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Spatial Integration of Siberian Regional Markets

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This paper studies market integration of 13 regions constituting Siberia with one another and all other Russian regions. The law of one price serves as a criterion of market integration. The data analyzed are time series of the regional costs of a basket of basic foods (staples basket) over 2001–2015. Pairs of regional markets are divided into four groups: perfectly integrated, conditionally integrated, not integrated but tending towards integration (converging), and neither integrated nor converging. Nonlinear time series models with asymptotically decaying trends describe price convergence. Integration of Siberian regional markets is found to be fairly strong; they are integrated and converging with about 70% of country's regions (including Siberian regions themselves).

Keywords: market integration, law of one price; price convergence; nonlinear trend; Russian regions.

JEL classification: C32, L81, P22, R15

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1. Introduction

The national product market is considered as a system with elements being its spatial segments, regional markets. This leads to the issue of connectivity among the elements so as to form a united whole, i.e., the issue of integration (Russian Encyclopedic Dictionary, p. 581). This issue can be examined from different perspectives. One of them is studying how markets of individual regions are integrated with one another, that is, studying the spatial structure of market integration. This paper deals with Siberian regions, analyzing integration of each of them with all country's regions.¹

The following definition of market integration is adopted in this paper. Markets of two regions are deemed integrated if there are no impediments to trade between them. According to the law of one price (in its strict form), provided that such impediments are absent, prices of tradable goods (i.e., those that can take part in inter-regional trade) become the same in both regions. Thus, the law of one price can be applied as the criterion of market integration. However, there is a 'natural,' irremovable barrier between significantly distant regions, namely, the distance itself between them. In this case, the law of one price in a weak form can hold: regional markets are deemed integrated if the difference in prices does not exceed transportation costs. A situation that is intermediate between integration and non-integration is considered as well. It is the movement towards integration, which manifests itself in a permanent convergence of prices between two regions.

It is worth noting that integration between markets of two regions does not necessarily imply direct trade between them. Even if they do not trade with each other, prices in one region can impact on prices in another region through a network of 'intermediate' regions (Fackler and Goodwin, 2001).

A number of papers study integration of regional markets in Russia in the period after the Russian financial crisis of 1998. Akhmedjonov and Lau (2012) obtain a spatial pattern of integration of the Russian markets for diesel, gasoline, electricity, and coal in 2003–2010. They analyze integration of regional markets with the whole national market. Applying such an approach, 35% to 57 % (depending on specific good) of regional markets are found to be integrated with the national market. Lau and Akhmedjonov (2012) consider markets for outer clothing across 44 Russian regions in 2002–2009. They find 72% of regional markets to be integrated. Perevysin and Skrobotov (2017) analyze the law of one price for 69 goods in 2003–2015, using regional and average national prices. The results obtained suggest that the law of one price does not hold for 32 % of goods; as concerns regions, the pattern is rather mixed.

¹ For the spatial structure of integration of the whole Russian market, see Gluschenko (2017).

Stupnikova (2015) studies impact of embargo – introduced in response to the anti-Russian economic sanctions – on integration of the Russian vegetable market. To do so, she examines dynamics of prices during August 2013 through July 2014, comparing it with dynamics in August to December 2014. Some negative effects of the import restrictions are revealed. There are also papers analyzing integration of regional markets for intermediate goods, particularly, wheat – e.g., Yusupova (2004).

This paper contributes to the above literature, studying for the first time market integration of regions constituting Siberia with all regions of Russia (including the Siberian regions themselves).

The remainder of the paper is organized as follows. Section 2 expounds methodology and data applied. Section 3 reports and discusses the estimation results. Section 4 concludes.

2. Methodology and data

According to the definition adopted, the law of one price holds in the integrated markets. It is the strict law of one price, $p_{rt}/p_{st} = 1$ (where p_{rt} and p_{st} are prices for a good in regions r and s at period t , $t = 0, \dots, T$), if transportation costs can be neglected, or the weak law of one price, $p_{rt}/p_{st} = 1 + c_{rs}$ (where c_{rs} is the difference in prices caused by transaction costs of inter-regional trade). In the first case, integration is denoted as perfect; in the second case it is denoted as conditional, since the value of c_{rs} can be due not only to transportation costs, but also to ‘artificial’ or eliminable (in principle) impediments to integration (regional protectionism, local price regulations, organized crime, etc). A nonlinear, asymptotically decaying trend describes the movement towards integration (convergence): $p_{rt}/p_{st} = 1 + c_{rs}(t)$, $c_{rs}(t) \rightarrow 0$ as $t \rightarrow \infty$.

The tool for the analysis is time series econometrics. Time series of differences in prices in region pairs are analyzed. In doing so, the prices are supposed dependent on their previous values, i.e., autocorrelated. Describe $P_{rt} = \log(p_{rt}/p_{0t})$ as the price differential (or price disparity, since $P_{rt} \approx p_{rt}/p_{0t} - 1$), and let $C_{rs} = \log(1 + c_{rs})$. Then the econometric models of the strict and weak law of one price are the autoregression models AR(1): $P_{rst} = v_t$, $v_t = \rho v_{t-1} + \varepsilon_t$, and $P_{rst} = C_{rs} + v_t$, $v_t = \rho v_{t-1} + \varepsilon_t$. They can be transformed into:

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

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

where v_t is the regression residual, $\rho = \lambda + 1$ is the autoregression coefficient, $\Delta P_{rst} \equiv P_{rst} - P_{rs,t-1}$, $\gamma = -\lambda C_{rs}$, $\varepsilon_t \sim N(0, \sigma^2)$, $t = 1, \dots, T$ (to economize notation, the region indices for disturbances and model parameters are suppressed). Region pairs where these models describe the behavior of prices are deemed integrated with each other (perfectly or conditionally, respectively).

Intuitively, this means that the prices of the good in regions r and s coincide or differ by a non-zero constant (up to random shocks)

The econometric model of convergence looks like $P_{rst} = C_{rs}(t) + v_t$, $v_t = \rho v_{t-1} + \varepsilon_t$, where $C_{rs}(t) = \log(1 + c_{rs}(t))$. Transforming it, we get:

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

Three modes of the trend are applied: the log-exponential trend $C(t) = \log(1 + \gamma e^{\delta t})$, exponential trend $C(t) = \gamma e^{\delta t}$, and fractional trend $C(t) = \gamma(1 + \delta t)$, where γ and δ , δ are parameters to be estimated. Parameter γ characterizes the initial difference in prices; $\delta < 0$ and $\delta > 0$ characterize convergence rates. The respective nonlinear models have the forms:

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

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

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

If at least one of these models describes time series P_{rst} , this suggests that the difference in prices between regions r and s tends to zero over time. Such regions are deemed to move towards integration with each other (converging).

To test time series for stationarity about zero in Model (1), about a constant in Model (2), and about a trend in Model (3), the augmented Dickey-Fuller test and Phillips-Perron test are applied. Gluschenko (2017, Appendix) reports technical details of adopted methodology of testing. The hypothesis of non-stationarity (unit root) is deemed rejected if both tests reject it at the level of 10%. The 10% significance level is also applied to parameters γ and δ , δ .

Models (1), (2), and (3) are sequentially estimated for each time series P_{rst} , accepting the first significant model in this sequence (the ‘specific to general’ approach). All three versions of Model (3) are estimated for each region pair. If Model (3) with different modes of the trend turn out to be significant, the mode with the minimal sum of squared residuals is accepted.

If no one model describes time series P_{rst} , regions r and s trends are deemed neither integrated nor tending towards integration with each other. Such time series can be a random walk or a process with a rising trend ($\delta > 0$, $\delta < 0$) that suggests divergence.

Thus, region pairs are divided into four groups: perfectly integrated, conditionally integrated, not integrated but tending towards integration (converging), and non-integrated (in the latter group, diverging region pairs can be discerned). Appendix A provides examples of specific region pairs from these four groups, depicting the actual evolution of the price differentials vs. their theoretical long-run paths.

An aggregated market for basic foods (staples) is considered, using the cost of a basket of these goods as a price representative for the analysis. The basket includes 33 items; Rosstat

(2005, Appendix 6, p. 161)² reports its composition. Series p_{rt} have a monthly frequency and cover 2001–2015 (180 time observations). The data are drawn from the Integrated Interagency Informational and Statistical System of Russia (EMISS), www.fedstat.ru/indicator/31481.do.



Figure 1. Map of Siberia

² Available on www.gks.ru/free_doc/new_site/prices/potr/PRIL6.DOC.

The spatial sample includes 79 regions ('composite' regions being treated as whole ones), all Russia's regions but the Chechen Republic, Republic of Crimea, and City of Sevastopol, where full data on prices are lacking. Siberia consists of 13 regions; there are 7 regions in Western Siberia: the Republic of Altai, Altai Krai, Kemerovo Oblast, Novosibirsk Oblast, Omsk Oblast, Tomsk Oblast, and Tymen Oblast; Eastern Siberia comprise 6 regions: the Republic of Buryatia, Republic of Khakasia, Republic of Tuva, Transbaikal Krai, Krasnoyarsk Krai, and Irkutsk Oblast (see Figure 1).

The total number of region pairs to be analyzed is equal to 936 ($66 \times 13 = 858$ of pairs of Siberian regions with the rest of country's regions and $13 \times 12 / 2 = 78$ region pairs within Siberia). Table 1 reports the numbers of region pairs in different subsamples.

Table 1. The numbers of region pairs

Regions	The number of pairs with regions of:					
	whole of Russia	European Russia	Siberia	Western Siberia	Eastern Siberia	Russian Far East
Individual region of Western Siberia	78	57	12	6	6	9
Individual region of Eastern Siberia	78	57	12	7	5	9
All regions of Western Siberia	525	399	63	21	42	63
All regions of Eastern Siberia	453	342	57	42	15	54
All Siberian regions	936	741	78	63	57	117

Figure 2 reports summary statistics – the mean and standard deviation – of the absolute price differentials, $|P_{rst}|$, over Siberian regions and, for comparison, over all regions of Russia.

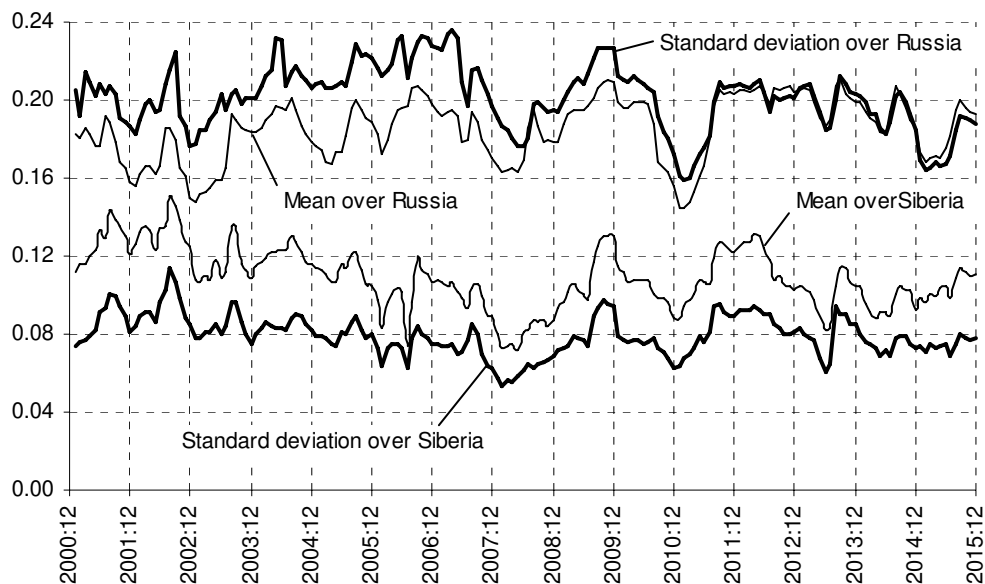


Figure 2. Summary statistics of the absolute price differentials

As Figure 2 shows, price dispersion measured by these two indicators is significantly lower in Siberia than in the whole of Russia. The mean of $|P_{rst}|$ fluctuates around 0.109 in the range of 0.072 to 0.150 in Siberia, whereas these values in Russia as a whole are equal to 0.185 and 0.144 to 0.211. The standard deviation of $|P_{rst}|$ in Siberia has the range of 0.053 to 0.114 (fluctuating around 0.079), while the national range is 0.159 to 0.236 (with the average of 0.201). However, it should be noted that these difference are due to the Far Eastern regions, especially to the northern ones. Comparing Siberia with the European part of Russia, price dispersions in these macroregions are comparable. Namely, the mean of $|P_{rst}|$ fluctuates around 0.107; and its standard deviation fluctuates around 0.085 in European Russia.

3. Results

Estimation of the considered models for each Siberian region gives the number of regions that are perfectly or conditionally integrated with it, converging, and not integrated (among these, diverging). Given the great number of region pairs (hence, regressions), it is hardly possible to present specific estimation results completely. Appendix B reports estimation results for region pairs within Siberia only. Table 2 tabulates the results obtained in a summarized form. It reports percentage of regional markets with which the market of an individual Siberian region or markets of all regions from Western Siberia, or Eastern Siberia, or Siberia as a whole is/are integrated, converging, and diverging. These percentages are computed as the ratio of the number of region pairs belonging to a respective group to the total number of pairs from Table 1.

Integration of Siberian regional markets is fairly strong: they are integrated – perfectly and conditionally – with 63.3% of country's regions (including the Siberian regions themselves). Adding converging region pairs, we get the total of 68.4%. (However, divergence – with 7.9% of Russian regions – takes place as well.) Denote such a figure (lines 'Sum' in Table 2) as the integration rate. Individual regions of Siberia are also rather strongly integrated with the rest regions of the country. Their integration rates range from 62.8% to 88.5%. The exceptions are two weakly integrated regions, namely, the Republic of Altai and Novosibirsk Oblast, where the integration rates are equal to 38.5% and 44.9%, respectively.

Integration of Siberian regions with regions of the European part of Russia is also rather strong. At the same time, integration with Far Eastern regions is relatively weak. It comes as no surprise, since this macroregion includes a number of regions with poor transport accessibility. This makes arbitrage in goods impossible there. Hence, it cannot act as the mechanism of the establishment and maintenance of spatial equilibrium.

Table 2. The percentage of region pairs belonging to different groups

Region	Group	Pairs with:					
		all Russian regions	regions of European Russia	all Siberian regions	Western-Siberian regions	Eastern-Siberian regions	Far-Eastern regions
Republic of Altai	PI	15.4	14.0	33.3	0.0	66.7	0.0
	CI	19.2	14.0	0.0	0.0	0.0	77.8
	C	3.8	3.5	8.3	0.0	16.7	0.0
	Sum	38.5	31.6	41.7	0.0	83.3	77.8
	D	21.8	28.1	8.3	16.7	0.0	0.0
Altai Krai	PI	34.6	45.6	8.3	16.7	0.0	0.0
	CI	30.8	19.3	41.7	50.0	33.3	88.9
	C	14.1	14.0	16.7	0.0	33.3	11.1
	Sum	79.5	78.9	66.7	66.7	66.7	100.0
	D	1.3	1.8	0.0	0.0	0.0	0.0
Kemerovo Oblast	PI	44.9	59.6	8.3	16.7	0.0	0.0
	CI	28.2	22.8	58.3	33.3	83.3	22.2
	C	3.8	3.5	0.0	0.0	0.0	11.1
	Sum	76.9	86.0	66.7	50.0	83.3	33.3
	D	6.4	1.8	8.3	16.7	0.0	33.3
Novosibirsk Oblast	PI	20.5	17.5	50.0	0.0	100.0	0.0
	CI	17.9	10.5	8.3	16.7	0.0	77.8
	C	6.4	3.5	8.3	16.7	0.0	22.2
	Sum	44.9	31.6	66.7	33.3	100.0	100.0
	D	17.9	24.6	0.0	0.0	0.0	0.0
Omsk Oblast	PI	26.9	36.8	0.0	0.0	0.0	0.0
	CI	43.6	40.4	50.0	33.3	66.7	55.6
	C	1.3	1.8	0.0	0.0	0.0	0.0
	Sum	71.8	78.9	50.0	33.3	66.7	55.6
	D	10.3	7.0	0.0	0.0	0.0	44.4
Tomsk Oblast	PI	29.5	31.6	41.7	0.0	83.3	0.0
	CI	33.3	31.6	25.0	50.0	0.0	55.6
	C	2.6	1.8	8.3	16.7	0.0	0.0
	Sum	65.4	64.9	75.0	66.7	83.3	55.6
	D	9.0	7.0	0.0	0.0	0.0	33.3
Tyumen Oblast	PI	10.3	10.5	0.0	0.0	0.0	22.2
	CI	42.3	43.9	58.3	50.0	66.7	11.1
	C	21.8	22.8	33.3	33.3	33.3	0.0
	Sum	74.4	77.2	91.7	83.3	100.0	33.3
	D	2.6	1.8	0.0	0.0	0.0	11.1
Western Siberia	PI	26.0	30.8	20.2	4.8	35.7	3.2
	CI	30.8	26.1	34.5	33.3	35.7	55.6
	C	7.7	7.3	10.7	9.5	11.9	6.3
	Sum	64.5	64.2	65.5	47.6	83.3	65.1
	D	9.9	10.3	2.4	4.8	0.0	17.5
Republic of Buryatia	PI	32.1	31.6	58.3	42.9	80.0	0.0
	CI	30.8	33.3	33.3	42.9	20.0	11.1
	C	0.0	0.0	0.0	0.0	0.0	0.0
	Sum	62.8	64.9	91.7	85.7	100.0	11.1
	D	2.6	1.8	0.0	0.0	0.0	11.1
Republic of Tuva	PI	33.3	29.8	66.7	42.9	100.0	11.1
	CI	42.3	50.9	0.0	0.0	0.0	44.4
	C	3.8	1.8	16.7	28.6	0.0	0.0
	Sum	79.5	82.5	83.3	71.4	100.0	55.6
	D	1.3	0.0	0.0	0.0	0.0	11.1
Republic of Khakasia	PI	33.3	35.1	50.0	28.6	80.0	0.0
	CI	29.5	24.6	33.3	42.9	20.0	55.6
	C	2.6	1.8	8.3	14.3	0.0	0.0
	Sum	65.4	61.4	91.7	85.7	100.0	55.6
	D	6.4	1.8	0.0	0.0	0.0	44.4

Region	Group	Pairs with:					
		all Russian regions	regions of European Russia	all Siberian regions	Western-Siberian regions	Eastern-Siberian regions	Far-Eastern regions
Transbaikal Krai	PI	30.8	26.3	66.7	42.9	100.0	11.1
	CI	55.1	64.9	33.3	57.1	0.0	22.2
	C	2.6	3.5	0.0	0.0	0.0	0.0
	Sum	88.5	94.7	100.0	100.0	100.0	33.3
	D	5.1	5.3	0.0	0.0	0.0	11.1
Krasnoyarsk Krai	PI	17.9	17.5	33.3	14.3	60.0	0.0
	CI	41.0	49.1	25.0	14.3	40.0	11.1
	C	3.8	1.8	16.7	28.6	0.0	0.0
	Sum	62.8	68.4	75.0	57.1	100.0	11.1
	D	2.6	1.8	0.0	0.0	0.0	11.1
Irkutsk Oblast	PI	34.6	33.3	66.7	42.9	100.0	0.0
	CI	50.0	57.9	33.3	57.1	0.0	22.2
	C	2.6	3.5	0.0	0.0	0.0	0.0
	Sum	87.2	94.7	100.0	100.0	100.0	22.2
	D	9.0	5.3	0.0	0.0	0.0	44.4
Eastern Siberia	PI	30.3	28.9	56.9	35.7	86.7	3.7
	CI	41.5	46.8	26.4	35.7	13.3	27.8
	C	2.6	2.0	6.9	11.9	0.0	0.0
	Sum	74.4	77.8	90.3	83.3	100.0	31.5
	D	4.5	2.6	0.0	0.0	0.0	22.2
Siberia	PI	28.0	30.0	37.2	20.2	56.9	3.4
	CI	35.7	35.6	30.8	34.5	26.4	42.7
	C	5.3	4.9	9.0	10.7	6.9	3.4
	Sum	69.0	70.4	76.9	65.5	90.3	49.6
	D	7.4	6.7	1.3	2.4	0.0	19.7

Note: PI = perfectly integrated, CI = conditionally integrated, C = converging, and D = diverging.

It is interesting to note that integration of the Western Siberian regions with the Far Eastern regions is slightly stronger than with regions of the European part of Russia. In particular, the Altai Krai and Novosibirsk Oblast are integrated with all regions of the Russian Far East.

Hand in hand with this, market integration within Western Siberia is poor. Only 47.6% of its regions are integrated or converging with one another, while all regions within Eastern Siberia are integrated with one another (among these, 86.7% are perfectly integrated). Table 3 provides more detailed pattern of integration within Siberia.³ Although the matrix in the table is symmetric, all its elements are reported for convenience.

The Republic of Altai stands out here (it ranks 11th among the least integrated regions of Russia; see Gluschenko, 2017). It is integrated with no one region in Western Siberia; the Republic of Altai is even responsible for the sole case of divergence in Siberia (with the Kemerovo Oblast). At the same time, it is integrated or converging with all but one of regions in Eastern Siberia. The Novosibirsk Oblast which is integrated with one region of Western Siberia and converging with one more is (conditionally) integrated with all Eastern Siberian regions. And in general, integration of Western Siberian regions with regions of Eastern Siberia is much stronger than with one another.

³ It is this subsample of region pairs, for which Appendix B reports estimates of Models (1)–(3).

Table 3. Matrix of integration between Siberian regions

	Republic of Altai	Altai Krai	Kemerovo Oblast	Novosibirsk Oblast	Omsk Oblast	Tomsk Oblast	Tyumen Oblast	Republic of Buryatia	Republic of Tuva	Republic of Khakasia	Transbaikal Krai	Krasnoyarsk Krai	Irkutsk Oblast
Republic of Altai			↓					+	+		+	↑	+
Altai Krai			+	±		±	±		↑	↑	±		±
Kemerovo Oblast	↓	+				±	±	±		±	±	±	±
Novosibirsk Oblast		+					↑	±	±	±	±	±	±
Omsk Oblast						±	±	±		±	±		±
Tomsk Oblast		±	±		±		↑	+	+	+	+		+
Tyumen Oblast		±	±	↑	±	↑		±	↑	±	±	↑	±
Republic of Buryatia	+		±	+	±	+	±		+	+	+	±	+
Republic of Tuva	+	↑		+		+	↑	+		+	+	+	+
Republic of Khakasia		↑	±	+	±	+	±	+	+		+	±	+
Transbaikal Krai	+	±	±	+	±	+	±	+	+	+		+	+
Krasnoyarsk Krai	↑		±	+			↑	±	+	±	+		+
Irkutsk Oblast	+	±	±	+	±	+	±	+	+	+	+	+	

Notes: + = perfect integration, ± = conditional integration, ↑ = convergence, and ↓ = divergence; thick lines divide regions of Western and Eastern Siberia.

Integration between regions of Western and Eastern Siberia is strong, the integration rate equalling 83.3%. The strongest integration is inherent in the Transbaikal Krai and Irkutsk Oblast: they are integrated with all Siberian regions. In total, the integration rate of all Siberian regions is equal to 79.6%.

6. Conclusion

Integration of regional markets of Siberia with markets of all regions of Russia has been analyzed. Such an analysis has made it possible to classify region pairs into four groups: perfectly integrated, conditionally integrated, moving towards integration (converging), and non-integrated. The results obtained suggest that the integration rate of Siberian regions is fairly high, equalling to more than 68%, while this rate of all Russian regions equals 55% (Gluschenko, 2017, p.11).

In spite of remoteness of Siberian markets from the European part of Russia, they are integrated with it even somewhat stronger than with all country's regions (the integration rate exceeds 70%). An unexpected feature of the pattern obtained is the fact that Western Siberia is stronger integrated with the Russian Far East than Eastern Siberia (neighboring upon the Far

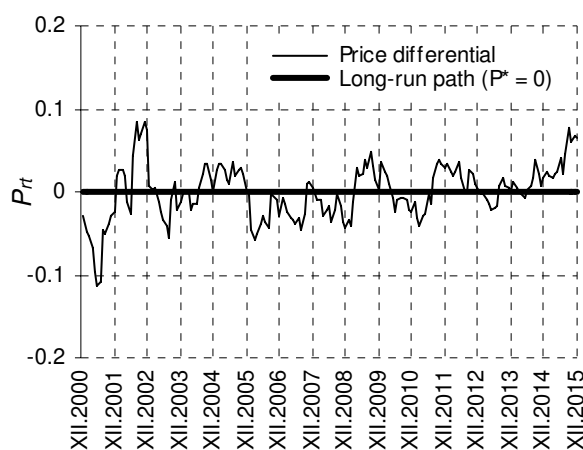
East).

The integration rate within Siberia is equal to 77%. Integration between regional markets of Western and Eastern Siberia is also strong, the integration rate equaling more than 83%. However, integration within Western Siberia is weak; more than a half of regions here are not integrated with one another. Contrastingly, Eastern Siberian regions are completely integrated with one another.

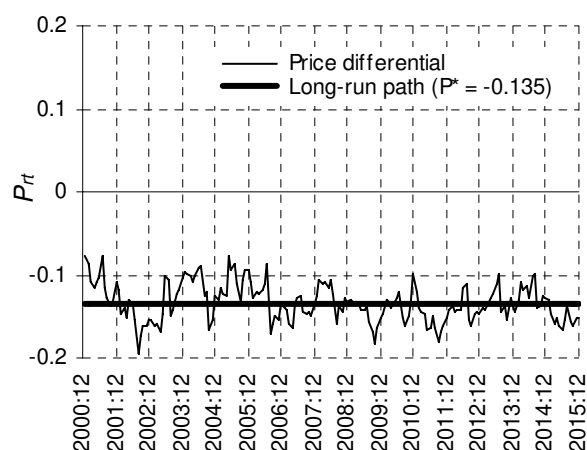
References

- Akhmedjonov, A., Lau, C.K. (2012) Do energy prices converge across Russian regions? *Economic Modelling*, 29: 1623–1631.
- Fackler, P.L., Goodwin, B.K. (2001) Spatial price analysis. In: Gardner, B., Rausser, G. (eds) *Handbook of Agricultural Economics*, vol. 1B. Elsevier, Amsterdam, pp. 971–1024.
- Gluschenko, K. (2017). Spatial pattern of Russia's market integration. MPRA Paper No. 79971.
- Lau, C.K., Akhmedjonov, A. (2012) Trade barriers and market integration in textile sector: evidence from post-reform Russia. *Journal of the Textile Institute*, 103: 532–540.
- Perevysin, Yu.N., Skrobotov, A.A. (2017). Convergence of prices for selected goods in Russian regions. *Journal of the New Economic Association*, No. 3, 71–102. [In Russian.] *Russian Encyclopedic Dictionary*, 2nd ed. Moscow: Bol'shaya Rossiyskaya Entsiklopedia, 2002. [In Russian.]
- Stupnikova, A.V. (2015) The sanction's impact on the integration level of the Russian market of vegetables. *Spatial Economics*, No. 3, 74–96. [In Russian.]
- Yusupova, G.F. (2004). Tendencies of price convergence in Russian markets. *Modern Competition*, No. 6, 45–61. [In Russian.]

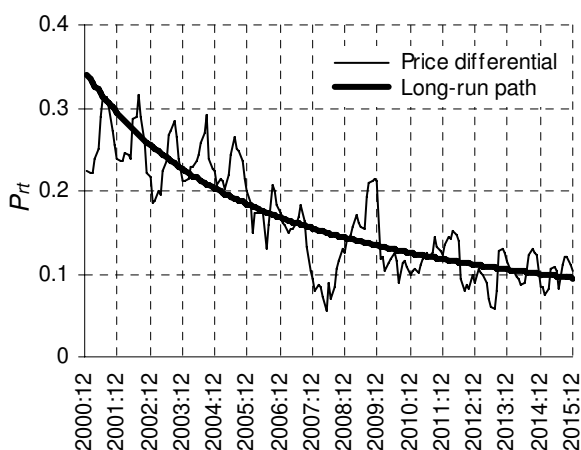
Appendix A. Examples of price differential in different groups of region pairs



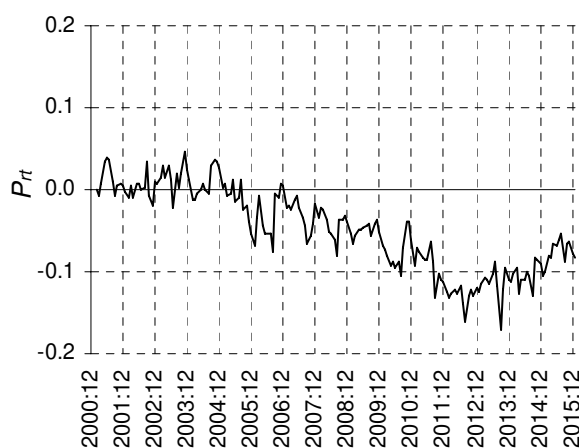
(a) Perfect integration:
 $r = \text{Transbaikals Krai}, s = \text{Irkutsk Oblast}$



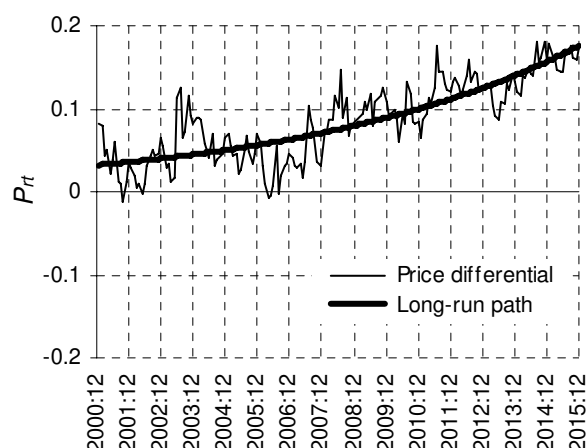
(b) Conditional integration:
 $r = \text{Altai Krai}, s = \text{Novosibirsk Oblast}$
 $(P^* = -\gamma\lambda)$



(c) Convergence:
 $r = \text{Tyumen Oblast}, s = \text{Novosibirsk Oblast}, C(t) = 0.341/(1 + 0.014t)$



(d) Non-integration:
 $r = \text{Omsk Oblast}, s = \text{Altai Krai}$



(e) Non-integration (divergence):
 $r = \text{Republic of Altai}, s = \text{Kemerovo Oblast},$
 $C(t) = 0.032e^{0.0095t}$

Figure A1. Examples of four types of region pairs.

Appendix B. Full set of estimates for within Siberia region pairs

Region r	Model	λ	Unit root test			γ	δ, δ'	SSR
			p -values (PP/ADF)					
Region $s =$ Republic of Altai								
Altai Krai	(1)	-0.011 (0.012)	0.434	/0.448				
	(2)	-0.165 (0.042)	0.411	/0.809	-0.019***	(0.005)		
	(3a)	-0.175 (0.043)	0.348	/0.786	-0.091***	(0.014)	0.0019	(0.0013)
	(3b)	-0.175 (0.043)	0.444	/0.938	-0.095***	(0.015)	0.0020	(0.0014)
	(3c)	-0.178 (0.043)	0.365	/0.781	-0.092***	(0.013)	-0.0020**	(0.0008)
Kemerovo Oblast	(1)	-0.019 (0.017)	0.404	/0.407				
	(2)	-0.094 (0.034)	0.700	/0.740	-0.009***	(0.003)		
	(3a)	-0.341 (0.056)	0.000	/0.037	-0.032***	(0.005)	0.0090***	(0.0011)
	(3b)	-0.342 (0.056)	0.000	/0.040	-0.032***	(0.005)	0.0095***	(0.0011)
	(3c)	-0.304 (0.054)	0.024	/0.158	-0.046***	(0.005)	-0.0042***	(0.0002)
Novosibirsk Oblast	(1)	-0.165 (0.041)	0.009	/0.137				
	(2)	-0.214 (0.045)	0.013	/0.450	0.004**	(0.002)		
	(3a)	-0.214 (0.046)	0.052	/0.590	0.025	(0.018)	-0.0026	(0.0076)
	(3b)	-0.214 (0.046)	0.059	/0.696	0.025	(0.018)	-0.0025	(0.0075)
	(3c)	-0.214 (0.046)	0.120	/0.684	0.023	(0.019)	0.0021	(0.0104)
Omsk Oblast	(1)	-0.006 (0.011)	0.475	/0.475				
	(2)	-0.081 (0.031)	0.729	/0.669	-0.014***	(0.005)		
	(3a)	-0.289 (0.053)	0.005	/0.184	-0.085***	(0.008)	0.0058***	(0.0007)
	(3b)	-0.287 (0.052)	0.005	/0.218	-0.087***	(0.009)	0.0063***	(0.0008)
	(3c)	-0.293 (0.053)	0.039	/0.283	-0.101***	(0.007)	-0.0036***	(0.0002)
Tomsk Oblast	(1)	-0.118 (0.035)	0.043	/0.198				
	(2)	-0.146 (0.039)	0.170	/0.546	-0.003	(0.002)		
	(3a)	-0.271 (0.049)	0.001	/0.075	-0.001	(0.001)	0.0268***	(0.0085)
	(3b)	-0.272 (0.049)	0.001	/0.083	-0.001	(0.001)	0.0275***	(0.0087)
	(3c)	-0.232 (0.046)	0.042	/0.288	-0.009**	(0.003)	-0.0051***	(0.0003)
Tyumen Oblast	(1)	-0.011 (0.011)	0.250	/0.250				
	(2)	-0.075 (0.030)	0.887	/0.841	0.013**	(0.006)		
	(3a)	-0.234 (0.046)	0.004	/0.418	0.356***	(0.030)	-0.0068***	(0.0010)
	(3b)	-0.232 (0.046)	0.004	/0.503	0.307***	(0.023)	-0.0062***	(0.0010)
	(3c)	-0.209 (0.044)	0.047	/0.625	0.332***	(0.038)	0.0106***	(0.0030)
Republic of Buryatia	(1)	-0.082 (0.030)	0.063	/0.091				
	(2)	-0.084 (0.031)	0.380	/0.480	0.001	(0.002)		
	(3a)	-0.111 (0.035)	0.335	/0.524	0.122	(0.116)	-0.0215	(0.0223)
	(3b)	-0.111 (0.035)	0.356	/0.490	0.116	(0.108)	-0.0211	(0.0221)
	(3c)	-0.103 (0.034)	NA	NA	0.163	(0.443)	0.0779	(0.2306)
Republic of Tuva	(1)	-0.070 (0.027)	0.062	/0.063				
	(2)	-0.160 (0.042)	0.680	/0.848	0.008***	(0.003)		
	(3a)	-0.256 (0.051)	0.055	/0.756	0.128***	(0.026)	-0.0105***	(0.0032)
	(3b)	-0.255 (0.051)	0.063	/0.881	0.121***	(0.023)	-0.0102***	(0.0031)
	(3c)	-0.244 (0.050)	0.160	/0.915	0.144***	(0.044)	0.0233	(0.0145)
Republic of Khakasia	(1)	-0.082 (0.031)	0.128	/0.156				
	(2)	-0.087 (0.033)	0.818	/0.864	0.001	(0.002)		
	(3a)	-0.129 (0.039)	0.668	/0.642	0.114	(0.080)	-0.0206	(0.0168)
	(3b)	-0.128 (0.039)	0.787	/0.750	0.109	(0.075)	-0.0202	(0.0166)
	(3c)	-0.118 (0.037)	0.749	/0.856	0.179	(0.415)	0.0859	(0.2237)
Transbaikal Krai	(1)	-0.068 (0.027)	0.059	/0.078				
	(2)	-0.166 (0.042)	0.017	/0.053	0.010***	(0.003)		
	(3a)	-0.244 (0.049)	0.001	/0.008	0.140***	(0.030)	-0.0091***	(0.0031)
	(3b)	-0.243 (0.049)	0.001	/0.009	0.131***	(0.026)	-0.0088***	(0.0030)
	(3c)	-0.230 (0.047)	0.026	/0.054	0.142***	(0.044)	0.0161	(0.0110)
Krasnoyarsk Krai	(1)	-0.032 (0.018)	0.235	/0.200				
	(2)	-0.100 (0.033)	0.506	/0.561	0.008**	(0.003)		
	(3a)	-0.357 (0.055)	0.000	/0.026	0.202***	(0.017)	-0.0113***	(0.0014)
	(3b)	-0.355 (0.055)	0.000	/0.029	0.186***	(0.014)	-0.0108***	(0.0013)
	(3c)	-0.298 (0.051)	0.013	/0.114	0.219***	(0.032)	0.0246***	(0.0071)

Region r	Model	λ	Unit root test			γ	δ, δ'	SSR
			p -values (PP/ADF)					
Irkutsk Oblast	(1)	-0.049	(0.022)	0.077	/0.054			
	(2)	-0.101	(0.034)	0.237	/0.272	0.006**	(0.003)	
	(3a)	-0.202	(0.045)	0.011	/0.064	0.168***	(0.035)	-0.0119*** (0.0035)
	(3b)	-0.201	(0.045)	0.012	/0.074	0.157***	(0.031)	-0.0115*** (0.0034)
	(3c)	-0.183	(0.043)	0.072	/0.168	0.216**	(0.094)	0.0356 (0.0272)
Region s =Altai Krai								
Kemerovo Oblast	(1)	-0.056	(0.024)	0.094	/0.098			
	(2)	-0.077	(0.029)	0.386	/0.430	0.002	(0.002)	
	(3a)	-0.207	(0.044)	0.024	/0.193	0.154***	(0.034)	-0.0230*** (0.0061)
	(3b)	-0.206	(0.044)	0.028	/0.228	0.144***	(0.031)	-0.0223*** (0.0060)
	(3c)	-0.179	(0.034)	NA	NA	0.471***	(0.162)	0.1944*** (0.0739)
Novosibirsk Oblast	(1)	-0.006	(0.010)	0.732	/0.687			
	(2)	-0.307	(0.053)	0.000	/0.014	0.041***	(0.007)	
	(3a)	-0.324	(0.054)	0.000	/0.032	0.135***	(0.008)	0.0007 (0.0006)
	(3b)	-0.324	(0.054)	0.000	/0.035	0.126***	(0.007)	0.0007 (0.0005)
	(3c)	-0.324	(0.054)	0.014	/0.084	0.126***	(0.007)	-0.0006 (0.0005)
Omsk Oblast	(1)	-0.032	(0.020)	0.334	/0.339			
	(2)	-0.071	(0.028)	0.644	/0.592	-0.004**	(0.002)	
	(3a)	-0.169	(0.043)	0.459	/0.779	-0.015**	(0.008)	0.0113*** (0.0034)
	(3b)	-0.171	(0.043)	0.532	/0.904	-0.015*	(0.008)	0.0118*** (0.0035)
	(3c)	-0.128	(0.037)	0.687	/0.884	-0.029***	(0.010)	-0.0042*** (0.0008)
Tomsk Oblast	(1)	-0.014	(0.013)	0.261	/0.261			
	(2)	-0.163	(0.040)	0.017	/0.065	0.016***	(0.004)	
	(3a)	-0.204	(0.043)	0.001	/0.001	0.137***	(0.017)	-0.0034** (0.0013)
	(3b)	-0.204	(0.043)	0.001	/0.001	0.129***	(0.015)	-0.0033** (0.0013)
	(3c)	-0.201	(0.043)	0.018	/0.018	0.130***	(0.018)	0.0041* (0.0023)
Tyumen Oblast	(1)	-0.004	(0.006)	0.416	/0.416			
	(2)	-0.076	(0.029)	0.091	/0.091	0.022**	(0.009)	
	(3a)	-0.187	(0.043)	0.002	/0.002	0.498***	(0.036)	-0.0041*** (0.0008)
	(3b)	-0.189	(0.043)	0.002	/0.002	0.407***	(0.025)	-0.0036*** (0.0007)
	(3c)	-0.195	(0.043)	0.021	/0.021	0.426***	(0.030)	0.0052*** (0.0012)
Republic. of Buryatia	(1)	-0.017	(0.013)	0.186	/0.186			
	(2)	-0.085	(0.030)	0.236	/0.308	0.011**	(0.004)	
	(3a)	-0.151	(0.039)	0.052	/0.112	0.240***	(0.040)	-0.0067*** (0.0021)
	(3b)	-0.151	(0.039)	0.059	/0.129	0.216***	(0.034)	-0.0062*** (0.0019)
	(3c)	-0.143	(0.038)	0.131	/0.204	0.228***	(0.051)	0.0098* (0.0056)
Republic of Tuva	(1)	-0.009	(0.009)	0.322	/0.325			
	(2)	-0.120	(0.036)	0.071	/0.114	0.020***	(0.006)	
	(3a)	-0.168	(0.042)	0.030	/0.076	0.242***	(0.027)	-0.0031*** (0.0012)
	(3b)	-0.168	(0.042)	0.033	/0.085	0.218***	(0.022)	-0.0029*** (0.0011)
	(3c)	-0.175	(0.042)	0.071	/0.125	0.229***	(0.026)	0.0042** (0.0018)
Republic of Khakasia	(1)	-0.015	(0.011)	0.174	/0.174			
	(2)	-0.105	(0.034)	0.144	/0.199	0.014***	(0.005)	
	(3a)	-0.265	(0.051)	0.000	/0.000	0.229***	(0.018)	-0.0057*** (0.0009)
	(3b)	-0.265	(0.051)	0.000	/0.000	0.207***	(0.015)	-0.0053*** (0.0009)
	(3c)	-0.251	(0.050)	0.012	/0.016	0.216***	(0.020)	0.0080*** (0.0021)
Transbaikal Krai	(1)	-0.011	(0.011)	0.331	/0.333			
	(2)	-0.129	(0.037)	0.010	/0.010	0.023***	(0.007)	
	(3a)	-0.162	(0.042)	0.010	/0.010	0.256***	(0.037)	-0.0029* (0.0015)
	(3b)	-0.162	(0.042)	0.010	/0.010	0.229***	(0.030)	-0.0027** (0.0014)
	(3c)	-0.165	(0.042)	0.045	/0.045	0.239***	(0.035)	0.0039* (0.0023)
Krasnoyarsk Krai	(1)	-0.006	(0.008)	0.389	/0.389			
	(2)	-0.077	(0.029)	0.305	/0.345	0.015**	(0.006)	
	(3a)	-0.173	(0.043)	0.063	/0.248	0.323***	(0.029)	-0.0046*** (0.0010)
	(3b)	-0.175	(0.043)	0.064	/0.275	0.282***	(0.022)	-0.0042*** (0.0009)
	(3c)	-0.198	(0.044)	0.060	/0.178	0.307***	(0.026)	0.0071*** (0.0017)

Region r	Model	λ	Unit root test			γ	δ, δ'	SSR
			p -values (PP/ADF)					
Irkutsk Oblast	(1)	-0.009	(0.009)	0.259	/0.259			
	(2)	-0.105	(0.033)	0.025	/0.025	0.018***	(0.006)	
	(3a)	-0.230	(0.048)	0.001	/0.001	0.284***	(0.021)	-0.0043*** (0.0008)
	(3b)	-0.231	(0.048)	0.000	/0.000	0.251***	(0.017)	-0.0040*** (0.0008)
	(3c)	-0.240	(0.049)	0.014	/0.014	0.265***	(0.020)	0.0061*** (0.0015)
Region s = Kemerovo Oblast								
Novosibirsk Oblast	(1)	-0.001	(0.008)	0.644	/0.644			
	(2)	-0.035	(0.018)	0.320	/0.320	0.004**	(0.002)	
	(3a)	-0.072	(0.028)	0.461	/0.565	0.066***	(0.022)	0.0056** (0.0024)
	(3b)	-0.071	(0.028)	0.547	/0.669	0.064***	(0.020)	0.0052** (0.0023)
	(3c)	-0.062	(0.025)	0.319	/0.319	0.077***	(0.020)	-0.0029*** (0.0010)
Omsk Oblast	(1)	-0.025	(0.017)	0.333	/0.334			
	(2)	-0.178	(0.043)	0.072	/0.211	-0.014***	(0.004)	
	(3a)	-0.193	(0.045)	0.122	/0.351	-0.062***	(0.013)	0.0022 (0.0017)
	(3b)	-0.193	(0.045)	0.141	/0.413	-0.064***	(0.013)	0.0022 (0.0018)
	(3c)	-0.195	(0.045)	0.195	/0.444	-0.064***	(0.012)	-0.0019* (0.0011)
Tomsk Oblast	(1)	-0.014	(0.014)	0.408	/0.408			
	(2)	-0.097	(0.030)	0.038	/0.027	0.007***	(0.002)	
	(3a)	-0.128	(0.035)	0.047	/0.044	0.048***	(0.014)	0.0040* (0.0023)
	(3b)	-0.128	(0.035)	0.053	/0.050	0.047***	(0.013)	0.0038* (0.0023)
	(3c)	-0.122	(0.034)	0.113	/0.106	0.052***	(0.013)	-0.0024** (0.0012)
Tyumen Oblast	(1)	-0.003	(0.006)	0.436	/0.420			
	(2)	-0.113	(0.035)	0.018	/0.018	0.030***	(0.009)	
	(3a)	-0.133	(0.037)	0.020	/0.020	0.354***	(0.034)	-0.0015 (0.0009)
	(3b)	-0.133	(0.037)	0.022	/0.022	0.304***	(0.025)	-0.0013 (0.0008)
	(3c)	-0.134	(0.037)	0.067	/0.067	0.306***	(0.027)	0.0015 (0.0010)
Republic of Buryatia	(1)	-0.018	(0.014)	0.198	/0.198			
	(2)	-0.130	(0.037)	0.009	/0.009	0.013***	(0.004)	
	(3a)	-0.131	(0.037)	0.025	/0.025	0.113***	(0.028)	-0.0010 (0.0023)
	(3b)	-0.131	(0.037)	0.027	/0.027	0.107***	(0.025)	-0.0009 (0.0022)
	(3c)	-0.131	(0.037)	0.075	/0.075	0.106***	(0.026)	0.0010 (0.0026)
Republic of Tuva	(1)	-0.010	(0.010)	0.371	/0.366			
	(2)	-0.126	(0.037)	0.059	/0.108	0.018***	(0.005)	
	(3a)	-0.137	(0.038)	0.093	/0.165	0.127***	(0.024)	0.0017 (0.0016)
	(3b)	-0.137	(0.038)	0.107	/0.192	0.120***	(0.021)	0.0016 (0.0015)
	(3c)	-0.137	(0.038)	0.165	/0.249	0.121***	(0.020)	-0.0013 (0.0011)
Republic of Khakasia	(1)	-0.014	(0.012)	0.204	/0.204			
	(2)	-0.126	(0.036)	0.010	/0.010	0.013***	(0.004)	
	(3a)	-0.127	(0.037)	0.030	/0.030	0.110***	(0.023)	-0.0003 (0.0020)
	(3b)	-0.127	(0.037)	0.033	/0.033	0.104***	(0.021)	-0.0003 (0.0019)
	(3c)	-0.126	(0.037)	0.082	/0.082	0.104***	(0.021)	0.0002 (0.0019)
Transbaikal Krai	(1)	-0.009	(0.012)	0.373	/0.373			
	(2)	-0.148	(0.040)	0.005	/0.005	0.022***	(0.006)	
	(3a)	-0.156	(0.041)	0.011	/0.011	0.139***	(0.024)	0.0016 (0.0015)
	(3b)	-0.156	(0.041)	0.012	/0.012	0.130***	(0.021)	0.0015 (0.0014)
	(3c)	-0.156	(0.041)	0.051	/0.051	0.131***	(0.020)	-0.0013 (0.0011)
Krasnoyarsk Krai	(1)	-0.002	(0.006)	0.561	/0.561			
	(2)	-0.135	(0.038)	0.008	/0.008	0.023***	(0.006)	
	(3a)	-0.137	(0.039)	0.025	/0.025	0.186***	(0.018)	-0.0003 (0.0009)
	(3b)	-0.137	(0.039)	0.028	/0.028	0.171***	(0.016)	-0.0003 (0.0008)
	(3c)	-0.137	(0.039)	0.075	/0.075	0.171***	(0.016)	0.0003 (0.0009)
Irkutsk Oblast	(1)	-0.007	(0.008)	0.334	/0.334			
	(2)	-0.138	(0.038)	0.006	/0.006	0.020***	(0.006)	
	(3a)	-0.138	(0.038)	0.019	/0.019	0.159***	(0.022)	0.0000 (0.0013)
	(3b)	-0.138	(0.038)	0.021	/0.021	0.148***	(0.019)	0.0000 (0.0012)
	(3c)	-0.138	(0.038)	0.065	/0.065	0.148***	(0.019)	0.0000 (0.0012)

Region r	Model	λ	Unit root test				γ	δ, δ'	SSR
			p -values (PP/ADF)						
Region s =Novosibirsk Oblast									
Omsk Oblast	(1)	-0.001	(0.007)	0.789	/0.768				
	(2)	-0.060	(0.024)	0.290	/0.410	-0.012**	(0.005)		
	(3a)	-0.177	(0.043)	0.046	/0.143	-0.113***	(0.011)	0.0041	(0.0007)
	(3b)	-0.179	(0.043)	0.048	/0.158	-0.118***	(0.012)	0.0046	(0.0008)
	(3c)	-0.155	(0.040)	0.147	/0.286	-0.131***	(0.012)	-0.0028	(0.0004)
Omsk Oblast	(1)	-0.025	(0.018)	0.147	/0.147				
	(2)	-0.063	(0.027)	0.155	/0.155	-0.003*	(0.001)		
	(3a)	-0.095	(0.032)	0.088	/0.088	-0.015	(0.011)	0.0086*	(0.0049)
	(3b)	-0.095	(0.032)	0.099	/0.099	-0.015	(0.011)	0.0089*	(0.0050)
	(3c)	-0.087	(0.031)	0.188	/0.188	-0.023**	(0.011)	-0.0038***	(0.0012)
Tomsk Oblast	(1)	-0.009	(0.008)	0.225	/0.225				
	(2)	-0.039	(0.021)	0.338	/0.338	0.006	(0.004)		
	(3a)	-0.153	(0.039)	0.009	/0.009	0.342***	(0.034)	-0.0079***	(0.0013)
	(3b)	-0.154	(0.039)	0.008	/0.008	0.297***	(0.026)	-0.0073***	(0.0012)
	(3c)	-0.151	(0.038)	0.042	/0.042	0.341***	(0.046)	0.0144***	(0.0043)
Republic of Buryatia	(1)	-0.051	(0.023)	0.028	/0.028				
	(2)	-0.053	(0.024)	0.195	/0.195	-0.001	(0.002)		
	(3a)	-0.065	(0.027)	0.221	/0.221	-0.003	(0.014)	0.0166	(0.0259)
	(3b)	-0.065	(0.027)	0.258	/0.258	-0.003	(0.013)	0.0169	(0.0263)
	(3c)	-0.060	(0.025)	0.337	/0.337	-0.010	(0.018)	-0.0046**	(0.0023)
Republic of Tuva	(1)	-0.075	(0.026)	0.010	/0.018				
	(2)	-0.107	(0.033)	0.322	/0.544	0.003	(0.002)		
	(3a)	-0.185	(0.044)	0.208	/0.500	0.139***	(0.044)	-0.0204**	(0.0079)
	(3b)	-0.185	(0.044)	0.245	/0.591	0.130***	(0.039)	-0.0197**	(0.0077)
	(3c)	-0.170	(0.038)	NA	NA	0.417**	(0.207)	0.1724**	(0.0869)
Republic of Khakasia	(1)	-0.061	(0.024)	0.013	/0.013				
	(2)	-0.061	(0.024)	0.119	/0.119	-0.001	(0.001)		
	(3a)	-0.086	(0.028)	0.073	/0.073	-0.001	(0.004)	0.0242	(0.0232)
	(3b)	-0.086	(0.028)	0.082	/0.082	-0.001	(0.004)	0.0246	(0.0235)
	(3c)	-0.077	(0.027)	0.181	/0.181	-0.007	(0.009)	-0.0050***	(0.0009)
Transbaikal Krai	(1)	-0.055	(0.023)	0.017	/0.017				
	(2)	-0.090	(0.030)	0.038	/0.038	0.004*	(0.002)		
	(3a)	-0.137	(0.039)	0.024	/0.024	0.135***	(0.052)	-0.0145**	(0.0072)
	(3b)	-0.136	(0.039)	0.026	/0.026	0.127***	(0.047)	-0.0140**	(0.0070)
	(3c)	-0.133	(0.031)	NA	NA	0.594***	(0.186)	0.1714***	(0.0546)
Krasnoyarsk Krai	(1)	-0.024	(0.014)	0.075	/0.075				
	(2)	-0.044	(0.021)	0.234	/0.234	0.002	(0.002)		
	(3a)	-0.162	(0.041)	0.037	/0.072	0.229***	(0.037)	-0.0185***	(0.0035)
	(3b)	-0.161	(0.041)	0.041	/0.080	0.209***	(0.032)	-0.0176***	(0.0034)
	(3c)	-0.172	(0.023)	NA	NA	0.844***	(0.142)	0.1992***	(0.0404)
Irkutsk Oblast	(1)	-0.043	(0.018)	0.018	/0.018				
	(2)	-0.062	(0.024)	0.106	/0.106	0.002	(0.002)		
	(3a)	-0.146	(0.039)	0.015	/0.015	0.168***	(0.045)	-0.0185***	(0.0059)
	(3b)	-0.146	(0.039)	0.016	/0.016	0.157***	(0.040)	-0.0179***	(0.0058)
	(3c)	-0.133	(0.035)	NA	NA	0.265	(0.415)	0.0722	(0.1471)
Region s =Omsk Oblast									
Omsk Oblast	(1)	-0.006	(0.010)	0.621	/0.625				
	(2)	-0.134	(0.035)	0.013	/0.019	0.020***	(0.005)		
	(3a)	-0.240	(0.048)	0.001	/0.004	0.110***	(0.011)	0.0036***	(0.0009)
	(3b)	-0.240	(0.048)	0.001	/0.004	0.105***	(0.010)	0.0034***	(0.0008)
	(3c)	-0.230	(0.047)	0.024	/0.037	0.111***	(0.009)	-0.0024***	(0.0005)
Tomsk Oblast	(1)	-0.002	(0.005)	0.545	/0.545				
	(2)	-0.159	(0.040)	0.002	/0.002	0.055***	(0.014)		
	(3a)	-0.164	(0.041)	0.006	/0.006	0.441***	(0.035)	-0.0007	(0.0007)
	(3b)	-0.164	(0.041)	0.006	/0.006	0.366***	(0.024)	-0.0006	(0.0006)
	(3c)	-0.164	(0.041)	0.039	/0.039	0.367***	(0.025)	0.0006	(0.0007)

Region r	Model	λ	Unit root test			γ	δ, δ'	SSR
			p -values (PP/ADF)					
Republic of Buryatia	(1)	-0.010	(0.011)	0.442	/0.458			
	(2)	-0.171	(0.042)	0.004	/0.010	0.030***	(0.008)	
	(3a)	-0.172	(0.042)	0.014	/0.030	0.187***	(0.027)	0.0004 (0.0013)
	(3b)	-0.172	(0.042)	0.015	/0.033	0.171***	(0.023)	0.0003 (0.0012)
	(3c)	-0.172	(0.042)	0.056	/0.083	0.171***	(0.023)	-0.0003 (0.0012)
Republic of Tuva	(1)	-0.005	(0.008)	0.435	/0.435			
	(2)	-0.119	(0.035)	0.065	/0.110	0.026***	(0.008)	
	(3a)	-0.143	(0.039)	0.074	/0.135	0.202***	(0.028)	0.0019 (0.0012)
	(3b)	-0.144	(0.039)	0.083	/0.156	0.184***	(0.023)	0.0018 (0.0011)
	(3c)	-0.144	(0.039)	0.140	/0.213	0.186***	(0.021)	-0.0015* (0.0008)
Republic of Khakasia	(1)	-0.009	(0.010)	0.430	/0.457			
	(2)	-0.251	(0.050)	0.000	/0.002	0.045***	(0.009)	
	(3a)	-0.262	(0.051)	0.001	/0.007	0.185***	(0.015)	0.0008 (0.0008)
	(3b)	-0.262	(0.051)	0.001	/0.007	0.170***	(0.013)	0.0007 (0.0007)
	(3c)	-0.262	(0.051)	0.019	/0.042	0.170***	(0.012)	-0.0006 (0.0006)
Transbaikal Krai	(1)	-0.005	(0.009)	0.492	/0.492			
	(2)	-0.131	(0.038)	0.010	/0.010	0.030***	(0.009)	
	(3a)	-0.149	(0.040)	0.014	/0.014	0.214***	(0.032)	0.0019 (0.0013)
	(3b)	-0.149	(0.040)	0.014	/0.014	0.194***	(0.026)	0.0017 (0.0011)
	(3c)	-0.150	(0.040)	0.054	/0.054	0.195***	(0.023)	-0.0015* (0.0008)
Krasnoyarsk Krai	(1)	-0.003	(0.007)	0.637	/0.635			
	(2)	-0.169	(0.042)	0.035	/0.115	0.042***	(0.010)	
	(3a)	-0.172	(0.042)	0.074	/0.198	0.264***	(0.025)	0.0005 (0.0009)
	(3b)	-0.172	(0.042)	0.084	/0.231	0.235***	(0.020)	0.0005 (0.0008)
	(3c)	-0.173	(0.042)	0.139	/0.282	0.234***	(0.019)	-0.0005 (0.0007)
Irkutsk Oblast	(1)	-0.005	(0.008)	0.421	/0.421			
	(2)	-0.176	(0.043)	0.004	/0.013	0.040***	(0.010)	
	(3a)	-0.183	(0.044)	0.011	/0.028	0.237***	(0.023)	0.0008 (0.0009)
	(3b)	-0.183	(0.044)	0.011	/0.031	0.213***	(0.019)	0.0007 (0.0008)
	(3c)	-0.184	(0.044)	0.050	/0.079	0.213***	(0.018)	-0.0006 (0.0007)
Region s = Tomsk Oblast								
Tyumen Obl.	(1)	-0.006	(0.006)	0.296	/0.296			
	(2)	-0.054	(0.024)	0.185	/0.185	0.010**	(0.005)	
	(3a)	-0.101	(0.033)	0.077	/0.077	0.318***	(0.042)	-0.0040*** (0.0014) 0.0494
	(3b)	-0.102	(0.033)	0.085	/0.085	0.278***	(0.033)	-0.0036*** (0.0012) 0.0494
	(3c)	-0.111	(0.034)	0.112	/0.112	0.304***	(0.040)	0.0062** (0.0025)
Republic of Buryatia	(1)	-0.073	(0.026)	0.005	/0.005			
	(2)	-0.105	(0.032)	0.019	/0.019	0.003*	(0.002)	
	(3a)	-0.151	(0.040)	0.012	/0.012	0.093**	(0.039)	-0.0142* (0.0079) 0.0609
	(3b)	-0.151	(0.040)	0.013	/0.013	0.089**	(0.036)	-0.0139* (0.0077) 0.0609
	(3c)	-0.140	(0.038)	0.064	/0.064	0.103	(0.099)	0.0323 (0.0539)
Republic of Tuva	(1)	-0.037	(0.018)	0.037	/0.037			
	(2)	-0.112	(0.033)	0.013	/0.013	0.008***	(0.003)	
	(3a)	-0.115	(0.034)	0.038	/0.038	0.083**	(0.034)	-0.0014 (0.0039)
	(3b)	-0.115	(0.034)	0.042	/0.042	0.080**	(0.032)	-0.0014 (0.0038)
	(3c)	-0.116	(0.034)	0.094	/0.094	0.085**	(0.036)	0.0023 (0.0054)
Republic of Khakasia	(1)	-0.066	(0.023)	0.004	/0.004			
	(2)	-0.109	(0.031)	0.010	/0.010	0.003*	(0.002)	
	(3a)	-0.150	(0.039)	0.011	/0.011	0.085***	(0.032)	-0.0112* (0.0060) 0.0495
	(3b)	-0.150	(0.039)	0.011	/0.011	0.082***	(0.030)	-0.0110* (0.0059) 0.0495
	(3c)	-0.152	(0.040)	0.052	/0.052	0.112	(0.076)	0.0321 (0.0387)
Transbaikal Krai	(1)	-0.028	(0.017)	0.086	/0.086			
	(2)	-0.120	(0.035)	0.011	/0.011	0.010***	(0.003)	
	(3a)	-0.123	(0.036)	0.036	/0.036	0.094***	(0.032)	-0.0010 (0.0032)
	(3b)	-0.123	(0.036)	0.040	/0.040	0.090***	(0.029)	-0.0010 (0.0031)
	(3c)	-0.124	(0.037)	0.090	/0.090	0.094***	(0.032)	0.0015 (0.0039)

Region r	Model	λ	Unit root test			γ	δ, δ'	SSR
			p -values (PP/ADF)					
Krasnoyarsk Krai	(1)	-0.013	(0.010)	0.167	/0.167			
	(2)	-0.062	(0.024)	0.101	/0.101	0.006**	(0.003)	
	(3a)	-0.082	(0.031)	0.165	/0.165	0.149***	(0.042)	-0.0041 (0.0029)
	(3b)	-0.082	(0.031)	0.190	/0.190	0.140***	(0.037)	-0.0041 (0.0028)
	(3c)	-0.105	(0.035)	0.153	/0.153	0.208***	(0.058)	0.0148* (0.0088)
Irkutsk Oblast	(1)	-0.023	(0.012)	0.052	/0.052			
	(2)	-0.083	(0.027)	0.028	/0.028	0.006**	(0.002)	
	(3a)	-0.106	(0.032)	0.048	/0.048	0.119***	(0.031)	-0.0043 (0.0028)
	(3b)	-0.106	(0.033)	0.053	/0.053	0.113***	(0.028)	-0.0041 (0.0027)
	(3c)	-0.115	(0.035)	0.099	/0.099	0.137***	(0.040)	0.0092 (0.0069)
Region s = Tyumen Oblast								
Republic of Buryatia	(1)	-0.008	(0.009)	0.346	/0.346			
	(2)	-0.094	(0.032)	0.042	/0.042	-0.016***	(0.006)	
	(3a)	-0.100	(0.033)	0.073	/0.073	-0.182***	(0.032)	-0.0016 (0.0017)
	(3b)	-0.100	(0.033)	0.084	/0.084	-0.200***	(0.039)	-0.0017 (0.0019)
	(3c)	-0.100	(0.033)	0.138	/0.138	-0.206***	(0.044)	0.0023 (0.0027)
Republic of Tuva	(1)	-0.018	(0.014)	0.462	/0.315			
	(2)	-0.133	(0.037)	0.362	/0.562	-0.017***	(0.005)	
	(3a)	-0.189	(0.043)	0.002	/0.002	-0.172***	(0.022)	-0.0041*** (0.0015) 0.1118
	(3b)	-0.190	(0.043)	0.002	/0.002	-0.189***	(0.026)	-0.0044*** (0.0016) 0.1118
	(3c)	-0.186	(0.043)	0.178	/0.459	-0.197***	(0.034)	0.0065* (0.0034)
Republic of Khakasia	(1)	-0.008	(0.010)	0.271	/0.247			
	(2)	-0.153	(0.040)	0.003	/0.003	-0.025***	(0.007)	
	(3a)	-0.176	(0.042)	0.004	/0.004	-0.181***	(0.018)	-0.0019* (0.0010) 0.0852
	(3b)	-0.176	(0.042)	0.003	/0.003	-0.199***	(0.022)	-0.0020* (0.0011) 0.0853
	(3c)	-0.178	(0.042)	0.030	/0.030	-0.206***	(0.025)	0.0028* (0.0017) 0.0851
Transbaikal Krai	(1)	-0.013	(0.011)	0.221	/0.221			
	(2)	-0.107	(0.035)	0.035	/0.035	-0.012***	(0.004)	
	(3a)	-0.186	(0.043)	0.003	/0.003	-0.163***	(0.017)	-0.0044*** (0.0012) 0.0597
	(3b)	-0.186	(0.043)	0.002	/0.002	-0.178***	(0.020)	-0.0047*** (0.0013) 0.0597
	(3c)	-0.184	(0.043)	0.029	/0.029	-0.189***	(0.027)	0.0075** (0.0031) 0.0597
Krasnoyarsk Krai	(1)	-0.014	(0.012)	0.131	/0.117			
	(2)	-0.134	(0.038)	0.321	/0.477	-0.014***	(0.004)	
	(3a)	-0.156	(0.040)	0.010	/0.010	-0.122***	(0.017)	-0.0026* (0.0015) 0.0508
	(3b)	-0.156	(0.040)	0.010	/0.010	-0.130***	(0.020)	-0.0027* (0.0016) 0.0508
	(3c)	-0.154	(0.040)	0.049	/0.049	-0.130***	(0.023)	0.0032 (0.0026)
Irkutsk Oblast	(1)	-0.008	(0.010)	0.373	/0.378			
	(2)	-0.109	(0.033)	0.019	/0.019	-0.013***	(0.004)	
	(3a)	-0.137	(0.036)	0.013	/0.013	-0.148***	(0.019)	-0.0029** (0.0014) 0.0447
	(3b)	-0.137	(0.036)	0.013	/0.013	-0.160***	(0.022)	-0.0031** (0.0014) 0.0447
	(3c)	-0.137	(0.036)	0.053	/0.053	-0.167***	(0.027)	0.0045* (0.0027) 0.0447
Region s = Republic of Buryatia								
Republic of Tuva	(1)	-0.049	(0.023)	0.032	/0.032			
	(2)	-0.079	(0.029)	0.076	/0.076	0.003	(0.002)	
	(3a)	-0.088	(0.031)	0.437	/0.514	0.020	(0.025)	0.0071 (0.0091)
	(3b)	-0.088	(0.031)	0.136	/0.136	0.020	(0.025)	0.0069 (0.0089)
	(3c)	-0.086	(0.031)	0.351	/0.490	0.027	(0.023)	-0.0032 (0.0031)
Republic of Khakasia	(1)	-0.119	(0.035)	0.001	/0.001			
	(2)	-0.120	(0.036)	0.013	/0.013	0.000	(0.001)	
	(3a)	-0.121	(0.036)	0.036	/0.036	0.002	(0.018)	0.0056 (0.0589)
	(3b)	-0.121	(0.036)	0.040	/0.040	0.002	(0.018)	0.0056 (0.0587)
	(3c)	-0.121	(0.036)	0.091	/0.091	0.003	(0.019)	-0.0023 (0.0314)
Transbaikal Krai	(1)	-0.045	(0.024)	0.054	/0.054			
	(2)	-0.113	(0.035)	0.022	/0.022	0.006**	(0.002)	
	(3a)	-0.131	(0.037)	0.026	/0.026	0.025	(0.017)	0.0075 (0.0049)
	(3b)	-0.131	(0.037)	0.028	/0.028	0.025	(0.016)	0.0072 (0.0048)
	(3c)	-0.131	(0.037)	0.075	/0.075	0.030**	(0.013)	-0.0038*** (0.0011)

Region r	Model	λ	Unit root test			γ	δ, δ'	SSR
			p -values (PP/ADF)					
Krasnoyarsk Krai	(1)	-0.021	(0.016)	0.166	/0.166			
	(2)	-0.080	(0.030)	0.078	/0.078	0.006**	(0.002)	
	(3a)	-0.080	(0.030)	0.151	/0.151	0.059*	(0.034)	0.0019 (0.0047)
	(3b)	-0.080	(0.030)	0.175	/0.175	0.057*	(0.032)	0.0019 (0.0045)
	(3c)	-0.080	(0.030)	0.228	/0.228	0.055**	(0.027)	-0.0020 (0.0027)
Irkutsk Oblast	(1)	-0.033	(0.018)	0.065	/0.065			
	(2)	-0.088	(0.030)	0.050	/0.050	0.004**	(0.002)	
	(3a)	-0.089	(0.031)	0.100	/0.100	0.039	(0.025)	0.0024 (0.0052)
	(3b)	-0.089	(0.031)	0.115	/0.115	0.039	(0.024)	0.0023 (0.0051)
	(3c)	-0.089	(0.031)	0.172	/0.172	0.040*	(0.022)	-0.0017 (0.0033)
Region s = Republic of Tuva								
Republic of Khakasia	(1)	-0.080	(0.030)	0.036	/0.047			
	(2)	-0.175	(0.042)	0.161	/0.658	-0.007***	(0.002)	
	(3a)	-0.218	(0.047)	0.141	/0.505	-0.015*	(0.008)	0.0084** (0.0039)
	(3b)	-0.217	(0.047)	0.163	/0.595	-0.015*	(0.008)	0.0086** (0.0040)
	(3c)	-0.217	(0.047)	0.236	/0.644	-0.021***	(0.007)	-0.0039*** (0.0009)
Transbaikal Krai	(1)	-0.190	(0.045)	0.000	/0.000			
	(2)	-0.200	(0.046)	0.000	/0.000	0.002	(0.002)	
	(3a)	-0.200	(0.046)	0.003	/0.003	0.012	(0.022)	-0.0012 (0.0183)
	(3b)	-0.200	(0.046)	0.002	/0.002	0.012	(0.022)	-0.0012 (0.0182)
	(3c)	-0.200	(0.046)	0.028	/0.028	0.012	(0.023)	0.0013 (0.0227)
Krasnoyarsk Krai	(1)	-0.105	(0.034)	0.015	/0.027			
	(2)	-0.161	(0.041)	0.199	/0.417	0.004**	(0.002)	
	(3a)	-0.205	(0.046)	0.114	/0.499	0.076***	(0.028)	-0.0141** (0.0072)
	(3b)	-0.204	(0.046)	0.131	/0.588	0.074***	(0.027)	-0.0139** (0.0070)
	(3c)	-0.199	(0.045)	0.253	/0.624	0.098	(0.070)	0.0398 (0.0495)
Irkutsk Oblast	(1)	-0.153	(0.040)	0.000	/0.000			
	(2)	-0.160	(0.041)	0.002	/0.002	0.001	(0.002)	
	(3a)	-0.169	(0.042)	0.006	/0.006	0.030	(0.038)	-0.0142 (0.0246)
	(3b)	-0.169	(0.042)	0.006	/0.006	0.030	(0.038)	-0.0142 (0.0244)
	(3c)	-0.170	(0.042)	0.038	/0.038	0.058	(0.300)	0.0755 (0.5553)
Region s = Republic of Khakasia								
Transbaikal Krai	(1)	-0.067	(0.029)	0.064	/0.096			
	(2)	-0.164	(0.042)	0.003	/0.003	0.008***	(0.003)	
	(3a)	-0.182	(0.044)	0.005	/0.005	0.023*	(0.013)	0.0074* (0.0044) 0.0958
	(3b)	-0.182	(0.044)	0.004	/0.004	0.022*	(0.013)	0.0073* (0.0043) 0.0957
	(3c)	-0.189	(0.044)	0.030	/0.030	0.023***	(0.008)	-0.0044*** (0.0007) 0.0952
Krasnoyarsk Krai	(1)	-0.019	(0.017)	0.323	/0.325			
	(2)	-0.111	(0.035)	0.046	/0.068	0.007***	(0.002)	
	(3a)	-0.111	(0.035)	0.104	/0.143	0.068***	(0.024)	0.0000 (0.0032)
	(3b)	-0.111	(0.035)	0.119	/0.166	0.066***	(0.022)	0.0000 (0.0031)
	(3c)	-0.111	(0.035)	0.177	/0.225	0.066***	(0.023)	0.0001 (0.0032)
Irkutsk Oblast	(1)	-0.053	(0.024)	0.028	/0.028			
	(2)	-0.154	(0.040)	0.003	/0.003	0.007***	(0.002)	
	(3a)	-0.155	(0.040)	0.011	/0.011	0.044**	(0.018)	0.0008 (0.0038)
	(3b)	-0.155	(0.040)	0.011	/0.011	0.043**	(0.018)	0.0008 (0.0037)
	(3c)	-0.155	(0.040)	0.050	/0.050	0.042**	(0.017)	-0.0009 (0.0031)
Region s =Transbaikal Krai								
Krasnoyarsk Krai	(1)	-0.146	(0.039)	0.000	/0.000			
	(2)	-0.181	(0.043)	0.001	/0.001	0.003*	(0.002)	
	(3a)	-0.239	(0.048)	0.000	/0.000	0.093**	(0.039)	-0.0321** (0.0161) 0.0617
	(3b)	-0.239	(0.048)	0.000	/0.000	0.090**	(0.037)	-0.0316*** (0.0158) 0.0617
	(3c)	-0.268	(0.044)	NA	NA	0.365***	(0.134)	0.3507*** (0.1279)
Irkutsk Oblast	(1)	-0.139	(0.039)	0.000	/0.000			
	(2)	-0.139	(0.040)	0.009	/0.009	0.000	(0.001)	
	(3a)	-0.130	(0.029)	0.002	/0.002	2.611**	(1.120)	-0.1877*** (0.0365)
	(3b)	-0.168	(0.041)	0.006	/0.006	0.000	(0.000)	0.1012 (0.0906)
	(3c)	-0.162	(0.041)	0.044	/0.044	-0.002	(0.002)	-0.0054 (0.0002)

Region r	Model	λ	Unit root test				δ, δ'	SSR
			p -values (PP/ADF)		γ			
Region s = Krasnoyarsk Krai								
Irkutsk Oblast	(1)	-0.088	(0.032)	0.006	/0.006			
	(2)	-0.120	(0.036)	0.015	/0.015	-0.002*	(0.001)	
	(3a)	-0.121	(0.036)	0.040	/0.040	-0.062	(0.049)	-0.0199 (0.0184)
	(3b)	-0.121	(0.036)	0.044	/0.044	-0.065	(0.052)	-0.0207 (0.0191)
	(3c)	-0.158	(0.030)	0.009	/0.009	-0.386***	(0.103)	0.2719***

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. SSR is reported only where it is needed.

5. Significant models are marked with bold font. In the case of Model (3), the bold font marks the chosen version of the model.

6. NA means that the nonlinear OLS algorithm has failed in estimating auxiliary regressions while testing for unit root.