conditionally, in the time span under consideration, the price disparity can diminish over time (i.e., price convergence takes place). An asymptotically decaying trend of price differential can describe such a process: $P_{rst} = C_{rs}(t)$, $C_{rs}(t) \to 0$ as $t \to \infty$, and $\mathrm{sign}(C_{rs}(0))\cdot dC_{rs}(t)/dt < 0$. Taking account of autocorrelation, we get an AR(1) model with a trend:

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

Two types of trend are applied: exponential trend $C(t) = \gamma e^{\delta t}$, $\delta < 0$, and fractional trend $C(t) = \dfrac{\gamma}{1+\delta t}$, $\delta > 0$. The respective nonlinear models look like:

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

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

Price convergence takes place if time series P_{rst} is stationary about the trend (one of them or both), γ и δ are statistically significant, and parameter δ has the 'correct' sign. Then markets of regions r and s are deemed tending towards integration with each other. Incorrect sign of δ implies price divergence, hence the respective region pair is deemed non-integrated (and diverging). The rate of convergence towards integration (to the strict law of one price) can be characterized by half-life time θ, i.e., time needed for the price difference $p_{rt}/p_{st} - 1$ to halve. For the exponential trend, it equals

$$\theta = \frac{1}{\delta}\ln\left(\frac{\ln(0.5(e^{\gamma}+1))}{\gamma}\right);$$

for the fractional trend, it equals

$$\theta = \frac{1}{\delta}\left(\frac{\gamma}{\ln(0.5(e^{\gamma}+1))} - 1\right).$$

Gluschenko (2011) uses a different trend function, log-exponential trend $C(t) = \log(1 + \gamma e^{\delta t})$, $\delta < 0$.

Its advantage is the ease of interpretation: γ is immediately the initial (at $t = 0$) difference in prices; the half-life time depends only on δ, and in a simple way at that: $\theta = \ln(0.5)/\delta$. However, the log-exponential trend has a crucial shortcoming of not obtaining symmetry properties with respect to permutation of region indices. That is, regressions of P_{rst} and P_{srt} with this trend yield estimates of all parameters (λ,γ, and δ) that differ in absolute values, despite $P_{srt} = -P_{rst}$. This can results in that model AR(1) with the log-exponential trend is accepted for P_{rst} and rejected for P_{srt} (or vice versa), which contradicts common sense. (In this study, this would occur for the pair Moscow – Saint Petersburg.) Contrastingly, in models (3a) and (3b), permutation of region indices changes only the sign of γ, keeping λ and δ (as well as all regression statistics) invariant.

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

Index s in what follows is fixed and corresponds to Moscow which is taken as a benchmark for comparison. Regressions (1), (2), (3a), and (3b) are estimated separately for each region r. The 10% significance level is accepted as a critical level for all parameters and unit root tests. If Models (3a) and (3b) turn out to be completive, the model providing the best fit – namely, the minimal sum of squared residuals – is accepted.

The most important for these regressions is testing time series for stationarity, i.e. the hypothesis tested is whether time series P_{rst} has a unit root, $\lambda = 0$ (against $\lambda < 0$). Its rejection implies that the time series is stationary, fluctuating around its long-run path. Intuitively this means that when a random shock makes the price differential to deviate from the long-run path, market forces return it (after a time) back. Otherwise, if the time series is non-stationary, no return occurs. The long-run path is the price parity, $P^* = 0$, in Model (1), and a time-invariant constant, $P^* = C_{rs}$, in Model (2). In the case of Models (3), the long-run path is trend $C(t)$.

To test for a unit root, the augmented Dickey-Fuller (ADF) test and Plillips-Perron test are applied that take account of possible autocorrelation of a form other than AR(1). The unit root hypothesis is deemed rejected if both tests reject it. Different versions of these tests are possible. In this study, the following options are applied.

To choose the optimal lag length in the auxiliary regressions of the ADF test, the lag length varies from 0 to $K_{\max} = [12(T/100)^{1/4}]$, where $[x]$ stands for integer part of x, whereas the number of included observations remains constant and equals $T - 1 - K_{\max}$ according to Ng and Perron (2005). A modified Bayesian information criterion put forward by Ng and Perron (2001) serves for choosing the optimal lag length in order to avoid size distortions that can be caused by 'ordinary' information criteria (as they tend to select lag lengths that are generally too small). Then the reestimation of the auxiliary regression with the optimal lag length and actual number of observations yields the adjusted value of λ and, in turn, test statistic $\tau = \lambda/\sigma_\lambda$,. Note that the auxiliary regression is purely technical: it is used only for obtaining adjusted value of τ; the estimates of λ and other regression parameters are taken from the original regression.

In contrast to the ADF test, the Phillips-Perron test adjusts values of σ_λ rather than λ. This test is known to suffer from size distortions. These may be avoided with the use of an autoregressive spectral density estimator instead of kernel-based estimators (Perron and Ng, 1996). 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.

The above methods are realizable by choosing respective options for the ADF and Phillips-Perron tests in the EViews package. These standard tools have been employed to test linear Models (1) and (2). For Models (3a) and (3b), nonlinear counterparts of the ADF and Phillips-Perron tests have been developed with similar testing procedures. To obtain distributions of the test statistics for the nonlinear models, τ-statistics have been estimated for sample size $T = 180$ with the use of a sample of 1,000,000 random walks. Figure 1 plots the 10-percent tails of the distributions of these τ-statistics, comparing them with the Dickey-Fuller distributions for the cases of linear and quadratic trends from MacKinnon (1996). Table 1 reports selected critical values of the τ-statistics.

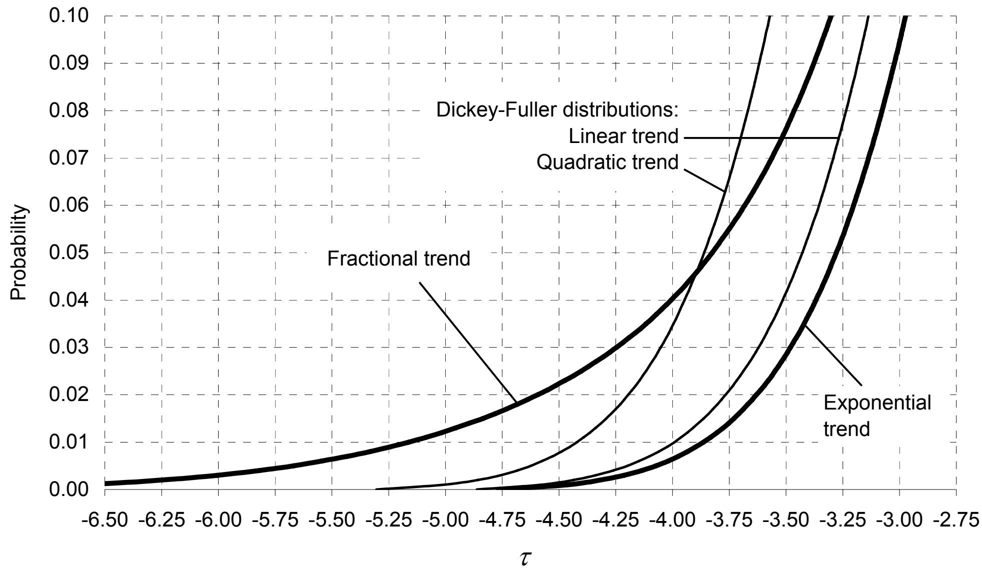

Figure 1. Distributions of τ-statistics for models with nonlinear trends ($T = 180$)

Table 1. Critical values of the unit root test τ-statistics for models with nonlinear trends

Significance level	Exponential trend (3a)	Fractional trend (3b)
0.1%	–4.463	–6.616
1%	–3.865	–5.162
5%	–3.279	–3.825
10%	–2.974	–3.302
20%	–2.614	–2.796

Not infrequently, a time series P_{rst} satisfies more than one model. Then the 'most proper' model is to be selected. Theoretically, one should proceed 'from general to specific,' that is, from the most general Model (3) to Model (2) and then to Model (1), accepting the first significant model in this sequence. However, the reverse sequence, 'specific to general,' seems more reasonable from the intuitive point of view. 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 artifact) rather than by properties of the process itself. Hence, it is logical to accept Model (1). Similarly, when a time series satisfies Equations (3a) or/and (3b) and (2) and/or (1), the reason may be a very weak trend, incidentally manifesting itself in the data. Hence, the model without trend should be accepted. Based on these considerations, the specific-to-general approach is applied in this study.

3. Data

In this study, by a region is meant a federal subject of Russia (among them, the federal cities of Moscow and Saint Petersburg). However, the composite federal subjects (that include or included autonomous *okrugs*, namely, the Arkhangelsk, Tyumen, and Irkutsk *oblasts*, and the Perm, Krasnoyarsk, Transbaikal and Kamchatka *krais*) are considered as single regions, jointly with autonomous *okrugs*. The spatial sample for the analysis covers 79 regions, all Russia's regions but the Chechen Republic (as well as the Republic of Crimea and the city of Sevastopol), where full data on prices are lacking.

A market for an aggregated good, the minimum food basket, is considered. This basket, also known as the staples basket, is used by the Russian Statistical Agency, Rosstat, since 2000. It includes 33 basic foods; quantities of the goods in the basket being uniform across regions and time. Rosstat (2014) reports the composition of the staples basket. The time series of the cost of the staples basket have a monthly frequency and cover January 2001 through December 2015 (180 time observations for each region). The price data are drawn from the Integrated Interagency Informational and Statistical System of Russia (EMISS), https://www.fedstat.ru/indicator/31481.do.

Figure 2 depicts the evolution of the cost of the staples basket in Moscow relative to the Russian average (which is the weighted average over regions with weights being regions' proportions of the national population). In the first three years of the time span under consideration, the relative cost of the basket in Moscow was almost 30% above the Russian average (its annual averages equaling 1.27–1.29). It started fast decreasing after that, reaching the annual average of 1.12. In other words, the cost of the basket rose in 2003–2008 slower than in the country as a whole. During the next three years, it increased again and stabilized since 2012 at the level of circa 1.2 (the annual averages in 2012–2015 equaled 1.18–1.20).[4] Thus, there is no an unambiguous trend in the evolution of the cost of the basket during the period under consideration: convergence of the Moscow prices with the Russian average changes to divergence and then to stabilization.

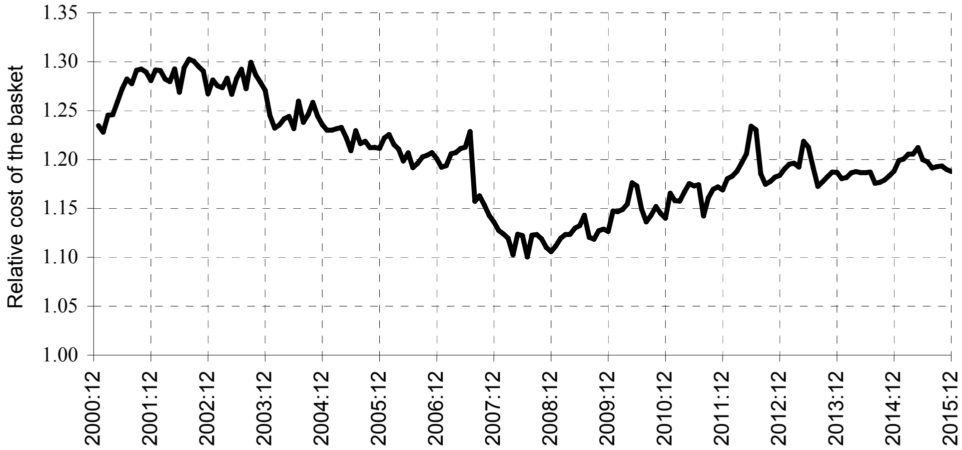

Figure 2. Cost of the minimum food basket in Moscow relative to the Russian average

Figure 3 reports descriptive statistics of the data. It shows the dynamics of the cross-region mean of the price differential $\overline{P_t}$ and the standard deviations of the price differential, $\sigma(P_t)$. The graph of $\overline{P_t}$ suggests the evolution of the price disparity with respect to the Moscow prices. It leads to the same conclusion as the above scrutiny of the evolution of the basket cost in Moscow relative to the Russian average from Figure 2. The point is that this indicator and $\overline{P_t}$ have a similar meaning. Taking $\overline{P_t}$ with the reverse sign and rescaling it, their graphs become very close to each other.

[4] No significant changes occurred in 2016 as well. The annual average of the cost of the basket increased by one percent point relative to the previous year.

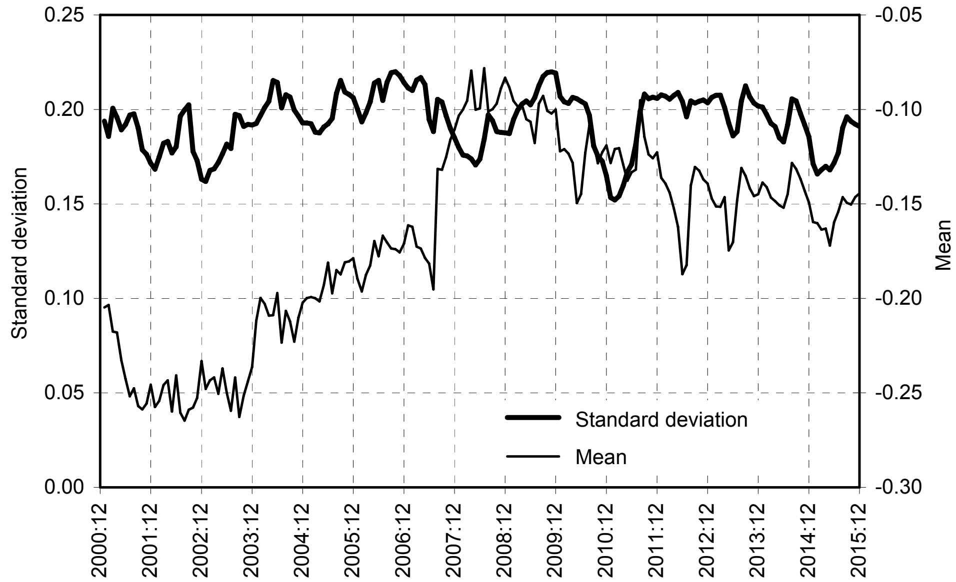

Figure 3. Descriptive statistics of the price differential

The standard deviations of the price differential, if fact, give an idea of dispersion of the cost of the basket in the country excluding Moscow. The evolution of price dispersion suggests the absence of both convergence and divergence of prices between the rest regions. Statistical testing reveals no any trend in $\sigma(P_t)$. The standard deviation fluctuates about the value of 0.194. However, its volatility is fairly high: fluctuations range between –22% to +15%. This can be probably explained by uneven in time and asynchronous across regions inflation. 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).

4. Results

Table 2 reports the results of the econometric analysis. It contains estimates of significant models only (that is, the models with all parameters being statistically significant and a unit root being rejected by both tests); recall that the specific-to-general approach is applied to select models. Appendix reports the full set of estimates of all four models.

As the table suggests, integration of the Moscow market with the rest of Russia is very poor. It is integrated with markets of 16 regions (8 cases of perfect integration and 8 cases of conditional integration) out of 78, or only one fifth (20.6%). Along with this, there is a tendency to improvement in integration: prices in 12 regions of the country (15.4%) converge to the Moscow prices. Certainly, convergence of prices between some region and Moscow does not necessarily imply that it will eventually equalize prices.

Most probably, this process will result (beyond the time span under consideration) in stabilization of the price differential at some nonzero level, i.e. in conditional integration. The convergence rate varies greatly across regions: the half-life time ranges from 1.3 to 29.8 years. In total, integration (perfect and conditional) with the Moscow market and price convergence occur in 28 regions (35.9%). Thus, almost two thirds of regional markets (64.1%) are neither integrated with the Moscow market nor moving towards integration with it. Among them, there is a case of price divergence: the behavior of the price differential between Moscow and the Magadan Oblast obeys the model with the exponential trend (3a) with a positive exponent.

Table 2. Estimation and unit root test results

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		Half-life time, θ (years)
1. Rep. of Karelia	(1)	-0.020	(0.012)	0.100 /0.100					
2. Rep. of Komi	(1)	-0.031	(0.015)	0.035 /0.035					
3. Arkhangelsk Obl.	(1)	-0.020	(0.011)	0.069 /0.069					
4. Vologda Obl.	none								
5. Murmansk Obl.	(1)	-0.046	(0.023)	0.079 /0.091					
6. St. Petersburg City	none								
7. Leningrad Obl.	(1)	-0.016	(0.009)	0.080 /0.080					
8. Novgorod Obl.	none								
9. Pskov Obl	(3a)	-0.135	(0.035)	0.018 /0.050	-0.398^{***}	(0.028)	-0.0098^{***}	(0.0010)	6.8
10. Kaliningrad Obl.	none								
11. Bryansk Obl.	none								
12. Vladimir Obl.	none								
13. Ivanovo Obl.	(3a)	-0.164	(0.041)	0.020 /0.052	-0.369^{***}	(0.019)	-0.0042^{***}	(0.0006)	15.6
14. Kaluga Obl.	(2)	-0.073	(0.028)	0.091 /0.091	-0.018^{***}	(0.007)			
15. Kostroma Obl.	none								
16. Moscow City	Benchmark								
17. Moscow Obl.	none								
18. Oryol Obl.	none								
19. Ryazan Obl.	none								
20. Smolensk Obl.	none								
21. Tver Obl.	none								
22. Tula Obl.	none								
23. Yaroslavl Obl.	none								
24. Rep. of Mariy El	none								
25. Rep. of Mordovia	none								
26. Chuvash Rep.	none								
27. Kirov Obl.	none								
28. Nizhni Novgorod Obl.	none								
29. Belgorod Obl.	none								
30. Voronezh Obl.	none								
31. Kursk Obl.	none								
32. Lipetsk Obl.	none								
33. Tambov Obl.	none								
34. Rep. of Kalmykia	none								
35. Rep. of Tatarstan	(3a)	-0.218	(0.047)	0.016 /0.100	-0.411^{***}	(0.014)	-0.0023^{***}	(0.0004)	29.3
36. Astrakhan Obl.	none								

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		Half-life time, θ (years)
37. Volgograd Obl.	none								
38. Penza Obl.	none								
39. Samara Obl.	(2)	-0.107	(0.034)	0.042 /0.057	-0.017^{***}	(0.006)			
40. Saratov Obl.	(2)	-0.063	(0.024)	0.092 /0.092	-0.021^{***}	(0.008)			
41. Ulyanovsk Obl.	(2)	-0.076	(0.029)	0.086 /0.086	-0.024^{***}	(0.009)			
42. Rep. of Adygeya	none								
43. Rep. of Dagestan	none								
44. Rep. of Ingushetia	(2)	-0.120	(0.035)	0.012 /0.012	-0.021^{***}	(0.006)			
45. Kabardian-Balkar Rep.	none								
46. Karachaev-Cirkassian Rep.	none								
47. Rep. of Northern Ossetia	none								
48. Krasnodar Krai	(1)	-0.012	(0.008)	0.003 /0.037					
49. Stavropol Krai	none								
50. Rostov Obl.	none								
51. Rep. of Bashkortostan	(3b)	-0.144	(0.037)	0.060 /0.067	-0.372^{***}	(0.026)	0.0034^{***}	(0.0010)	29.8
52. Udmurt Rep.	(2)	-0.143	(0.039)	0.023 /0.059	-0.041^{***}	(0.011)			
53. Kurgan Obl.	(3b)	-0.172	(0.039)	0.037 /0.050	-0.397^{***}	(0.028)	0.0055^{***}	(0.0013)	18.6
54. Orenburg Obl.	(2)	-0.133	(0.036)	0.006 /0.006	-0.042^{***}	(0.011)			
55. Perm Krai	none								
56. Sverdlovsk Obl.	(3b)	-0.094	(0.017)	0.004 /0.022	-1.050^{***}	(0.259)	0.0925^{***}	(0.0285)	1.5
57. Chelyabinsk Obl.	(3b)	-0.134	(0.036)	0.080 /0.081	-0.282^{***}	(0.036)	0.0046^{**}	(0.0021)	20.7
58. Rep. of Altai	(3a)	-0.274	(0.047)	0.000 /0.000	-0.334^{***}	(0.023)	-0.0088^{***}	(0.0010)	7.4
59. Altai Krai	none								
60. Kemerovo Obl.	(3b)	-0.183	(0.042)	0.058 /0.097	-0.326^{***}	(0.026)	0.0035^{***}	(0.0012)	27.9
61. Novosibirsk Obl.	(3b)	-0.127	(0.018)	0.000 /0.039	-1.333^{***}	(0.287)	0.1233^{***}	(0.0327)	1.3
62. Omsk Obl.	none								
63. Tomsk Obl.	none								
64. Tyumen Obl.	none								
65. Rep. of Buryatia	none								
66. Rep. of Tuva	none								
67. Rep. of Khakasia	none								
68. Krasnoyarsk Krai	none								
69. Irkutsk Obl.	(3b)	-0.157	(0.038)	0.080 /0.094	-0.227^{***}	(0.061)	0.0160^{*}	(0.0091)	5.8
70. Transbaikal Krai	(3b)	-0.207	(0.044)	0.017 /0.017	-0.254^{***}	(0.054)	0.0213^{**}	(0.0092)	4.4
71. Rep. of Sakha (Yakutia)	none								
72. Jewish Autonomous Obl.	(1)	-0.033	(0.019)	0.070 /0.070					
73. Chukotka A.O.	(2)	-0.090	(0.032)	0.060 /0.060	0.074^{***}	(0.027)			
74. Primorsky Krai	none								
75. Khabarovsk Krai	none								
76. Amur Obl.	(1)	-0.028	(0.015)	0.068 /0.068					
77. Kamchatka Krai	none								
78. Magadan Obl.	(3a)	-0.108	(0.033)	0.054 /0.054	0.233^{***}	(0.029)	0.0038^{***}	(0.0010)	none
79. Sakhalin Obl.	none								

Notes: 1. PP and ADF stand for the Phillips-Perron test and augmented Dickey-Fuller test, respectively; 2. Standard errors are in parentheses; 3. Significance at 1% (***), 5% (**), and 10% (*); 4. 'Obl.' = Oblast, 'Rep.' = Republic, and 'A.O.' = Autonomous Okrug.

The use of the general-to-specific approach practically would not change the pattern. In doing so, as could be expected, the number of perfectly integrated markets decreases (to 5) in favor of conditionally integrated ones; in turn, the latter number diminishes (also to 5) in favor of regions moving towards integration (their number increases to 17). The total number of such regions diminishes by one (because of the change of conditional integration in the Saratov Oblast to price divergence with a very weak trend).

Consistency of results suggested by the ADF and Phillips-Perron tests is fairly high. The discrepancies take place in 23 regressions out of all 312, i.e., in 7.4%. In 20 regressions of the forms (3a) and (3b) as well as in one regression of the form (2), the Phillips-Perron test rejects the unit root hypothesis, while the ADF test does not. In two regressions of the form (1), the ADF test rejects this hypothesis and the Phillips-Perron test does not. It may be guessed that the ADF test has lower power in regressions with the nonlinear trend. However, the check of this guess would need a very effortful comparative study of the power properties of the ADF and Phillips-Perron tests in such regressions. If one would accept this guess to be true, for all that, and focus on the Phillips-Perron test only, the republics of Kalmykia, Dagestan, Northern Ossetia, and Tuva, Kabardian-Balkar Republic, Altai and Krasnoyarsk *krays*, and Tomsk Oblast enter additionally to the group of regions moving towards integration with the Moscow market, and the Tymen oblast enters to the group of conditionally integrated regions. Then the total number of regional markets integrated (perfectly or conditionally) with Moscow market and moving towards integration with it would rise to 37, that is, to 47.4% of the total number of regions.

It should be noted that the applied methods of testing for stationarity reject unit roots under more rigorous conditions than methods in common use. If those (using the 'ordinary' Bayesian information criterion with no sample-dependent penalty factor in the ADF test and a kernel-based spectral estimator in the Phillips-Perron test) were applied, the pattern would be much more optimistic. While the number of perfectly integrated regions would remain the same, the number of conditionally integrated regions would increase to 18 and the number of regions moving towards integration with Moscow would increase to 19. The total number of such regions would reach 45 (57.7% out of all regions). The use of the general-to-specific approach would give the same number (with a different grouping of regions). However, according to Perron and Ng (1996) and Ng and Perron (2001), such an 'improvement' of the pattern may be due to size distortions of the unit root test, hence, their lesser reliability.

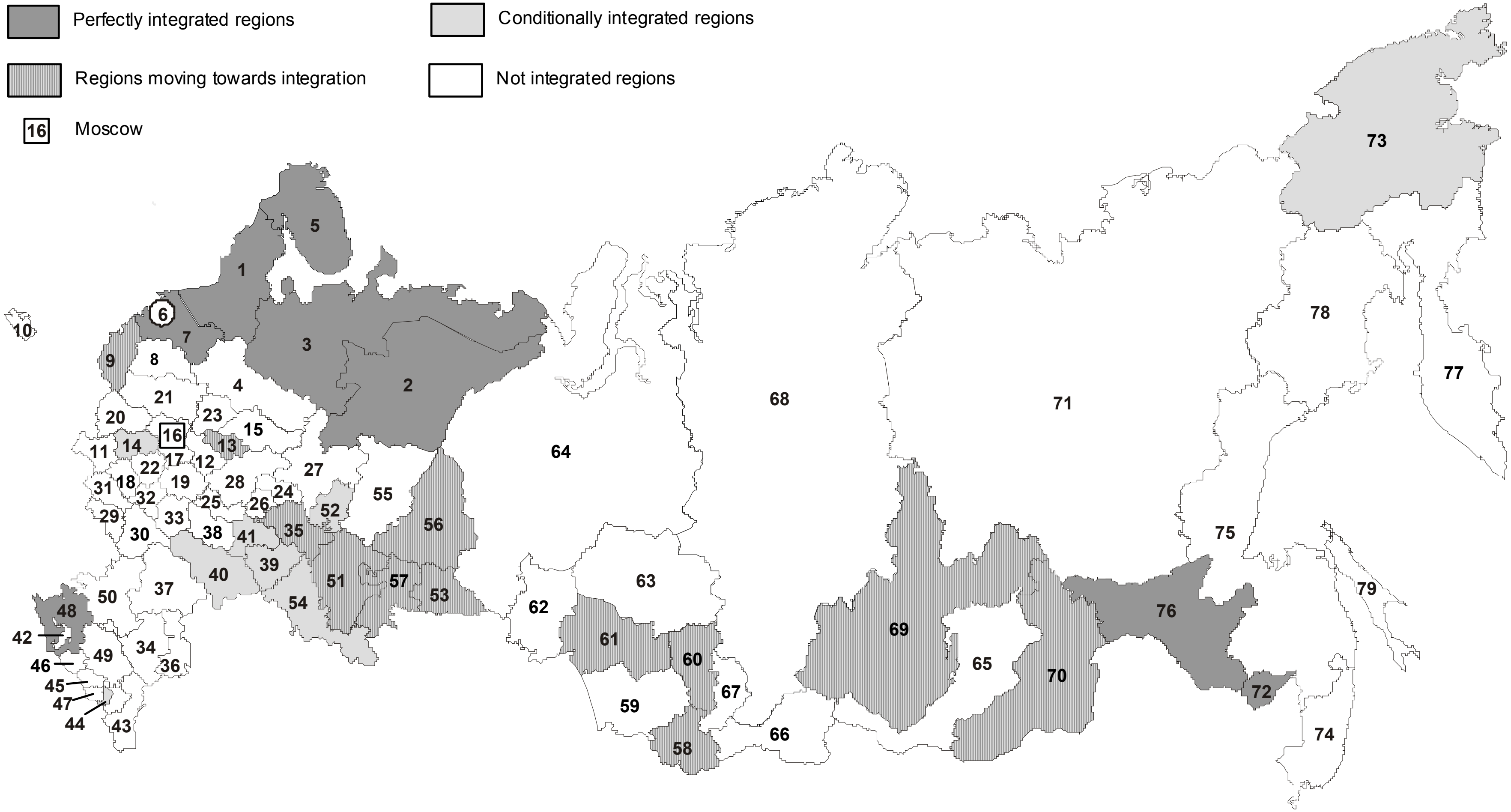

Fig. 4. Geographical pattern of integration of the Moscow market with markets of other Russian regions.

Notes: See Table 2 for numerical designations of regions. Not numbered region is the Chechen Republic.

Let us turn to the spatial pattern of integration of the Moscow market depicted in Figure 4. It looks very strange from the viewpoint of the economic geography. The Moscow market is not integrated with the markets of the nearby regions (except for conditionally integrated Kaluga Oblast, and the Ivanovo Oblast, where prices converge to the Moscow prices). The most surprising is the absence of integration with the surrounding Moscow Oblast. At the same time, there is perfect integration with the northern regions of the European part of Russia (and the Leningrad Oblast), although the Krasnodar Krai at the South is also perfectly integrated.[5] Conditional integration is observed – in addition to the Kaluga Oblast – in a small cluster of regions to the East and South from Moscow (and in one region estranged from this cluster, the Republic of Ingushetia). Another, also small, cluster of regions abuts upon it, where convergence of prices to the Moscow ones occurs.

As for the Asian part of Russia, there is a sole region that is conditionally integrated with the Moscow market, namely, the Chukotka Autonomous Okrug (where the cost of the basket was 28% higher than in Moscow on average over the period under consideration). Markets of two Far Eastern regions (the Jewish Autonomous Oblast and Amur Oblast) prove to be perfectly integrated with the Moscow market. Besides, the movement towards integration with the Moscow market takes place in a small number of southern Siberian regions (as well as in one Far Eastern region).

All this differs greatly from theoretically expected pattern. In a well-established market, such a pattern would look like, relatively speaking, as a system of concentric 'circles' with the center in the region under consideration, A. The first 'circle' consists of nearby regions, where costs of transportation between them and region A are small. Therefore, perfect integration between markets of these regions and region A is observed. The next 'circle' is comprised of more distant regions. Model (2) with a constant reflecting transportation costs describes integration with them. At last, the third 'circle' is made up of regions that are very distant from A, if there are such in a given country.[6] Integration with these may be absent. A real pattern, of course, would deviate in a varying degree from the above one. Nonetheless, the former is usually similar in outline (albeit crudely) with the latter.

Only a part of the pattern from Figure 4 that relates to the regions eastward from the Urals conforms to the theoretical pattern, if the following consideration is taken into account. Speaking of Russia, transitional type of its economy should be borne in mind. At present, the Russian market for consumer goods may properly be deemed well-established. However, it was still in the making as recently as in the

[5] It is worth noting that this is fairly puzzling. In spite of a rather high price disparity between the Krasnodar Krai and Moscow, the both tests reject unit root in Model (1) at the level of better than 5%. In doing so, they use 12 lags, which causes suspicion of seasonality. However, eliminating seasonality, the results of testing for unit root do not qualitatively change.

[6] For instance, Hawaii, some parts of Alaska, and Virgin Islands in the US, the residues of former overseas possessions in few European countries.

beginning of the 2000s. Apparently, this may be an explanation of the fact that convergence of prices with the Moscow ones occurs in a significant number of regions, implying convergence to the spatial equilibrium. It is not inconceivable that price convergence has completed in a number of regions (maybe, even in many of them). However, Model (3) inherently characterizes dynamics of the price differential over the period under consideration as a whole. As the cost of staples basket was less then in Moscow ($\gamma < 0$) in all regions moving towards integration with the Moscow market, price convergence implies that, on average over 2001–2015, the cost of the basket rose faster in these regions than in Moscow.

Perfect integration of the Moscow market with markets of a number of northern regions may seem strange. However, as it has been noted before, integration of the regional markets does not necessarily imply direct trade between them. Regional markets can interact through a chain (or, more exactly, a network) of other regions. The long-run path of the price differential of these regions, namely, price parity according to Model (1), can be explained by differences in the structure of retail prices in Moscow and the northern regions. Obviously, the share of transportation costs in prices for goods is much more substantial in these regions. At the same time, the share of the 'nontradable component' is high in the Moscow prices. The absence of statistical data on distribution costs by region makes it impossible to quantitatively assess it. However, indirect data can be involved. The average wage in Moscow exceeded the national average by the factor of 1.8–1.9 during 2011–2015 (Rosstat, 2016, p. 230). Approximately the same difference must be in the trade industry. As regards the lease of places of business and storage rooms, it can be judged from scrappy data that rents in Moscow are higher than on average in the country by the factor of 1.5–3. As a result, labor costs and rents increase retail prices in Moscow much greater that by 18.6% as on average in Russia.[7]

What is really strange is the absence of integration of the Moscow market with markets of most of regions from Central Russia, even nearby ones. (Because of much higher share of 'nontradable component' in the Moscow prices, market integration here would have to be conditional.) Figure 5 shows time series of average price differential in nonintegrated regions (except for the Magadan Oblast, where the prices diverge from the Moscow ones); it also separately shows the time series for the Moscow Oblast. The price differential averaged over nonintegrated regions is similar to that averaged over all regions in Figure 3. This is no surprise, as the nonintegrated regions comprise two thirds of the total number of regions.

[7] This is a counterpart of the Balassa–Samuelson effect, namely, a higher overall price level in rich countries because of more expensive (nontradable) services in these countries.

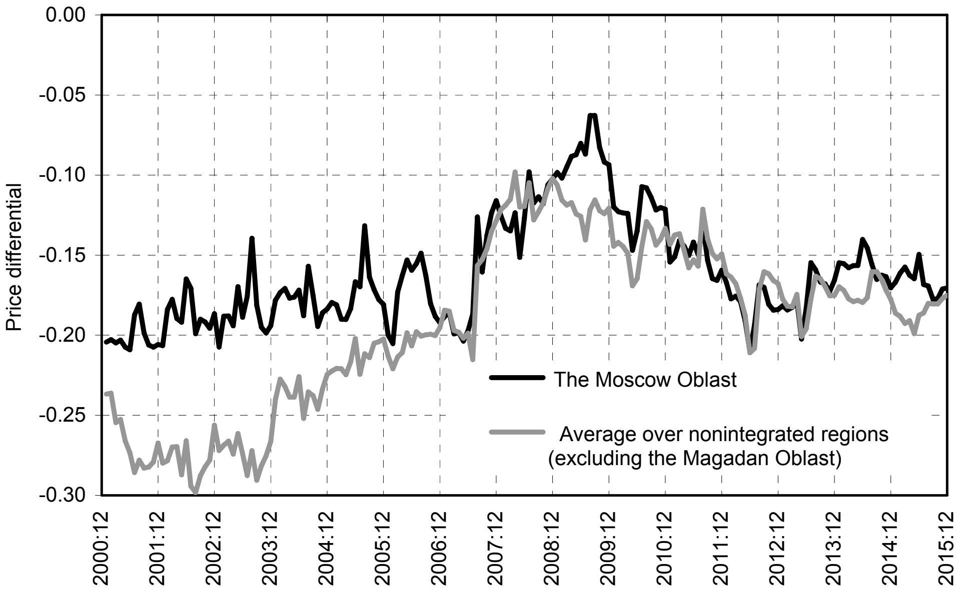

Fig. 5. The evolution of price differentials in nonintegrated regions

There is no uniform definition of spatial market integration. The definition used here is one of a set of possible definitions. Theoretically, regional markets can be deemed connected (integrated to some extent), if demand and supply shocks arising in one region are transmitted to some degree to another region (Fackler and Goodwin, 2001). Judging from the graphs in Figure 5, this does not occur. Most probably, local processes in the Moscow market mainly determine the dynamics of the given price differentials. In this paper, the presence of cointegration of time series $\ln(p_{rt})$ and $\ln(p_{st})$ reveals the interaction of prices in Moscow and other regions. Models (1)–(3) are in fact cointegration relationships with predetermined cointegrating vector $(1, -1)$. Possibly, the application of different definitions of integration and respective analytical methodologies (e.g., Granger causality, studying impulse response functions, estimation of cointegrating vectors, etc.) would make it possible to find that the interaction of prices in Moscow and nonintegrated regions, albeit weak, does exist. However, such analyses would reveal only formal properties of the price interactions. Their intuitive explanation needs a ‘field survey’ of processes going in the Moscow market for consumer goods.

5. Conclusion

In this paper, regional markets for an aggregated good, namely, the staples basket, has been considered; the cost of this basket has played a role of price representative. The analysis has been focused on integration of the Moscow market with markets of other regions of Russia. The law of one price in its strict and weak forms has served as the criterion of integration; long-run convergence to this law (price convergence) has served as the criterion of the movement towards integration. The data used cover the period of 2001–2015.

It has been found that the Moscow market is very poorly integrated with markets of other regions, being integrated with only 20.6% of them. Along with this, a tendency to improvement in integration is observed: convergence to the law of one price has been revealed in 15.4% of country's regions. A positive feature is the fact that there is only one case of price divergence. It occurs in the Magadan Oblast, where the cost of the minimum food basket was higher than in Moscow from the very beginning and rose on average over 2001–2015 faster than in Moscow. However, this region has poor transport accessibility, which makes goods arbitrage impossible. That is why the price dynamics in the Magadan Oblast is determined by solely local demand and supply.

The spatial pattern of integration of the Moscow market proves to be far from the theoretically expected pattern. In particular, this relates to the absence of integration with nearby regions. It is impossible to find explanation of this phenomenon through a formal analysis. But a meaningful analysis of features inherent in operation of the Moscow market for consumer goods that could provide such an explanation, as it seems, does not exist in the literature.

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[8] For English version, see Gluschenko, K. (2005). Crime and prices. *Institute for Advanced Studies, Vienna, Economics Series* No. 167 (http://www.ihs.ac.at/publications/eco/es-167.pdf).

Appendix. Full set of estimates

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		SSR
1. Rep. of Karelia	**(1)**	-0.020	(0.012)	0.100 /0.100					
	(2)	-0.040	(0.020)	0.282 /0.282	-0.002	(0.002)			
	(3a)	-0.130	(0.036)	0.368 /0.341	-0.229***	(0.041)	-0.0159***	(0.0036)	
	(3b)	-0.136	(0.024)	NA	-0.700***	(0.205)	0.1270***	(0.0448)	
2. Rep. of Komi	**(1)**	-0.031	(0.015)	0.035 /0.035					
	(2)	-0.035	(0.017)	0.282 /0.282	-0.001	(0.002)			
	(3a)	-0.120	(0.035)	0.051 /0.087	-0.335***	(0.102)	-0.0300***	(0.0091)	
	(3b)	-0.070	(0.029)	0.655 /0.580	-0.251	(0.564)	0.0437	(0.1192)	
3. Arkhangelsk Obl.	**(1)**	-0.020	(0.011)	0.069 /0.069					
	(2)	-0.023	(0.014)	0.498 /0.498	0.000	(0.002)			
	(3a)	-0.114	(0.033)	0.228 /0.406	-0.387***	(0.090)	-0.0241***	(0.0057)	
	(3b)	-0.045	(0.026)	0.820 /0.577	-0.225	(1.097)	0.0235	(0.1543)	
4. Vologda Obl.	(1)	-0.011	(0.007)	0.139 /0.139					
	(2)	-0.028	(0.016)	0.386 /0.386	-0.003***	(0.002)			
	(3a)	-0.096	(0.033)	0.409 /0.549	-0.293***	(0.042)	-0.0099***	(0.0021)	
	(3b)	-0.102	(0.031)	0.263 /0.407	-0.418***	(0.158)	0.0298*	(0.0179)	
5. Murmansk Obl.	**(1)**	-0.046	(0.023)	0.079 /0.091					
	(2)	-0.057	(0.025)	0.311 /0.351	0.001	(0.001)			
	(3a)	-0.059	(0.026)	0.519 /0.564	0.016	(0.037)	0.0043	(0.0171)	
	(3b)	-0.045	(0.022)	0.623 /0.650	0.000	(0.002)	-0.1416***	(0.0103)	
6. St. Petersburg City	(1)	-0.015	(0.011)	0.153 /0.153					
	(2)	-0.032	(0.020)	0.498 /0.498	-0.002	(0.002)			
	(3a)	-0.141	(0.037)	0.179 /0.518	-0.197***	(0.027)	-0.0119***	(0.0023)	
	(3b)	-0.108	(0.022)	NA	-0.570**	(0.228)	0.0898**	(0.0435)	
7. Leningrad Obl.	**(1)**	-0.016	(0.009)	0.080 /0.080					
	(2)	-0.030	(0.017)	0.380 /0.380	-0.002	(0.002)			
	(3a)	-0.162	(0.040)	0.217 /0.633	-0.248***	(0.024)	-0.0131***	(0.0017)	
	(3b)	-0.133	(0.020)	0.001 /0.001	-0.831***	(0.192)	0.1219***	(0.0345)	
8. Novgorod Obl.	(1)	-0.009	(0.007)	0.204 /0.205					
	(2)	-0.047	(0.021)	0.311 /0.325	-0.008*	(0.004)			
	(3a)	-0.105	(0.034)	0.861 /0.659	-0.290***	(0.038)	-0.0056***	(0.0015)	
	(3b)	-0.124	(0.036)	0.616 /0.663	-0.339***	(0.052)	0.0115***	(0.0041)	
9. Pskov Obl.	(1)	-0.008	(0.005)	0.134 /0.134					
	(2)	-0.012	(0.012)	0.764 /0.764	-0.001	(0.003)			
	(3a)	-0.135	(0.035)	0.018 /0.050	-0.398***	(0.028)	-0.0098***	(0.0010)	0.0350
	(3b)	-0.100	(0.027)	0.069 /0.002	-0.583***	(0.201)	0.0303*	(0.0160)	0.0354
10. Kaliningrad Obl.	(1)	-0.015	(0.012)	0.188 /0.188					
	(2)	-0.037	(0.020)	0.541 /0.457	-0.004	(0.003)			
	(3a)	-0.054	(0.025)	0.676 /0.760	-0.620	(0.624)	-0.0244*	(0.0141)	
	(3b)	-0.084	(0.024)	0.086 /0.553	-0.488	(0.731)	0.0435	(0.0877)	
11. Bryansk Obl.	(1)	-0.002	(0.003)	0.393 /0.393					
	(2)	-0.043	(0.022)	0.311 /0.311	-0.013*	(0.007)			
	(3a)	-0.084	(0.030)	0.143 /0.143	-0.396***	(0.032)	-0.0022***	(0.0008)	
	(3b)	-0.089	(0.031)	0.174 /0.174	-0.410***	(0.036)	0.0031**	(0.0012)	
12. Vladimir Obl.	(1)	-0.006	(0.005)	0.221 /0.221					
	(2)	-0.033	(0.016)	0.289 /0.289	-0.006*	(0.004)			
	(3a)	-0.049	(0.025)	0.503 /0.503	-0.282***	(0.071)	-0.0031	(0.0024)	
	(3b)	-0.058	(0.027)	0.439 /0.439	-0.331***	(0.088)	0.0064	(0.0048)	
13. Ivanovo Obl.	(1)	-0.005	(0.005)	0.220 /0.220					

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		SSR
	(2)	-0.037	(0.019)	0.335 /0.335	-0.009*	(0.005)			
	(3a)	-0.164	(0.041)	0.020 /0.052	-0.369***	(0.019)	-0.0042***	(0.0006)	
	(3b)	-0.149	(0.039)	0.084 /0.127	-0.383***	(0.027)	0.0060***	(0.0013)	
14. Kaluga Obl.	(1)	-0.002	(0.004)	0.513 /0.513					
	(2)	-0.073	(0.028)	0.091 /0.091	-0.018**	(0.007)			
	(3a)	-0.077	(0.028)	0.171 /0.171	-0.231***	(0.028)	0.0008	(0.0010)	
	(3b)	-0.077	(0.028)	0.225 /0.225	-0.231***	(0.026)	-0.0008	(0.0009)	
15. Kostroma Obl.	(1)	-0.006	(0.005)	0.211 /0.211					
	(2)	-0.053	(0.021)	0.144 /0.163	-0.012**	(0.005)			
	(3a)	-0.084	(0.031)	0.273 /0.344	-0.307***	(0.042)	-0.0027**	(0.0014)	
	(3b)	-0.094	(0.033)	0.272 /0.342	-0.332***	(0.047)	0.0044*	(0.0022)	
16. Moscow City	Benchmark								
17. Moscow Obl.	(1)	-0.005	(0.006)	0.417 /0.421					
	(2)	-0.098	(0.032)	0.130 /0.176	-0.016***	(0.005)			
	(3a)	-0.106	(0.034)	0.295 /0.388	-0.175***	(0.022)	-0.0009	(0.0012)	
	(3b)	-0.107	(0.034)	0.340 /0.423	-0.177***	(0.024)	0.0011	(0.0015)	
18. Oryol Obl.	(1)	-0.004	(0.004)	0.310 /0.310					
	(2)	-0.057	(0.023)	0.139 /0.139	-0.016**	(0.007)			
	(3a)	-0.124	(0.037)	0.245 /0.381	-0.375***	(0.025)	-0.0026***	(0.0007)	
	(3b)	-0.134	(0.038)	0.237 /0.379	-0.390***	(0.027)	0.0036***	(0.0011)	
19. Ryazan Obl.	(1)	-0.003	(0.004)	0.458 /0.458					
	(2)	-0.034	(0.019)	0.373 /0.373	-0.009*	(0.005)			
	(3a)	-0.032	(0.019)	0.656 /0.656	-0.232**	(0.095)	0.0008	(0.0030)	
	(3b)	-0.032	(0.019)	0.650 /0.650	-0.226**	(0.088)	-0.0009	(0.0024)	
20. Smolensk Obl.	(1)	-0.007	(0.005)	0.202 /0.202					
	(2)	-0.032	(0.017)	0.396 /0.411	-0.005	(0.003)			
	(3a)	-0.083	(0.031)	0.262 /0.304	-0.296***	(0.038)	-0.0056***	(0.0015)	
	(3b)	-0.101	(0.033)	0.619 /0.694	-0.346***	(0.053)	0.0113***	(0.0040)	
21. Tver Obl.	(1)	-0.006	(0.006)	0.222 /0.222					
	(2)	-0.050	(0.022)	0.296 /0.312	-0.009**	(0.005)			
	(3a)	-0.151	(0.040)	0.626 /0.679	-0.287***	(0.019)	-0.0043***	(0.0008)	
	(3b)	-0.192	(0.045)	0.341 /0.681	-0.314***	(0.020)	0.0073***	(0.0013)	
22. Tula Obl.	(1)	-0.003	(0.005)	0.476 /0.476					
	(2)	-0.030	(0.018)	0.448 /0.448	-0.006	(0.004)			
	(3a)	-0.033	(0.020)	0.668 /0.668	-0.245**	(0.094)	-0.0012	(0.0031)	
	(3b)	-0.035	(0.021)	0.638 /0.638	-0.278**	(0.117)	0.0026	(0.0048)	
23. Yaroslavl Obl.	(1)	-0.003	(0.005)	0.488 /0.488					
	(2)	-0.054	(0.024)	0.191 /0.191	-0.012**	(0.005)			
	(3a)	-0.052	(0.025)	0.424 /0.424	-0.212***	(0.050)	0.0003	(0.0019)	
	(3b)	-0.052	(0.025)	0.455 /0.455	-0.211***	(0.049)	-0.0003	(0.0018)	
24. Rep. of Mariy El	(1)	-0.002	(0.004)	0.498 /0.498					
	(2)	-0.067	(0.027)	0.263 /0.298	-0.020	(0.009)			
	(3a)	-0.089	(0.031)	0.242 /0.329	-0.364	(0.037)	-0.0017	(0.0010)	
	(3b)	-0.090	(0.031)	0.279 /0.358	-0.373	(0.041)	0.0022	(0.0014)	
25. Rep. of Mordovia	(1)	-0.002	(0.005)	0.564 /0.550					
	(2)	-0.105	(0.033)	0.145 /0.197	-0.033**	(0.010)			
	(3a)	-0.125	(0.038)	0.264 /0.386	-0.342***	(0.026)	-0.0010*	(0.0007)	
	(3b)	-0.127	(0.038)	0.305 /0.415	-0.345***	(0.027)	0.0012	(0.0009)	
26. Chuvash Rep.	(1)	-0.002	(0.004)	0.509 /0.509					
	(2)	-0.057	(0.025)	0.315 /0.359	-0.018**	(0.008)			

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		SSR
	(3a)	-0.088	(0.031)	0.242 /0.288	-0.390***	(0.036)	-0.0019**	(0.0009)	
	(3b)	-0.090	(0.031)	0.274 /0.311	-0.399***	(0.041)	0.0025*	(0.0013)	
27. Kirov Obl.	(1)	-0.004	(0.006)	0.423 /0.423					
	(2)	-0.067	(0.026)	0.107 /0.107	-0.017**	(0.007)			
	(3a)	-0.079	(0.030)	0.487 /0.572	-0.297***	(0.046)	-0.0013	(0.0015)	
	(3b)	-0.082	(0.031)	0.492 /0.575	-0.311***	(0.051)	0.0020	(0.0020)	
28. Nizhni Novgorod Obl.	(1)	-0.002	(0.005)	0.518 /0.518					
	(2)	-0.065	(0.027)	0.134 /0.134	-0.016**	(0.007)			
	(3a)	-0.078	(0.031)	0.236 /0.236	-0.279***	(0.037)	-0.0013	(0.0013)	
	(3b)	-0.081	(0.032)	0.412 /0.485	-0.287***	(0.040)	0.0018	(0.0016)	
29. Belgorod Obl.	(1)	-0.002	(0.004)	0.529 /0.522					
	(2)	-0.074	(0.028)	0.169 /0.190	-0.024***	(0.009)			
	(3a)	-0.076	(0.029)	0.341 /0.377	-0.339***	(0.037)	-0.0003	(0.0010)	
	(3b)	-0.076	(0.029)	0.381 /0.413	-0.340***	(0.037)	0.0003	(0.0010)	
30. Voronezh Obl.	(1)	-0.005	(0.006)	0.328 /0.328					
	(2)	-0.047	(0.022)	0.268 /0.307	-0.012**	(0.006)			
	(3a)	-0.054	(0.025)	0.493 /0.529	-0.308***	(0.080)	-0.0015	(0.0023)	
	(3b)	-0.057	(0.026)	0.497 /0.526	-0.329***	(0.091)	0.0025	(0.0034)	
31. Kursk Obl.	(1)	-0.001	(0.004)	0.602 /0.602					
	(2)	-0.043	(0.022)	0.434 /0.463	-0.015*	(0.008)			
	(3a)	-0.046	(0.022)	0.567 /0.606	-0.286***	(0.069)	0.0017	(0.0019)	
	(3b)	-0.046	(0.022)	0.561 /0.595	-0.285***	(0.060)	-0.0015	(0.0012)	
32. Lipetsk Obl.	(1)	-0.001	(0.004)	0.557 /0.557					
	(2)	-0.059	(0.025)	0.169 /0.169	-0.020**	(0.009)			
	(3a)	-0.069	(0.027)	0.239 /0.239	-0.387***	(0.049)	-0.0013	(0.0012)	
	(3b)	-0.070	(0.028)	0.280 /0.280	-0.397***	(0.054)	0.0017	(0.0015)	
33. Tambov Obl.	(1)	-0.003	(0.004)	0.410 /0.381					
	(2)	-0.045	(0.023)	0.557 /0.453	-0.016*	(0.008)			
	(3a)	-0.077	(0.029)	0.426 /0.555	-0.449***	(0.049)	-0.0025**	(0.0010)	
	(3b)	-0.082	(0.029)	0.396 /0.537	-0.474***	(0.057)	0.0037**	(0.0017)	
34. Rep. of Kalmykia	(1)	-0.006	(0.007)	0.229 /0.098					
	(2)	-0.052	(0.024)	0.774 /0.544	-0.015**	(0.007)			
	(3a)	-0.213	(0.046)	0.071 /0.820	-0.469***	(0.025)	-0.0053***	(0.0007)	
	(3b)	-0.229	(0.046)	0.018 /0.516	-0.506***	(0.032)	0.0089***	(0.0015)	
35. Rep. of Tatarstan	(1)	-0.003	(0.004)	0.402 /0.402					
	(2)	-0.076	(0.029)	0.402 /0.381	-0.025***	(0.010)			
	(3a)	-0.218	(0.047)	0.016 /0.100	-0.411***	(0.014)	-0.0023***	(0.0004)	
	(3b)	-0.220	(0.047)	0.052 /0.145	-0.417***	(0.016)	0.0028***	(0.0005)	
36. Astrakhan Obl.	(1)	-0.006	(0.008)	0.501 /0.346					
	(2)	-0.094	(0.032)	0.559 /0.609	-0.023***	(0.008)			
	(3a)	-0.159	(0.040)	0.184 /0.736	-0.336***	(0.030)	-0.0033***	(0.0010)	
	(3b)	-0.167	(0.040)	0.178 /0.656	-0.355***	(0.036)	0.0050***	(0.0017)	
37. Volgograd Obl.	(1)	-0.003	(0.006)	0.538 /0.557					
	(2)	-0.081	(0.030)	0.162 /0.182	-0.022***	(0.008)			
	(3a)	-0.103	(0.032)	0.143 /0.151	-0.332***	(0.039)	-0.0022*	(0.0011)	
	(3b)	-0.105	(0.032)	0.185 /0.190	-0.346***	(0.045)	0.0031*	(0.0018)	
38. Penza Obl.	(1)	-0.001	(0.004)	0.582 /0.582					
	(2)	-0.043	(0.022)	0.307 /0.307	-0.014*	(0.007)			
	(3a)	-0.044	(0.023)	0.537 /0.537	-0.328***	(0.069)	-0.0003	(0.0017)	

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		SSR
	(3b)	-0.045	(0.024)	0.548 /0.548	-0.331***	(0.070)	0.0004	(0.0019)	
39. Samara Obl.	(1)	-0.006	(0.008)	0.388 /0.388					
	(2)	-0.107	(0.034)	0.042 /0.057	-0.017***	(0.006)			
	(3a)	-0.108	(0.034)	0.107 /0.138	-0.157***	(0.027)	0.0003	(0.0015)	
	(3b)	-0.108	(0.034)	0.164 /0.195	-0.157***	(0.026)	-0.0003	(0.0014)	
40. Saratov Obl .	(1)	0.001	(0.004)	0.718 /0.728					
	(2)	-0.063	(0.024)	0.092 /0.092	-0.021***	(0.008)			
	(3a)	-0.100	(0.032)	0.074 /0.074	-0.281***	(0.023)	0.0016**	(0.0007)	0.0411
	(3b)	-0.102	(0.032)	0.123 /0.123	-0.282***	(0.020)	-0.0014***	(0.0005)	0.0411
41. Ulyanovsk Obl.	(1)	-0.001	(0.004)	0.533 /0.533					
	(2)	-0.076	(0.029)	0.086 /0.086	-0.024***	(0.009)			
	(3a)	-0.124	(0.036)	0.036 /0.036	-0.363***	(0.020)	-0.0015***	(0.0005)	0.0377
	(3b)	-0.128	(0.037)	0.078 /0.078	-0.369***	(0.022)	0.0019***	(0.0007)	0.0376
42. Rep. of Adygeya	(1)	-0.006	(0.007)	0.359 /0.359					
	(2)	-0.081	(0.030)	0.770 /0.309	-0.020***	(0.008)			
	(3a)	-0.143	(0.038)	0.372 /0.628	-0.342***	(0.032)	-0.0035***	(0.0010)	
	(3b)	-0.161	(0.040)	0.169 /0.561	-0.374***	(0.037)	0.0059***	(0.0019)	
43. Rep. of Dagestan	(1)	-0.008	(0.007)	0.125 /0.073					
	(2)	-0.062	(0.027)	0.858 /0.588	-0.015**	(0.007)			
	(3a)	-0.245	(0.049)	0.005 /0.828	-0.388***	(0.019)	-0.0050***	(0.0006)	
	(3b)	-0.248	(0.048)	0.017 /0.619	-0.412***	(0.025)	0.0078***	(0.0014)	
44. Rep. of Ingushetia	(1)	-0.012	(0.012)	0.280 /0.280					
	(2)	-0.120	(0.035)	0.012 /0.012	-0.021***	(0.006)			
	(3a)	-0.124	(0.036)	0.037 /0.037	-0.155***	(0.035)	0.0010	(0.0020)	
	(3b)	-0.125	(0.037)	0.087 /0.087	-0.153***	(0.032)	-0.0010	(0.0015)	
45. Kabardian-Balkar Rep.	(1)	-0.005	(0.007)	0.439 /0.413					
	(2)	-0.170	(0.042)	0.138 /0.502	-0.051***	(0.013)			
	(3a)	-0.269	(0.052)	0.019 /0.940	-0.360***	(0.017)	-0.0019***	(0.0005)	
	(3b)	-0.276	(0.052)	0.062 /0.840	-0.366***	(0.018)	0.0025***	(0.0007)	
46. Karachaev-Cirkassian Rep.	(1)	-0.006	(0.006)	0.332 /0.314					
	(2)	-0.075	(0.029)	0.189 /0.199	-0.020**	(0.008)			
	(3a)	-0.203	(0.045)	0.151 /0.829	-0.374***	(0.021)	-0.0036***	(0.0006)	
	(3b)	-0.217	(0.046)	0.126 /0.703	-0.392***	(0.024)	0.0053***	(0.0011)	
47. Rep. of Northern Ossetia	(1)	-0.006	(0.007)	0.400 /0.195					
	(2)	-0.094	(0.032)	0.613 /0.531	-0.025***	(0.009)			
	(3a)	-0.218	(0.046)	0.072 /0.904	-0.372***	(0.022)	-0.0035***	(0.0006)	
	(3b)	-0.236	(0.048)	0.041 /0.818	-0.392***	(0.025)	0.0053***	(0.0011)	
48. Krasnodar Krai	**(1)**	-0.012	(0.008)	0.003 /0.037					
	(2)	-0.084	(0.029)	0.206 /0.501	-0.017***	(0.006)			
	(3a)	-0.341	(0.057)	0.000 /0.816	-0.326***	(0.012)	-0.0051***	(0.0005)	
	(3b)	-0.394	(0.060)	0.002 /0.669	-0.350***	(0.014)	0.0083***	(0.0009)	
49. Stavropol Krai	(1)	-0.006	(0.006)	0.337 /0.337					
	(2)	-0.054	(0.023)	0.172 /0.172	-0.013**	(0.006)			
	(3a)	-0.082	(0.031)	0.923 /0.790	-0.325***	(0.052)	-0.0031*	(0.0016)	
	(3b)	-0.092	(0.032)	0.815 /0.719	-0.365***	(0.063)	0.0058*	(0.0031)	
50. Rostov Obl.	(1)	-0.006	(0.006)	0.110 /0.102					0.0974
	(2)	-0.061	(0.025)	0.468 /0.288	-0.016**	(0.007)			0.0946
	(3a)	-0.121	(0.037)	0.867 /0.733	-0.373***	(0.037)	-0.0036***	(0.0011)	0.0921
	(3b)	-0.143	(0.039)	0.695 /0.637	-0.411***	(0.041)	0.0064***	(0.0019)	0.0910

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		SSR
51. Rep. of Bashkortostan	(1)	-0.002	(0.005)	0.495 /0.495					
	(2)	-0.067	(0.027)	0.269 /0.325	-0.019**	(0.008)			
	(3a)	-0.143	(0.037)	0.019 /0.027	-0.363***	(0.022)	-0.0026***	(0.0006)	0.0530
	(3b)	-0.144	(0.037)	0.060 /0.067	-0.372***	(0.026)	0.0034***	(0.0010)	0.0529
52. Udmurt Rep.	(1)	-0.002	(0.005)	0.530 /0.530					
	(2)	-0.143	(0.039)	0.023 /0.059	-0.041***	(0.011)			
	(3a)	-0.178	(0.042)	0.012 /0.032	-0.326***	(0.019)	-0.0013**	(0.0006)	0.0721
	(3b)	-0.178	(0.042)	0.051 /0.081	-0.327***	(0.020)	0.0014*	(0.0007)	0.0721
53. Kurgan Obl.	(1)	-0.004	(0.005)	0.455 /0.426					
	(2)	-0.057	(0.026)	0.402 /0.439	-0.015**	(0.007)			
	(3a)	-0.167	(0.039)	0.008 /0.019	-0.379***	(0.023)	-0.0037***	(0.0007)	0.0679
	(3b)	-0.172	(0.039)	0.037 /0.050	-0.397***	(0.028)	0.0055***	(0.0013)	0.0674
54. Orenburg Obl.	(1)	-0.001	(0.004)	0.603 /0.603					0.0567
	(2)	-0.133	(0.036)	0.006 /0.006	-0.042***	(0.011)			0.0527
	(3a)	-0.144	(0.037)	0.010 /0.010	-0.337***	(0.020)	-0.0008	(0.0006)	0.0521
	(3b)	-0.145	(0.037)	0.047 /0.047	-0.338***	(0.021)	0.0009	(0.0007)	0.0521
55. Perm Krai	(1)	-0.004	(0.006)	0.433 /0.433					
	(2)	-0.044	(0.022)	0.284 /0.284	-0.009*	(0.005)			
	(3a)	-0.066	(0.027)	0.253 /0.253	-0.297***	(0.060)	-0.0038*	(0.0020)	
	(3b)	-0.070	(0.027)	0.265 /0.265	-0.338***	(0.090)	0.0071	(0.0050)	
56. Sverdlovsk Obl.	(1)	-0.009	(0.009)	0.281 /0.281					
	(2)	-0.040	(0.021)	0.328 /0.328	-0.005	(0.003)			
	(3a)	-0.083	(0.029)	0.230 /0.252	-0.271***	(0.057)	-0.0081***	(0.0027)	
	(3b)	-0.094	(0.017)	0.004 /0.022	-1.050***	(0.259)	0.0925***	(0.0285)	
57. Chelyabinsk Obl.	(1)	-0.005	(0.008)	0.434 /0.434					
	(2)	-0.087	(0.031)	0.107 /0.137	-0.018***	(0.006)			
	(3a)	-0.132	(0.036)	0.037 /0.041	-0.268***	(0.029)	-0.0032***	(0.0011)	0.0736
	(3b)	-0.134	(0.036)	0.080 /0.081	-0.282***	(0.036)	0.0046**	(0.0021)	0.0733
58. Rep. of Altai	(1)	-0.014	(0.012)	0.308 /0.262					
	(2)	-0.064	(0.027)	0.496 /0.551	-0.010**	(0.005)			
	(3a)	-0.274	(0.047)	0.000 /0.000	-0.334***	(0.023)	-0.0088***	(0.0010)	0.1281
	(3b)	-0.238	(0.044)	0.013 /0.021	-0.383***	(0.046)	0.0181***	(0.0045)	0.1302
59. Altai Krai	(1)	-0.004	(0.006)	0.433 /0.433					
	(2)	-0.045	(0.022)	0.497 /0.521	-0.012*	(0.007)			
	(3a)	-0.135	(0.036)	0.051 /0.172	-0.441***	(0.038)	-0.0052***	(0.0010)	
	(3b)	-0.151	(0.036)	0.058 /0.113	-0.491***	(0.050)	0.0094***	(0.0024)	
60. Kemerovo Obl.	(1)	-0.004	(0.007)	0.555 /0.539					
	(2)	-0.114	(0.035)	0.097 /0.158	-0.029***	(0.009)			
	(3a)	-0.176	(0.042)	0.023 /0.063	-0.314***	(0.023)	-0.0025***	(0.0008)	0.0927
	(3b)	-0.183	(0.042)	0.058 /0.097	-0.326***	(0.026)	0.0035***	(0.0012)	0.0922
61. Novosibirsk Obl.	(1)	-0.012	(0.010)	0.247 /0.251					
	(2)	-0.035	(0.020)	0.574 /0.593	-0.004	(0.003)			
	(3a)	-0.138	(0.036)	0.032 /0.036	-0.356***	(0.045)	-0.0115***	(0.0020)	0.0817
	(3b)	-0.127	(0.018)	0.000 /0.039	-1.333***	(0.287)	0.1233***	(0.0327)	0.0807
62. Omsk Obl.	(1)	-0.001	(0.005)	0.603 /0.603					
	(2)	-0.071	(0.027)	0.159 /0.219	-0.024***	(0.009)			
	(3a)	-0.086	(0.029)	0.173 /0.258	-0.388***	(0.042)	-0.0016	(0.0010)	
	(3b)	-0.088	(0.029)	0.215 /0.291	-0.402***	(0.048)	0.0022	(0.0015)	
63. Tomsk Obl.	(1)	-0.008	(0.008)	0.312 /0.271					

Region	Model	λ		Unit root test p-values (PP/ADF)	γ		δ		SSR
	(2)	-0.050	(0.023)	0.400 /0.394	-0.009*	(0.005)			
	(3a)	-0.113	(0.035)	0.156 /0.249	-0.315***	(0.042)	-0.0063***	(0.0016)	
	(3b)	-0.139	(0.037)	0.095 /0.142	-0.389***	(0.062)	0.0149***	(0.0051)	
64. Tyumen Obl.	(1)	-0.135	(0.038)	0.048 /0.156					
	(2)	-0.158	(0.041)	0.207 /0.504	0.003	(0.002)			
	(3a)	-0.165	(0.042)	0.008 /0.008	0.010	(0.016)	0.0059	(0.0117)	
	(3b)	-0.163	(0.041)	0.042 /0.064	0.013	(0.015)	-0.0028	(0.0054)	
65. Rep. of Buryatia	(1)	-0.011	(0.011)	0.398 /0.353					
	(2)	-0.098	(0.032)	0.130 /0.177	-0.015***	(0.005)			
	(3a)	-0.127	(0.036)	0.104 /0.210	-0.221***	(0.038)	-0.0041**	(0.0019)	
	(3b)	-0.136	(0.037)	0.119 /0.211	-0.270***	(0.056)	0.0096*	(0.0051)	
66. Rep. of Tuva	(1)	-0.018	(0.014)	0.201 /0.201					
	(2)	-0.084	(0.030)	0.159 /0.215	-0.009**	(0.004)			
	(3a)	-0.178	(0.041)	0.037 /0.501	-0.223***	(0.030)	-0.0085***	(0.0019)	
	(3b)	-0.174	(0.040)	0.082 /0.369	-0.260***	(0.057)	0.0180**	(0.0081)	
67. Rep. of Khakasia	(1)	-0.011	(0.012)	0.416 /0.380					
	(2)	-0.106	(0.033)	0.377 /0.565	-0.016***	(0.005)			
	(3a)	-0.150	(0.038)	0.194 /0.857	-0.227***	(0.033)	-0.0048***	(0.0017)	
	(3b)	-0.161	(0.039)	0.140 /0.806	-0.269***	(0.049)	0.0104**	(0.0046)	
68. Krasnoyarsk Krai	(1)	-0.032	(0.019)	0.198 /0.190					
	(2)	-0.170	(0.042)	0.205 /0.531	-0.014***	(0.004)			
	(3a)	-0.285	(0.051)	0.002 /0.253	-0.144***	(0.016)	-0.0064***	(0.0014)	
	(3b)	-0.283	(0.051)	0.026 /0.233	-0.155***	(0.022)	0.0109***	(0.0040)	
69. Irkutsk Obl.	(1)	-0.021	(0.016)	0.344 /0.355					
	(2)	-0.102	(0.033)	0.137 /0.193	-0.011***	(0.004)			
	(3a)	-0.152	(0.038)	0.039 /0.055	-0.192***	(0.035)	-0.0075***	(0.0024)	0.0957
	(3b)	-0.157	(0.038)	0.080 /0.094	-0.227***	(0.061)	0.0160*	(0.0091)	0.0950
70. Transbaikal Krai	(1)	-0.027	(0.017)	0.104 /0.104					
	(2)	-0.102	(0.034)	0.423 /0.392	-0.010**	(0.004)			
	(3a)	-0.206	(0.044)	0.001 /0.001	-0.211***	(0.029)	-0.0093***	(0.0021)	0.1111
	(3b)	-0.207	(0.044)	0.017 /0.017	-0.254***	(0.054)	0.0213**	(0.0092)	0.1104
71. Rep. of Sakha (Yakutia)	(1)	-0.002	(0.008)	0.606 /0.606					
	(2)	-0.052	(0.025)	0.247 /0.247	0.013**	(0.006)			
	(3a)	-0.091	(0.031)	0.119 /0.119	0.159***	(0.037)	0.0041**	(0.0018)	
	(3b)	-0.086	(0.031)	0.198 /0.198	0.173***	(0.033)	-0.0027***	(0.0008)	
72. Jewish Autonomous Obl.	**(1)**	-0.033	(0.019)	0.070 /0.070					
	(2)	-0.034	(0.019)	0.361 /0.361	0.001	(0.002)			
	(3a)	-0.039	(0.021)	0.558 /0.558	0.012	(0.055)	0.0094	(0.0301)	
	(3b)	-0.037	(0.020)	0.570 /0.570	0.019	(0.057)	-0.0036	(0.0074)	
73. Chukotka A.O.	(1)	-0.003	(0.004)	0.424 /0.424					
	(2)	-0.090	(0.032)	0.060 /0.060	0.074***	(0.027)			
	(3a)	-0.099	(0.033)	0.100 /0.100	0.902***	(0.085)	-0.0009	(0.0009)	
	(3b)	-0.098	(0.033)	0.161 /0.161	0.898***	(0.089)	0.0009	(0.0010)	
74. Primorsky Krai	(1)	-0.013	(0.014)	0.315 /0.329					
	(2)	-0.029	(0.018)	0.469 /0.462	0.003	(0.002)			
	(3a)	-0.050	(0.024)	0.900 /0.928	0.035	(0.041)	0.0097	(0.0075)	
	(3b)	-0.043	(0.022)	0.882 /0.047	0.056	(0.042)	-0.0039***	(0.0015)	
75. Khabarovsk Krai	(1)	-0.008	(0.013)	0.460 /0.460					
	(2)	-0.025	(0.017)	0.558 /0.558	0.003	(0.002)			

Region	Model	λ		Unit root test *p*-values (PP/ADF)	γ		δ		SSR
	(3a)	-0.057	(0.025)	0.336 /0.336	0.030	(0.028)	0.0113*	(0.0061)	
	(3b)	-0.048	(0.023)	0.452 /0.452	0.053*	(0.030)	-0.0043***	(0.0009)	
76. Amur Obl.	**(1)**	-0.028	(0.015)	0.068 /0.068					
	(2)	-0.029	(0.017)	0.434 /0.434	0.000	(0.002)			
	(3a)	-0.119	(0.034)	0.029 /0.029	-0.504**	(0.194)	-0.0358***	(0.0114)	
	(3b)	-0.045	(0.028)	0.531 /0.546	-0.155	1.739)	0.0213	(0.3377)	
77. Kamchatka Krai	(1)	-0.003	(0.007)	0.530 /0.550					
	(2)	-0.108	(0.032)	0.151 /0.549	0.037***	(0.011)			
	(3a)	-0.107	(0.032)	0.370 /0.801	0.366***	(0.051)	-0.0005	(0.0013)	
	(3b)	-0.107	(0.033)	0.413 /0.775	0.365***	(0.052)	0.0005	(0.0014)	
78. Magadan Obl.	(1)	-0.001	(0.005)	0.647 /0.586					
	(2)	-0.041	(0.022)	0.414 /0.432	0.014*	(0.008)			
	(3a)	-0.108	(0.033)	0.054 /0.054	0.233***	(0.029)	0.0038***	(0.0010)	
	(3b)	-0.099	(0.032)	0.138 /0.138	0.252***	(0.028)	-0.0025***	(0.0005)	
79. Sakhalin Obl.	(1)	-0.005	(0.008)	0.439 /0.439					
	(2)	-0.035	(0.020)	0.382 /0.382	0.009**	(0.005)			
	(3a)	-0.043	(0.023)	0.541 /0.541	0.183**	(0.091)	0.0024	(0.0038)	
	(3b)	-0.041	(0.022)	0.572 /0.572	0.198*	(0.089)	-0.0015	(0.0026)	

Notes: 1. PP and ADF stand for the Phillips-Perron test and augmented Dickey-Fuller test, respectively. 2. Standard errors are in parenthesis. 3. Significance at 1% (***), 5% (**), and 10% (*). 4. SSR = sum of squared residuals. 5. Chosen model specifications (under both ‘specific-to-general’ and ‘general-to-specific’ approaches) are marked with bold font. 6. NA means that the nonlinear OLS algorithm has failed in estimating auxiliary regressions while testing for unit root. 7. ‘Obl.’ = Oblast, ‘Rep.’ = Republic, and ‘A.O.’ = Autonomous Okrug.