**Supplementary information**

**Spatial market efficiency of grain markets in Russia and global food security: Evidence from a comparison with the USA**

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**Table S1.** Variation of grain production, relative to the last 3-years-average (%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Economic regions/  Federal states | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| *Russia, wheat* | | | | | | | |
| North Caucasus | 107 | 104 | 108 | 68 | 102 | 131 | 135 |
| Central | 159 | 81 | 79 | 97 | 137 | 127 | 122 |
| Black Earth | 136 | 46 | 86 | 96 | 163 | 131 | 106 |
| Volga | 109 | 34 | 81 | 84 | 99 | 96 | 134 |
| West Siberia | 140 | 86 | 96 | 46 | 113 | 97 | 125 |
| Ural | 87 | 38 | 144 | 61 | 93 | 95 | 141 |
| *USA, corn* | | | | | | | |
| Iowa | 111 | 92 | 104 | 81 | 101 | 111 | 118 |
| Illinois | 99 | 90 | 95 | 65 | 122 | 132 | 105 |
| Nebraska | 117 | 99 | 104 | 85 | 113 | 108 | 113 |
| Minnesota | 109 | 108 | 97 | 110 | 100 | 91 | 111 |
| South Dakota | 150 | 93 | 105 | 83 | 137 | 119 | 113 |
| Kansas | 134 | 109 | 81 | 70 | 107 | 127 | 120 |
| Missouri | 111 | 86 | 88 | 64 | 135 | 183 | 100 |

Source: reproduced from Götz *et al*. (2016) for Russia and own calculations for the USA (USDA-ERS, 2017).

**Table S2.** Augmented Dickey-Fuller test for prices in levels and first differences

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| price series | determ.  component | lags | test-stat. | Δ price series | determ. component | lags | test-stat. |
| *Russia (interregional analysis)* | | | | | | | |
| Central | Constant & trend | 3 | -2.924 | Δ Central | None | 0 | -3.396\*\*\* |
| N. Caucasus | Constant | 1 | -1.581 | Δ N. Caucasus | None | 0 | -7.305\*\*\* |
| Black Earth | None | 1 | -0.755 | Δ Black Earth | None | 0 | -2.823\*\*\* |
| Volga | Constant | 4 | -2.252 | Δ Volga | None | 0 | -4.086\*\*\* |
| Urals | Constant | 1 | -2.170 | Δ Urals | None | 0 | -2.793\*\*\* |
| W. Siberia | Constant | 0 | -2.211 | Δ W. Siberia | None | 1 | -2.081\*\*\* |
| *USA (interregional analysis)* | | | | | | | |
| Arkansas | Constant | 0 | -1.925 | Δ Arkansas | None | 0 | -7.579\*\*\* |
| California | Constant | 0 | -1.893 | Δ California | None | 0 | -7.437\*\*\* |
| Colorado | Constant | 0 | -1.690 | Δ Colorado | None | 0 | -7.157\*\*\* |
| Illinois | Constant | 0 | -2.376 | Δ Illinois | None | 0 | -7.289\*\*\* |
| Iowa | Constant | 0 | -2.448 | Δ Iowa | None | 0 | -9.139\*\*\* |
| Kansas | Constant | 0 | -1.793 | Δ Kansas | None | 0 | -7.218\*\*\* |
| Minnesota | Constant | 0 | -1.799 | Δ Minnesota | None | 0 | -7.570\*\*\* |
| Missouri | Constant | 0 | -1.857 | Δ Missouri | None | 0 | -7.538\*\*\* |
| Nebraska | Constant | 0 | -1.884 | Δ Nebraska | None | 0 | -7.589\*\*\* |
| Oklahoma | Constant | 0 | -1.802 | Δ Oklahoma | None | 0 | -7.248\*\*\* |
| Oregon | Constant | 0 | -1.696 | Δ Oregon | None | 0 | -7.182\*\*\* |
| S. Dakota | Constant | 0 | -2.400 | Δ S. Dakota | None | 0 | -8.358\*\*\* |
| Texas | Constant | 0 | -1.695 | Δ Texas | None | 0 | -7.252\*\*\* |
| Virginia | Constant | 0 | -1.996 | Δ Virginia | None | 0 | -7.312\*\*\* |
| Washington | Constant | 0 | -1.642 | Δ Washington | None | 0 | -6.579\*\*\* |
| Wyoming | Constant | 0 | -0.693 | Δ Wyoming | None | 0 | -7.002\*\*\* |
| *Black Earth (intraregional analysis)* | | | | | | | |
| Belgorod | None | 1 | 1.314 | Δ Adygea | None | 0 | -4.836\*\*\* |
| Kursk | None | 1 | 1.795 | Δ Krasnodar | None | 0 | -5.472\*\*\* |
| Lipetsk | None | 1 | 0.517 | Δ Rostov | None | 0 | -4.419\*\*\* |
| Tambov | None | 3 | 1.134 | Δ Stavropol | None | 2 | -2.467\*\*\* |
| Voronezh | Constant | 1 | -1.891 | Δ Voronezh | None | 0 | -4.659\*\*\* |
| *West Siberia (intraregional analysis)* | | | | | | | |
| Altai | Constant | 1 | -2.237 | Δ Altai | None | 0 | -3.696\*\*\* |
| Kemerovo | Constant | 1 | -2.395 | Δ Kemerovo | None | 0 | -3.926\*\*\* |
| Novosibirsk | Constant | 0 | -1.439 | Δ Novosibirsk | None | 0 | -5.364\*\*\* |
| Omsk | Constant | 0 | -1.431 | Δ Omsk | None | 1 | -4.599\*\*\* |
| Tomsk | Constant | 1 | -2.074 | Δ Tomsk | None | 1 | -3.765\*\*\* |
| Tyumen | Constant | 0 | -1.806 | Δ Tyumen | None | 1 | -5.063\*\*\* |
| *Iowa (intraregional analysis)* | | | | | | | |
| Cedar Rapids | Constant | 0 | -2.140 | Δ Cedar Rapids | None | 0 | -10.444\*\*\* |
| Clinton | Constant | 0 | -1.163 | Δ Clinton | None | 0 | -9.478\*\*\* |
| Davenport | Constant | 0 | -2.275 | Δ Davenport | None | 0 | -9.609\*\*\* |
| Eddyville | Constant & trend | 0 | -2.928 | Δ Eddyville | None | 0 | -11.082\*\*\* |
| Emmetsburg | Constant | 0 | -1.895 | Δ Emmetsburg | None | 0 | -10.301\*\*\* |
| Keokuk | Constant | 0 | -2.412 | Δ Keokuk | None | 0 | -9.951\*\*\* |
| Muscatine | Constant | 0 | -2.263 | Δ Muscatine | None | 0 | -9.335\*\*\* |
| W. Burlington | Constant | 0 | -2.118 | Δ W. Burlington | None | 0 | -9.464\*\*\* |
| (*continued*) | | | | | | | |
| **Table S2.** (*continued*) | | | | | | | |
| price series | determ.  component | lags | test-stat. | Δ price series | determ. component | lags | test-stat. |
| *North Carolina (intraregional analysis)* | | | | | | | |
| Candor | Constant | 0 | -1.667 | Δ Candor | None | 0 | -10.105\*\*\* |
| Cofield | Constant | 0 | -1.763 | Δ Cofield | None | 0 | -9.559\*\*\* |
| Creswell | Constant | 0 | -2.312 | Δ Creswell | None | 0 | -11.270\*\*\* |
| Laurinburg | Constant | 0 | -1.817 | Δ Laurinburg | None | 0 | -9.200\*\*\* |
| Roaring River | Constant | 0 | -1.588 | Δ Roaring River | None | 0 | -10.089\*\*\* |
| Statesville | Constant | 0 | -1.861 | Δ Statesville | None | 0 | -10.143\*\*\* |

Note: Lag length selection is based on Schwarz Information Criterion. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01.

**Table S3.** Tests of cointegration: interregional analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| price pair | Hansen & Seo test  (2002)**†,** *a* | | Larsen test (2012)**†,** *b* | | Johansen test  (1988) *c* | |
| sup-Wald  test statistic | 5% cr. value | p-value | | trace test statistic | p-value |
| *Russia* | | | | | | |
| Central – Black Earth | 11.111 | 18.398 | 0.06 | | 21.606\*\* **/** 4.031 | 0.033 **/** 0.408 |
| Central – Volga | 17.262 | 18.596 | 0.07 | | 34.094\*\*\* **/** 5.105 | 0.001 / 0.272 |
| Central – Urals | 20.363\*\*\* | 18.566 | 0.21 | | 27.700\*\*\* **/** 7.133 | 0.004 / 0.120 |
| Central – W. Siberia | 14.133\*\* | 13.109 | 0.40 | | 22.342\*\* **/** 6.243 | 0.026 / 0.173 |
| N. Caucasus – Central | 21.037\*\* | 19.054 | 0.02 | | 14.645 **/** 3.468 | 0.248 / 0.497 |
| N. Caucasus – Black Earth | 13.932\* | 14.769 | 0.08 | | 37.811\*\*\* **/** 4.477 | 0.001 / 0.346 |
| N. Caucasus – Volga | 21.666\*\*\* | 18.271 | 0.04 | | 27.197\*\* **/** 8.189 | 0.034 / 0.237 |
| N. Caucasus – Urals | 24.227\*\*\* | 19.072 | 0.01 | | 16.076\*\* **/** 0.598 | 0.041 / 0.439 |
| N. Caucasus – W. Siberia | 20.543\*\* | 19.377 | 0.02 | | 36.835\*\*\* **/** 4.320 | 0.001 / 0.367 |
| Black Earth – Volga | 24.383\* | 05.088 | 0.04 | | 20.484\*\* **/** 4.454 | 0.047 / 0.349 |
| Black Earth – Urals | 25.332\*\*\* | 24.907 | 0.01 | | 18.413\* **/** 2.392 | 0.088 / 0.699 |
| Black Earth – W. Siberia | 15.223\* | 16.237 | 0.08 | | 26.237\*\*\* **/** 4.579 | 0.007 / 0.333 |
| Volga – Urals | 17.746\* | 18.451 | 0.46 | | 35.220\*\*\* **/** 6.298 | 0.001 / 0.169 |
| Volga – W. Siberia | 12.149\* | 13.296 | 0.06 | | 25.246\*\*\* **/** 7.248 | 0.009 / 0.114 |
| Urals – W. Siberia | 18.002\* | 18.528 | 0.62 | | 17.093 **/** 6.817 | 0.129 / 0.136 |
| *USA* | | | | | | |
| Arkansas – Illinois | 11.387 | 15.980 | 0.70 | | 9.528 / 4.674 | 0.685/ 0.321 |
| Arkansas – Iowa | 16.040\*\* | 15.947 | 0.05 | | 16.436\*\* / 3.528\* | 0.036/ 0.060 |
| Arkansas – Kansas | 9.476 | 16.519 | 0.98 | | 8.789 / 3.297 | 0.755 / 0.526 |
| Arkansas – Minnesota | 12.576 | 16.233 | 0.34 | | 11.386 / 3.629 | 0.505 / 0.470 |
| Arkansas – Missouri | 14.236\*\* | 16.049 | 0.58 | | 21.525\*\* / 9.164 | 0. 033/ 0.543 |
| Arkansas – Nebraska | 16.593\*\* | 16.349 | 0.01 | | 9.898 / 0.001 | 0.123 / 0.972 |
| Arkansas – S. Dakota | 7.041 | 16.557 | 0.26 | | 10.643\* / 0.001 | 0.094 / 0.997 |
| California – Illinois | 12.655\* | 13.636 | 0.03 | | 24.530\*\*\*/ 4.142 | 0.012 / 0.391 |
| California – Iowa | 15.553\* | 17.087 | 0.41 | | 31.955\*\*\*/ 3.468 | 0.001 / 0.497 |
| California – Kansas | 14.403 | 16.642 | 0.21 | | 20.587\*\*/ 3.186 | 0.045 / 0.546 |
| California – Minnesota | 17.510\*\* | 16.011 | 0.01 | | 23.688\*\*\*/ 3.018 | 0.016/ 0.577 |
| (*continued*) | | | | | | |
| **Table S3.** (*continued*) | | | | | | |
| price pair | Hansen & Seo test  (2002)**†,** *a* | | Larsen test  (2012)**†,** *b* | | Johansen test  (1988) *c* | |
| sup-Wald  test statistic | 5% cr. value | p-value | | trace test statistic | p-value |
| California – Missouri | 12.342\* | 13.603 | 0.26 | 30.757\*\*\*/ 2.906 | | 0.001/0.598 |
| California – Nebraska | 20.138\*\* | 18.474 | 0.12 | 29.767\*\*\*/3.097 | | 0.001/ 0.562 |
| California – S. Dakota | 11.643 | 14.028 | 0.01 | 32.662\*\*\*/ 3.516 | | 0.001/0.488 |
| Colorado – Illinois | 10.432 | 13.864 | 0.09 | 19.105\*\*/ 2.434 | | 0.013/ 0.118 |
| Colorado – Iowa | 11.573 | 13.418 | 0.28 | 26.259\*\*\*/ 2.519 | | 0.001/ 0.112 |
| Colorado – Kansas | 9.499 | 13.660 | 0.21 | 15.657\*\*/ 5.172\*\*\* | | 0.047/ 0.022 |
| Colorado – Minnesota | 12.088 | 16.271 | 0.12 | 8.843/ 2.741\* | | 0.380/ 0.097 |
| Colorado – Missouri | 15.229\* | 15.647 | 0.22 | 14.072\*/ 3.073\* | | 0.081/ 0.079 |
| Colorado – Nebraska | 9.4381 | 13.448 | 0.85 | 6.240/ 1.953 | | 0.667/ 0.162 |
| Colorado – S. Dakota | 12.891\* | 13.665 | 0.24 | 21.907\*\*\*/ 3.841 | | 0.004/ 0.106 |
| Oklahoma – Illinois | 12.826\* | 13.925 | 0.06 | 24.428\*\*/ 3.562 | | 0.012/ 0.481 |
| Oklahoma – Iowa | 14.715\*\* | 13.729 | 0.05 | 29.764\*\*/ 3.366 | | 0.002/ 0.514 |
| Oklahoma – Kansas | 15.683\* | 16.575 | 0.16 | 16.399\*\*/ 3.434\* | | 0.036/ 0.063 |
| Oklahoma – Minnesota | 20.062\*\*\* | 15.917 | 0.01 | 12.074/ 3.231\* | | 0.153/ 0.072 |
| Oklahoma – Missouri | 17.247\*\* | 15.919 | 0.07 | 17.505\*\*/ 3.841\* | | 0.024/ 0.071 |
| Oklahoma – Nebraska | 14.978 | 16.306 | 0.31 | 8.888/ 3.271\* | | 0.375/ 0.070 |
| Oklahoma – S. Dakota | 12.941\* | 13.593 | 0.08 | 17.751\*\*/ 3.186\* | | 0.022/ 0.074 |
| Oregon – Illinois | 18.956\*\*\* | 13.741 | 0.01 | 25.721\*\*\*/ 6.552 | | 0.008/ 0.152 |
| Oregon – Iowa | 17.515\* | 18.234 | 0.10 | 25.060\*\*/ 3.042 | | 0.010/ 0.572 |
| Oregon – Kansas | 16.902\*\*\* | 13.892 | 0.02 | 20.637\*\*/ 7.298 | | 0.044/ 0.106 |
| Oregon – Minnesota | 18.092\*\* | 16.285 | 0.01 | 14.581/ 3.248 | | 0.251/ 0.535 |
| Oregon – Missouri | 11.520 | 13.244 | 0.24 | 23.816\*\*/ 3.558 | | 0.015/ 0.481 |
| Oregon – Nebraska | 10.207 | 13.271 | 0.22 | 10.411\*/ 0.008 | | 0.102/ 0.938 |
| Oregon – S. Dakota | 17.228\*\*\* | 13.601 | 0.01 | 21.960\*\*\*/ 2.844\* | | 0.004/ 0.091 |
| Texas – Illinois | 14.871\*\* | 14.115 | 0.05 | 16.911\*\*/ 15.494 | | 0.030/ 0.158 |
| Texas – Iowa | 12.696\* | 13.657 | 0.01 | 11.080\*/ 0.005 | | 0.080/ 0.950 |
| Texas – Kansas | 13.235\* | 14.024 | 0.26 | 33.326\*\*\*/ 2.475 | | 0.001/ 0.115 |
| Texas – Minnesota | 10.946 | 13.589 | 0.24 | 10.598\*/ 0.051 | | 0.095/ 0.852 |
| Texas – Missouri | 17.050\*\* | 16.727 | 0.25 | 20.667\*\*\*/ 2.874\* | | 0.007/ 0.090 |
| Texas – Nebraska | 15.481\*\* | 13.427 | 0.15 | 10.140/ 3.006\* | | 0.270/ 0.082 |
| Texas – S. Dakota | 11.019 | 16.406 | 0.37 | 19.959\*\*\*/ 2.704 | | 0.009/ 0.100 |
| Virginia – Illinois | 11.131 | 13.629 | 0.17 | 19.653\*/ 3.633 | | 0.060/ 0.469 |
| Virginia – Iowa | 9.079 | 13.096 | 0.13 | 34.631\*\*\*/ 4.825 | | 0.001/ 0.303 |
| Virginia – Kansas | 12.274 | 16.262 | 0.43 | 22.076\*\*/ 5.625 | | 0.027/ 0.221 |
| Virginia – Minnesota | 10.385 | 13.886 | 0.32 | 21.934\*\*/ 6.740 | | 0.029/ 0.140 |
| Virginia – Missouri | 13.757\*\* | 13.116 | 0.32 | 31.974\*\*\*/ 3.957 | | 0.001/ 0.418 |
| Virginia – Nebraska | 9.624 | 13.629 | 0.37 | 10.516\*/ 0.023 | | 0.098/ 0.899 |
| Virginia – S. Dakota | 11.328 | 13.578 | 0.01 | 13.822\*\*/ 0.030 | | 0.027/ 0.885 |
| Washington – Illinois | 12.481\* | 13.412 | 0.03 | 27.240\*\*\*/ 4.474 | | 0.004/ 0.346 |
| Washington – Iowa | 14.026\* | 14.300 | 0.20 | 33.120\*\*\*/ 2.623 | | 0.001/ 0.653 |
| Washington – Kansas | 13.458 | 15.638 | 0.25 | 21.222\*\*/ 4.293 | | 0.036/ 0.370 |
| Washington – Minnesota | 14.191\*\* | 13.198 | 0.24 | 14.326/ 2.656 | | 0.267/ 0.646 |
| Washington – Missouri | 16.208\*\* | 15.956 | 0.01 | 31.900\*\*\*/ 3.038 | | 0.001/ 0.573 |
| Washington – Nebraska | 9.983 | 14.110 | 0.70 | 12.671/ 2.669 | | 0.390/ 0.644 |
| Washington – S. Dakota | 12.162 | 13.877 | 0.27 | 22.459\*\*/ 2.559 | | 0.024/ 0.665 |
| Wyoming – Illinois | 10.723 | 13.364 | 0.36 | 21.784\*\*/ 9.164 | | 0.030/ 0.291 |
| Wyoming – Iowa | 9.385 | 13.961 | 0.49 | 22.083\*\*/ 3.140 | | 0.027/ 0.554 |
| (*continued*) | | | | | | |
| **Table S3.** (*continued*) | | | | | | |
| price pair | Hansen & Seo test  (2002)**†,** *a* | | Larsen test  (2012)**†,** *b* | Johansen test  (1988) *c* | | |
| sup-Wald  test statistic | 5% cr. value | p-value | trace test statistic | | p-value |
| Wyoming – Kansas | 11.594 | 14.075 | 0.22 | 20.220\*\*/ 7.547 | | 0.050/ 0.100 |
| Wyoming – Minnesota | 5.873 | 8.959 | 0.92 | 10.641/ 3.446 | | 0.577/ 0.500 |
| Wyoming – Missouri | 15.099\*\* | 13.511 | 0.08 | 15.860\*\*/ 3.834\*\* | | 0.044/ 0.050 |
| Wyoming – Nebraska | 10.925 | 13.366 | 0.46 | 11.351/ 3.514\* | | 0.190/ 0.060 |
| Wyoming – S. Dakota | 12.893 | 13.762 | 0.12 | 26.594\*\*\*/ 2.971\* | | 0.001/ 0.084 |

Note: **†** H0: linear cointegration | H1: threshold cointegration. Trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is ‘fixed Regression’. *a* two-regime TVECM with one threshold, *b* three-regime TVECM with two thresholds. *c* the first number in the column refers to the hypothesis H0: no cointegration | H1: at least one cointegration equation. The second number in the columns refers to the hypothesis H0: one cointegration equation | H1: two cointegration equations. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01.

**Table S4.** Tests of cointegration: intraregional analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| price pair | Hansen & Seo test  (2002)**†,** *a* | | | Larsen test  (2012)**†,** *b* | Johansen test  (1988) *c* | |
| sup-Wald  test statistic | | 5% cr. value | p-value | trace test statistic | p-value |
| *Black Earth* | | | | | | |
| Belgorod – Kursk | 14.270\*\* | | 13.568 | 0.13 | 14.799\*\*/ 2.892 | 0.018/ 0.105 |
| Belgorod – Lipetsk | 13.630 | | 16.228 | 0.16 | 29.167\*\*\*/ 4.277 | 0.002/ 0.372 |
| Belgorod – Tambov | 20.756\*\*\* | | 13.707 | 0.01 | 26.637\*\*\*/ 2.057 | 0.001/0.178 |
| Belgorod – Voronezh | 13.468\* | | 14.112 | 0.26 | 25.968\*\*\*/ 7.886\* | 0.007/0.086 |
| Kursk – Lipetsk | 12.413 | | 19.277 | 0.41 | 21.096\*\*\*/ 12.320\* | 0.001/ 0.088 |
| Kursk – Tambov | 18.881\*\* | | 17.054 | 0.01 | 43.219\*\*\*/ 7.574\* | 0.000/ 0.099 |
| Kursk – Voronezh | 24.478\* | | 25.016 | 0.38 | 44.483/\*\*\* 7.635\* | 0.000/ 0.096 |
| Lipetsk – Tambov | 11.915 | | 14.056 | 0.29 | 13.617\*\*/ 2.343 | 0.030/ 0.148 |
| Lipetsk – Voronezh | 18.238\*\* | | 18.120 | 0.41 | 10.719\*/ 0.551 | 0.091/0.520 |
| Tambov – Voronezh | 20.310\*\*\* | | 14.203 | 0.01 | 26.475\*\*\*/ 2.617 | 0.001/ 0.124 |
| *West Siberia* | | | | | | |
| Kemerovo – Altai | 12.935\*\* | | 12.939 | 0.18 | 18.767\* / 5.482 | 0.079 / 0.135 |
| Kemerovo – Novosibirsk | 19.089\*\*\* | | 13.139 | 0.03 | 30.322\*\*\* / 6.506 | 0.002 / 0.155 |
| Kemerovo – Omsk | 9.957 | | 12.789 | 0.56 | 21.270\*\* / 4.098 | 0.036 / 0.398 |
| Kemerovo – Tomsk | 9.368 | | 13.356 | 0.09 | 22.650\*\* / 4.798 | 0.023 / 0.306 |
| Novosibirsk – Altai | 15.724\*\* | | 13.972 | 0.32 | 26.038\*\*\* / 5.217 | 0.007 / 0.261 |
| Novosibirsk – Omsk | 23.676\*\*\* | | 17.139 | 0.01 | 38.701\*\*\* / 3.545 | 0.001 / 0.484 |
| Tomsk – Novosibirsk | 16.473\* | | 17.202 | 0.35 | 53.816\*\*\* / 3.928 | 0.001 / 0.423 |
| Tomsk – Altai | 21.845\*\* | | 21.089 | 0.32 | 25.430\*\*\* / 6.325 | 0.009 / 0.167 |
| Tomsk – Omsk | 15.671\*\* | | 13.328 | 0.15 | 21.658\*\* / 3.772 | 0.032 / 0.447 |
| Altai – Omsk | 13.971\*\* | | 13.345 | 0.04 | 23.557\*\* / 5.001 | 0.017 / 0.283 |
| Tyumen – Altai | 10.489 | | 12.914 | 0.09 | 25.297\*\*\* / 5.671 | 0.009 / 0.218 |
| Tyumen – Kemerovo | 14.738\* | | 15.638 | 0.02 | 18.526\* / 6.927 | 0.085 / 0.130 |
| Tyumen – Novosibirsk | 17.544\*\*\* | | 13.067 | 0.16 | 28.365\*\*\* / 2.805 | 0.003 / 0.618 |
| Tyumen – Omsk | 15.521\*\*\* | | 13.185 | 0.06 | 33.161\*\*\* / 3.703 | 0.001 / 0.458 |
| Tyumen – Tomsk | 13.238\* | | 13.432 | 0.13 | 33.269\*\*\* / 4.064 | 0.001 / 0.403 |
| (*continued*) | | | | | | |
| **Table S4.** (*continued*) | | | | | | |
| price pair | | Hansen & Seo test  (2002)**†,** *a* | | Larsen test  (2012)**†,** *b* | Johansen test  (1988) *c* | |
| sup-Wald  test statistic | 5% cr. value | p-value | trace test statistic | p-value |
| *Iowa* | | | | | | |
| Cedar Rapids – Emmetsburg | | 15.803\*\* | 15.107 | 0.02 | 16.035/ 20.261 | 0.172/ 0.177 |
| Clinton – Cedar Rapids | | 16.616\*\* | 15.122 | 0.03 | 24.361\*\*/ 4.720 | 0.012/ 0.315 |
| Clinton – Davenport | | 12.583 | 15.138 | 0.11 | 28.464\*\*/ 6.592 | 0.023/ 0.388 |
| Clinton – Emmetsburg | | 18.130\*\*\* | 14.897 | 0.01 | 21.362\*\*/ 5.334 | 0.035/ 0.248 |
| Eddyville – Cedar Rapids | | 19.128\*\*\* | 15.515 | 0.02 | 19.644\*/ 4.475 | 0.060/ 0.345 |
| Clinton – Muscatine | | 11.728 | 15.158 | 0.38 | 36.069\*\*\*/ 3.637 | 0.001/ 0.468 |
| Davenport – Cedar Rapids | | 11.988 | 14.900 | 0.09 | 10.243/ 2.104 | 0.615/ 0.756 |
| Davenport – Emmetsburg | | 14.038\* | 15.428 | 0.28 | 28.627\*\*/ 9.429 | 0.022/ 0.155 |
| Eddyville – Clinton | | 13.870\* | 15.136 | 0.08 | 24.082\*\*/ 5.418 | 0.014/ 0.240 |
| Eddyville – Davenport | | 14.210\* | 14.514 | 0.33 | 14.996/ 5.115 | 0.226/ 0.271 |
| Eddyville – Emmetsburg | | 14.515 | 17.805 | 0.06 | 18.428\*/ 2.966 | 0.0876/ 0.587 |
| Eddyville – Keokuk | | 31.678\* | 32.574 | 0.13 | 14.545\*\*/ 0.425 | 0.020/ 0.577 |
| Eddyville – Muscatine | | 13.144 | 15.105 | 0.09 | 20.042\*/ 5.567 | 0.053/ 0.226 |
| Keokuk – Cedar Rapids | | 13.884 | 15.448 | 0.32 | 13.176/ 4.144 | 0.349/ 0.391 |
| Keokuk – Clinton | | 15.017\*\* | 14.855 | 0.09 | 12.640/ 4.020 | 0.393/ 0.409 |
| Keokuk – Davenport | | 15.058 | 18.674 | 0.35 | 24.048\*\*/ 7.208 | 0.014/ 0.115 |
| Keokuk – Emmetsburg | | 10.561 | 15.130 | 0.09 | 15.995/ 5.114 | 0.174/ 0.271 |
| Keokuk – Muscatine | | 17.933\* | 18.504 | 0.27 | 23.704\*\*/ 7.129 | 0.016/ 0.119 |
| Muscatine – Cedar Rapids | | 16.707\*\* | 14.648 | 0.01 | 19.604\*/ 9.164 | 0.061/ 0.340 |
| Muscatine – Davenport | | 14.732\* | 14.835 | 0.70 | 7.034/ 0.705 | 0.321/ 0.460 |
| Muscatine – Emmetsburg | | 10.496 | 14.547 | 0.23 | 18.233\*/ 7.287 | 0.092/ 0.112 |
| W. Burlington – Cedar Rapids | | 18.285\* | 18.799 | 0.54 | 10.347/ 1.997 | 0.605/ 0.778 |
| W. Burlington – Clinton | | 12.711 | 14.691 | 0.12 | 12.578/ 3.912 | 0.398/ 0.425 |
| W. Burlington – Davenport | | 14.944 | 18.461 | 0.11 | 26.991\*\*\*/ 6.291 | 0.005/ 0.169 |
| W. Burlington – Eddyville | | 15.427\*\* | 14.625 | 0.01 | 20.565\*\*/ 6.149 | 0.045/ 0.179 |
| W. Burlington – Emmetsburg | | 21.514\*\*\* | 14.811 | 0.01 | 26.240\*\*/ 6.535 | 0.045/ 0.395 |
| W. Burlington – Keokuk | | 16.866 | 18.003 | 0.01 | 19.107\*/ 6.093 | 0.071/ 0.183 |
| W. Burlington Muscatine | | 20.126\*\* | 19.244 | 0.23 | 21.819\*\*/ 6.776 | 0.030/ 0.138 |
| *North Carolina* | | | | | | |
| Candor – Creswell | 18.470\*\*\* | | 14.107 | 0.03 | 19.048\*/ 3.416 | 0.072/ 0.505 |
| Cofield – Candor | 19.469\*\* | | 17.478 | 0.07 | 10.149/ 3.674 | 0.625/ 0.462 |
| Cofield – Creswell | 12.048 | | 14.379 | 0.18 | 21.288\*\*/ 4.576 | 0.036/ 0.333 |
| Laurinburg – Candor | 15.472\*\* | | 14.902 | 0.14 | 16.517/ 3.727 | 0.151/ 0.454 |
| Laurinburg – Cofield | 11.681 | | 17.164 | 0.25 | 8.813/ 3.467 | 0.753/ 0.497 |
| Laurinburg – Creswell | 15.206\*\* | | 14.573 | 0.10 | 22.975\*\*/ 4.832 | 0.020/ 0.302 |
| Laurinburg – Roaring River | 18.305\*\*\* | | 14.860 | 0.03 | 15.741/ 2.987 | 0.186/ 0.582 |
| Laurinburg – Statesville | 20.286 | | 14.865 | 0.01 | 14.781/ 3.979 | 0.239/ 0.415 |
| Roaring River – Candor | 12.362 | | 15.349 | 0.06 | 24.230\*\*/ 2.991 | 0.013/ 0.582 |
| Roaring River – Cofield | 13.446\* | | 13.669 | 0.16 | 13.100/ 3.062 | 0.355/ 0.569 |
| Roaring River – Creswell | 10.038 | | 14.862 | 0.34 | 26.770\*\*\*/ 3.523 | 0.005/ 0.487 |
| Roaring River – Statesville | 16.402 | | 17.659 | 0.09 | 14.970/2.862 | 0.228/ 0.606 |
| Statesville – Candor | 13.726\* | | 14.354 | 0.19 | 12.392/ 3.310 | 0.414/ 0.524 |
| Statesville – Cofield | 15.691 | | 17.822 | 0.07 | 11.612/ 3.862 | 0.484/ 0.433 |
| Statesville – Creswell | 12.661 | | 14.357 | 0.18 | 18.602\*/ 3.773 | 0.083/ 0.446 |

Note: **†** H0: linear cointegration | H1: threshold cointegration. Trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is ‘fixed Regression’. *a* two-regime TVECM with one threshold, *b* three-regime TVECM with two thresholds. *c* the first number in the column refers to the hypothesis H0: no cointegration | H1: at least one cointegration equation. The second number in the columns refers to the hypothesis H0: one cointegration equation | H1: two cointegration equations. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01.

**Table S5.** Parameters of long-run price equilibrium regression: USA, interregional analysis

|  |  |  |  |
| --- | --- | --- | --- |
| price pair | distance  (km) | long-run price  transmission elasticities () | intercept  parameter () |
| Arkansas – Illinois | 595 | - | - |
| Arkansas – Iowa | 475 | 1.020 | -0.054 |
| Arkansas – Kansas | 993 | - | - |
| Arkansas – Minnesota | 531 | - | - |
| Arkansas – Missouri | 393 | 0.888 | 0.593 |
| Arkansas – Nebraska | 581 | 0.912 | 0.468 |
| Arkansas – S. Dakota | 1144 | 0.895 | 0.635 |
| California – Illinois | 3288 | 0.948 | 1.151 |
| California – Iowa | 3084 | 0.957 | -0.685 |
| California – Kansas | 2356 | 1.201 | -2.134 |
| California – Minnesota | 3224 | 0.715 | 2.336 |
| California – Missouri | 2945 | 0.724 | 2.282 |
| California – Nebraska | 2675 | 0.767 | 2.064 |
| California – S. Dakota | 2548 | 0.760 | 2.170 |
| Colorado – Illinois | 1720 | 0.644 | 1.786 |
| Colorado – Iowa | 1273 | 0.752 | 1.230 |
| Colorado – Kansas | 494 | - | - |
| Colorado – Minnesota | 1482 | - | - |
| Colorado – Missouri | 974 | 0.856 | 0.715 |
| Colorado – Nebraska | 866 | - | - |
| Colorado – S. Dakota | 901 | 0.826 | 0.781 |
| Oklahoma – Illinois | 1315 | 0.613 | 1.935 |
| Oklahoma – Iowa | 1289 | 0.705 | 1.456 |
| Oklahoma – Kansas | 220 | 0.890 | 0.528 |
| Oklahoma – Minnesota | 1498 | 0.867 | 0.648 |
| Oklahoma – Missouri | 789 | 0.810 | 0.939 |
| Oklahoma – Nebraska | 874 | - | - |
| Oklahoma – S. Dakota | 1073 | 0.752 | 1.140 |
| Oregon – Illinois | 3642 | 0.843 | 0.593 |
| Oregon – Iowa | 2836 | 0.900 | 0.720 |
| Oregon – Kansas | 2472 | 0.755 | 1.454 |
| Oregon – Minnesota | 2926 | 0.765 | 1.401 |
| Oregon – Missouri | 2895 | 0.773 | 1.350 |
| Oregon – Nebraska | 2660 | 0.820 | 1.110 |
| Oregon – S. Dakota | 2245 | 0.806 | 1.253 |
| Texas – Illinois | 1226 | 0.674 | 1.575 |
| Texas – Iowa | 1487 | 0.787 | 0.985 |
| Texas – Kansas | 380 | 0.990 | -0.050 |
| Texas – Minnesota | 1695 | 0.986 | -0.022 |
| Texas – Missouri | 985 | 0.913 | 0.356 |
| Texas – Nebraska | 1032 | 0.903 | 0.414 |
| Texas – S. Dakota | 1262 | 0.848 | 0.595 |
| Virginia – Illinois | 1349 | 1.299 | -1.412 |
| Virginia – Iowa | 1897 | 1.097 | -0.387 |
| Virginia – Kansas | 2356 | 0.911 | 0.549 |
| (*continued*) | | | |
| **Table S5.** (*continued*) | | | |
| price pair | distance  (km) | long-run price  transmission elasticities () | intercept  parameter () |
| Virginia – Minnesota | 1833 | 0.869 | 0.745 |
| Virginia – Missouri | 1754 | 0.946 | 0.358 |
| Virginia – Nebraska | 2037 | 0.895 | 0.598 |
| Virginia – S. Dakota | 2565 | 0.902 | 0.646 |
| Washington – Illinois | 3375 | 0.687 | 0.784 |
| Washington – Iowa | 2393 | 0.799 | 0.080 |
| Washington – Kansas | 2351 | 0.956 | 1.366 |
| Washington – Minnesota | 2482 | 0.956 | 1.359 |
| Washington – Missouri | 2628 | 0.985 | 1.202 |
| Washington – Nebraska | 2342 | - | - |
| Washington – S. Dakota | 1801 | 1.008 | 1.173 |
| Wyoming – Illinois | 1782 | 0.585 | 2.208 |
| Wyoming – Iowa | 1221 | 0.690 | 1.692 |
| Wyoming – Kansas | 721 | 0.879 | 0.789 |
| Wyoming – Minnesota | 1310 | - | - |
| Wyoming – Missouri | 1033 | 0.788 | 1.232 |
| Wyoming – Nebraska | 800 | - | - |
| Wyoming – S. Dakota | 653 | 0.780 | 1.189 |

Note: The hyphen (-) = not applicable, because the existence of long-run equilibrium is not confirmed.

**Table S6.** Parameters of long-run price equilibrium regression: intraregional analysis

|  |  |  |  |
| --- | --- | --- | --- |
| price pair | distance (km) | long-run price  transmission elasticities () | intercept  parameter () |
| *Black Earth* | | | |
| Belgorod – Kursk | 142 | 0.932 | 0.666 |
| Belgorod – Lipetsk | 317 | 0.890 | 1.045 |
| Belgorod – Tambov | 477 | 0.944 | 0.442 |
| Belgorod – Voronezh | 255 | 0.919 | 0.773 |
| Kursk – Lipetsk | 323 | 0.861 | 1.262 |
| Kursk – Tambov | 451 | 0.949 | 0.478 |
| Kursk – Voronezh | 228 | 0.902 | 0.885 |
| Lipetsk – Tambov | 134 | 0.938 | 0.534 |
| Lipetsk – Voronezh | 133 | 0.987 | 0.120 |
| Tambov – Voronezh | 220 | 1.010 | -0.071 |
| *West Siberia* | | | |
| Kemerovo – Altai | 411 | 0.856 | 1.300 |
| Kemerovo – Novosibirsk | 267 | 0.672 | 3.043 |
| Kemerovo – Omsk | 906 | 0.652 | 3.234 |
| Kemerovo – Tomsk | 218 | 0.808 | 1.710 |
| Novosibirsk – Altai | 226 | 0.906 | 0.786 |
| Novosibirsk – Omsk | 654 | 0.797 | 1.852 |
| Tomsk – Novosibirsk | 268 | 0.776 | 2.160 |
| Tomsk – Altai | 490 | 0.913 | 0.759 |
| Tomsk – Omsk | 911 | 0.799 | 1.951 |
| Altai – Omsk | 880 | 0.728 | 2.560 |
| (*continued*) | | | |
| **Table S6.** (*continued*) | | | | |
| price pair | distance (km) | long-run price  transmission elasticities () | intercept  parameter () |
| Tyumen – Altai | 1504 | 0.855 | 1.259 |
| Tyumen – Kemerovo | 1548 | 0.788 | 1.981 |
| Tyumen – Novosibirsk | 1280 | 0.838 | 1.485 |
| Tyumen – Omsk | 624 | 0.757 | 2.223 |
| Tyumen – Tomsk | 1538 | 0.826 | 1.492 |
| *Iowa* | | | |
| Cedar Rapids – Emmetsburg | 354 | 0.780 | 1.143 |
| Clinton – Cedar Rapids | 138 | 0.979 | 0.110 |
| Clinton – Davenport | 66 | 0.733 | 1.367 |
| Clinton – Emmetsburg | 489 | 1.084 | -0.494 |
| Clinton – Muscatine | 114 | 0.950 | 0.264 |
| Davenport – Cedar Rapids | 129 | 1.048 | -0.278 |
| Davenport – Emmetsburg | 483 | 0.823 | 0.891 |
| Eddyville – Cedar Rapids | 174 | 1.066 | -0.374 |
| Eddyville – Clinton | 290 | 1.083 | -0.468 |
| Eddyville – Davenport | 240 | 0.928 | 0.359 |
| Eddyville – Emmetsburg | 367 | 0.856 | 0.726 |
| Eddyville – Keokuk | 182 | 0.891 | 0.523 |
| Eddyville – Muscatine | 166 | 1.088 | -0.474 |
| Keokuk – Cedar Rapids | 188 | - | - |
| Keokuk – Clinton | 253 | 1.083 | -0.451 |
| Keokuk – Davenport | 190 | 0.896 | 0.527 |
| Keokuk – Emmetsburg | 542 | 0.779 | 1.125 |
| Keokuk – Muscatine | 140 | 1.082 | -0.428 |
| Muscatine – Cedar Rapids | 105 | 0.973 | 0.122 |
| Muscatine – Davenport | 47 | 0.766 | 1.184 |
| Muscatine – Emmetsburg | 462 | 1.065 | -0.379 |
| W. Burlington – Cedar Rapids | 159 | 1.043 | -0.239 |
| W. Burlington – Clinton | 193 | - | - |
| W. Burlington – Davenport | 126 | 1.020 | -0.113 |
| W. Burlington – Eddyville | 151 | 0.970 | 0.129 |
| W. Burlington – Emmetsburg | 512 | 0.890 | 0.506 |
| W. Burlington – Keokuk | 66 | 0.921 | 0.389 |
| W. Burlington – Muscatine | 76 | 1.085 | -0.440 |
| *North Carolina* | | | |
| Candor – Creswell | 360 | 0.747 | 1.402 |
| Cofield – Candor | 333 | 1.043 | -0.286 |
| Cofield – Creswell | 97 | 0.883 | 0.656 |
| Laurinburg – Candor | 71 | 1.010 | -0.071 |
| Laurinburg – Cofield | 343 | - | - |
| Laurinburg – Creswell | 370 | 1.048 | -0.367 |
| Laurinburg – Roaring River | 261 | 0.966 | 0.152 |
| Laurinburg – Statesville | 211 | 0.921 | 0.356 |
| Roaring River – Candor | 192 | 0.988 | 0.065 |
| Roaring River – Cofield | 286 | 0.693 | 1.630 |
| Roaring River – Creswell | 475 | 0.752 | 1.382 |
| Roaring River – Statesville | 65 | 0.933 | 0.404 |
| Statesville – Candor | 157 | 0.934 | 0.392 |
| Statesville – Cofield | 439 | 1.059 | -0.304 |
| Statesville – Creswell | 470 | 1.108 | -0.627 |

Note: The hyphen (-) = not applicable, because the existence of long-run equilibrium is not confirmed.

**Table S7.** Results of TVECM and VECM: interregional analysis†

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  | |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* | |
| *Russia* | | | | | | | | | | | | | |
| Central – Black Earth | -0.379 | 0.360 | *-0.021* | -0.373 | 0.336 | *0.018* | -0.581\* | 0.089 | 0.564 | 0.596 | 0.929 | *0.039* | |
| Black Earth – Central | 0.564\* | 0.072 |  | 0.596\*\* | 0.035 |  | 0.616\*\* | 0.015 |  |  |  |  | |
| Central – Volga | - | - | - | -0.438\*\*\* | 0.001 | - | - | - | - | 0.641 | - | - | |
| Volga – Central | - | - |  | 0.279\*\* | 0.047 |  | - | - |  |  |  |  | |
| Central –Urals | -0.057 | 0.757 | *-0.047* | -0.276 | 0.259 | *0.029* | -0.316\*\* | 0.030 | 0.524 | - | 0.316 | *0.076* | |
| Urals – Central | 0.524\*\*\* | 0.004 |  | 0.326 | 0.214 |  | 0.190 | 0.233 |  |  |  |  | |
| Central – W. Siberia | -0.076 | 0.646 | *-0.062* | -0.194 | 0.311 | *0.021* | -0.304\*\* | 0.014 | 0.452 | - | 0.304 | *0.083* | |
| W. Siberia – Central | 0.454\*\* | 0.041 |  | 0.157 | 0.574 |  | -0.010 | 0.955 |  |  |  |  | |
| N. Caucasus – Black Earth | -0.371\*\* | 0.041 | *-0.021* | -0.371\*\* | 0.041 | *0.020* | -0.371\*\* | 0.041 | 0.371 | 0.371 | 0.371 | *0.041* | |
| Black Earth – N. Caucasus | -0.036 | 0.809 |  | -0.036 | 0.809 |  | -0.036 | 0.809 |  |  |  |  | |
| N. Caucasus – Central | -0.510\*\*\* | 0.025 | *-0.030* | -0.386\* | 0.088 | *0.020* | -0.308 | 0.136 | 0.510 | 0.385 | - | *0.050* | |
| Central – N. Caucasus | -0.281 | 0.187 |  | 0.215 | 0.299 |  | -0.061 | 0.744 |  |  |  |  | |
| N. Caucasus – Volga | -0.306\* | 0.078 | *-0.038* | -0.323 | 0.136 | *0.012* | -0.283\* | 0.060 | 0.306 | - | 0.283 | *0.050* | |
| Volga – N. Caucasus | -0.203 | 0.276 |  | -0.143 | 0.569 |  | -0.174 | 0.328 |  |  |  |  | |
| N. Caucasus – Urals | - | - | - | 0.045 | 0.774 | - | - | - | - | 0.464 | - | - | |
| Urals – N. Caucasus | - | - |  | 0.464\*\*\* | 0.000 |  | - | - |  |  |  |  | |
| N. Caucasus – W. Siberia | -0.219 | 0.146 | *-0.049* | -0.234\*\* | 0.036 | *0.029* | -0.234\*\* | 0.036 | - | 0.234 | 0.234 | *0.078* | |
| W. Siberia – N. Caucasus | -0.020 | 0.926 |  | 0.111 | 0.573 |  | 0.111 | 0.573 |  |  |  |  | |
| Black Earth – Volga | -0.179\* | 0.086 | *-0.046* | -0.271\* | 0.052 | *0.011* | -0.179\* | 0.086 | 0.179 | 0.271 | 0.179 | *0.057* | |
| Volga – Black Earth | 0.044 | 0.781 |  | -0.006 | 0.979 |  | 0.044 | 0.781 |  |  |  |  | |
| Black Earth – Urals | 0.122 | 0.318 | *-0.059* | 0.122 | 0.318 | *0.031* | 0.010 | 0.928 | 0.503 | 0.503 | 0.349 | *0.090* | |
| Urals – Black Earth | 0.503\*\*\* | 0.000 |  | 0.503\*\*\* | 0.000 |  | 0.349\*\* | 0.016 |  |  |  |  | |
| Black Earth – W. Siberia | - | - | - | 0.051 | 0.659 | - | - | - | - | 0.598 | - | - | |
| W. Siberia – Black Earth | - | - |  | 0.598\*\*\* | 0.000 |  | - | - |  |  |  |  | |
| Volga – Urals | -0.294 | 0.203 | *-0.058* | -0.038 | 0.858 | *0.038* | -0.506\*\* | 0.014 | 0.376 | 0.360 | 0.506 | *0.096* | |
| Urals – Volga | 0.376\* | 0.067 |  | 0.360\*\* | 0.043 |  | 0.226 | 0.245 |  |  |  |  | |
| (*continued*) | | | | | | | | | | | | | |
| **Table S7.** (*continued*) | | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  | |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* | |
| Volga – W. Siberia | -0.262 | 0.274 | *-0.056* | -0.362\*\* | 0.035 | *0.035* | -0.493\*\*\* | 0.004 | - | 0.362 | 0.493 | *0.091* | |
| W. Siberia – Volga | 0.385 | 0.125 |  | 0.186 | 0.228 |  | -0.051 | 0.763 |  |  |  |  | |
| Urals – W. Siberia | -0.370\* | 0.072 | *-0.027* | -0.337 | 0.183 | *0.012* | -0.370 | 0.141 | 0.370 | - | - | *0.039* | |
| W. Siberia – Urals | 0.381 | 0.157 |  | 0.306 | 0.324 |  | 0.022 | 0.951 |  |  |  |  | |
| *USA* | | | | | | | | | | | | | |
| Arkansas – Iowa | -0.303 | 0.468 | *-0.090* | -0.481 | 0.249 | *0.008* | -0.389 | 0.378 | - | - | - | *0.098* | |
| Iowa – Arkansas | 0.421 | 0.334 |  | -0.010 | 0.984 |  | -0.006 | 0.991 |  |  |  |  | |
| Arkansas – Missouri | -0.767\* | 0.059 | *-0.025* | -0.767\* | 0.059 | *0.024* | -0.312 | 0.488 | 0.767 | 0.767 | - | *0.049* | |
| Missouri – Arkansas | -0.076 | 0.898 |  | -0.076 | 0.898 |  | 0.671 | 0.120 |  |  |  |  | |
| Arkansas – Nebraska | -0.835\*\* | 0.020 | *-0.034* | -0.726\* | 0.059 | *0.012* | -0.835\*\* | 0.020 | 0.835 | 0.726 | 0.835 | *0.047* | |
| Nebraska – Arkansas | -0.351 | 0.520 |  | -0.118 | 0.817 |  | -0.351 | 0.520 |  |  |  |  | |
| Arkansas – S. Dakota | - | - | *-* | -0.020 | 0.951 | *-* | - | - | - | 0.581 | - | *-* | |
| S. Dakota – Arkansas | - | - |  | 0.581\* | 0.082 |  | - | - |  |  |  |  | |
| California – Illinois | 0.012 | 0.974 | *-0.044* | 0.065 | 0.859 | *0.016* | -0.010 | 0.978 | 0.640 | 0.680 | 0.613 | *0.060* | |
| Illinois – California | 0.640\* | 0.059 |  | 0.680\*\* | 0.037 |  | 0.613\* | 0.071 |  |  |  |  | |
| California – Iowa | 0.105 | 0.816 | *-0.032* | -0.118 | 0.831 | *0.010* | -0.576 | 0.175 | 0.813 | - | - | *0.042* | |
| Iowa – California | 0.813\*\* | 0.051 |  | 0.510 | 0.383 |  | -0.021 | 0.975 |  |  |  |  | |
| California – Kansas | - | - | *-* | -0.250 | 0.424 | *-* | - | - | - | 0.681 | - | *-* | |
| Kansas – California | - | - |  | 0.681\* | 0.057 |  | - | - |  |  |  |  | |
| California – Minnesota | -0.783\* | 0.061 | *-0.022* | -0.818\* | 0.081 | *0.012* | -0.815\*\* | 0.050 | 0.783 | 0.818 | - | *0.034* | |
| Minnesota – California | -0.307 | 0.700 |  | -0.237 | 0.780 |  | -0.531 | 0.526 |  |  |  |  | |
| California – Missouri | -0.131 | 0.730 | *-0.037* | -0.131 | 0.730 | *0.035* | -0.291 | 0.580 | 0.959 | 0.959 | 0.808 | *0.073* | |
| Missouri – California | 0.959\*\*\* | 0.002 |  | 0.959\*\*\* | 0.002 |  | 0.808\* | 0.097 |  |  |  |  | |
| California – Nebraska | -0.527 | 0.327 | *-0.028* | -0.791\*\* | 0.047 | *0.020* | -0.795\* | 0.080 | - | 0.791 | 0.795 | *0.047* | |
| Nebraska – California | 0.537 | 0.401 |  | 0.406 | 0.507 |  | 0.304 | 0.659 |  |  |  |  | |
| California – S. Dakota | -0.298 | 0.471 | *-0.035* | -0.343 | 0.431 | *0.005* | -0.298 | 0.471 | - | - | - | *0.041* | |
| S. Dakota – California | 0.719 | 0.152 |  | 0.741 | 0.146 |  | 0.719 | 0.152 |  |  |  |  | |
| (*continued*) | | | | | | | | | | | | | |
| **Table S7.** (*continued*) | | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  | |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* | |
| Colorado – Illinois | 1.036\*\* | 0.048 | *-0.028* | 1.036\*\* | 0.048 | *0.025* | 1.036\*\* | 0.048 | 0.736 | 0.736 | 0.736 | *0.053* | |
| Illinois – Colorado | 0.736\*\* | 0.015 |  | 0.736\*\* | 0.015 |  | 0.736\*\* | 0.015 |  |  |  |  | |
| Colorado – Iowa | - | - | *-* | 1.421\*\*\* | 0.007 | *-* | - | - | - | 0.991 | - | *-* | |
| Iowa – Colorado | - | - |  | 0.991\*\*\* | 0.001 |  | - | - |  |  |  |  | |
| Colorado – Missouri | 0.254 | 0.589 | *-0.042* | 0.223 | 0.587 | *0.032* | 0.254 | 0.589 | 0.632 | 0.556 | 0.632 | *0.074* | |
| Missouri – Colorado | 0.632\* | 0.075 |  | 0.556\* | 0.088 |  | 0.632\* | 0.075 |  |  |  |  | |
| Colorado – S. Dakota | -0.003 | 0.995 | *-0.019* | -0.099 | 0.856 | *0.025* | -0.003 | 0.995 | - | - | - | *0.044* | |
| S. Dakota – Colorado | 0.586 | 0.177 |  | 0.531 | 0.298 |  | 0.586 | 0.177 |  |  |  |  | |
| Oklahoma – Illinois | 1.347\*\* | 0.047 | *-0.024* | 1.347\*\* | 0.047 | *0.024* | 1.347\*\* | 0.047 | 0.875 | 0.875 | 0.875 | *0.048* | |
| Illinois – Oklahoma | 0.875\*\*\* | 0.003 |  | 0.875\*\*\* | 0.003 |  | 0.875\*\*\* | 0.003 |  |  |  |  | |
| Oklahoma – Iowa | 0.099 | 0.859 | *-0.091* | 0.099 | 0.859 | *0.023* | 0.099 | 0.859 | 0.895 | 0.895 | 0.895 | *0.114* | |
| Iowa – Oklahoma | 0.895\*\*\* | 0.008 |  | 0.895\*\*\* | 0.008 |  | 0.895\*\*\* | 0.008 |  |  |  |  | |
| Oklahoma – Kansas | -0.225 | 0.787 | *-0.012* | -0.225 | 0.787 | *0.023* | -0.225 | 0.787 | - | - | - | *0.035* | |
| Kansas – Oklahoma | 0.446 | 0.513 |  | 0.446 | 0.513 |  | 0.446 | 0.513 |  |  |  |  | |
| Oklahoma – Minnesota | -0.503 | 0.290 | *-0.040* | -0.503 | 0.290 | *0.014* | -0.239 | 0.641 | - | - | - | *0.054* | |
| Minnesota – Oklahoma | -0.243 | 0.636 |  | -0.243 | 0.636 |  | 0.333 | 0.450 |  |  |  |  | |
| Oklahoma – Missouri | 0.043 | 0.932 | *-0.053* | -0.006 | 0.990 | *0.028* | 0.043 | 0.932 | - | - | - | *0.081* | |
| Missouri – Oklahoma | 0.561 | 0.117 |  | 0.480 | 0.174 |  | 0.561 | 0.117 |  |  |  |  | |
| Oklahoma – S. Dakota | -0.138 | 0.709 | *-0.029* | -0.063 | 0.874 | *0.033* | -0.063 | 0.874 | - | - | - | *0.062* | |
| S. Dakota – Oklahoma | 0.446 | 0.182 |  | 0.483 | 0.158 |  | 0.483 | 0.158 |  |  |  |  | |
| Oregon – Illinois | 0.394 | 0.333 | *-0.020* | 0.622 | 0.217 | *0.014* | 1.408\*\* | 0.026 | 0.693 | 0.773 | 0.961 | *0.034* | |
| Illinois – Oregon | 0.693\* | 0.059 |  | 0.773\*\* | 0.048 |  | 0.961\*\*\* | 0.008 |  |  |  |  | |
| Oregon – Iowa | 0.901 | 0.165 | *-0.102* | 0.463 | 0.466 | *0.009* | 0.944 | 0.155 | 0.999 | - | 0.999 | *0.110* | |
| Iowa – Oregon | 0.999\*\*\* | 0.005 |  | 0.807 | 0.123 |  | 0.999\*\*\* | 0.006 |  |  |  |  | |
| Oregon – Kansas | 0.348 | 0.565 | *-0.016* | 0.579 | 0.402 | *0.010* | 0.593 | 0.392 | - | - | - | *0.026* | |
| Kansas – Oregon | 0.691 | 0.250 |  | 0.785 | 0.190 |  | 0.791 | 0.186 |  |  |  |  | |
| Oregon – Minnesota | -0.082 | 0.927 | *-0.004* | 0.015 | 0.987 | *0.008* | 0.255 | 0.797 | - | - | - | *0.012* | |
| Minnesota – Oregon | 0.680 | 0.465 |  | 0.739 | 0.411 |  | 0.814 | 0.348 |  |  |  |  | |
| (*continued*) | | | | | | | | | | | | | |
| **Table S7.** (*continued*) | | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | | band of  inaction *c* |
| Oregon – Missouri | - | - | *-* | 0.469 | 0.303 | *-* | - | - | - | 0.985 | - | | *-* |
| Missouri – Oregon | - | - |  | 0.985\*\*\* | 0.001 |  | - | - |  |  |  | |  |
| Oregon – Nebraska | - | - | *-* | 1.373\*\*\* | 0.008 | *-* | - | - | - | 0.970 | - | | *-* |
| Nebraska – Oregon | - | - |  | 0.970\*\*\* | 0.001 |  | - | - |  |  |  | |  |
| Oregon – S. Dakota | 0.031 | 0.945 | *-0.024* | 0.031 | 0.945 | *0.019* | 0.018 | 0.966 | - | - | - | | *0.043* |
| S. Dakota – Oregon | 0.748 | 0.132 |  | 0.748 | 0.132 |  | 0.741 | 0.134 |  |  |  | |  |
| Texas – Illinois | -0.999\*\*\* | 0.004 | *-0.009* | -0.999\*\*\* | 0.004 | *0.009* | -0.999\*\*\* | 0.004 | 0.999 | 0.999 | 0.999 | | *0.018* |
| Illinois – Texas | -3.653\*\*\* | 0.000 |  | -3.629\*\*\* | 0.000 |  | -3.653\*\*\* | 0.000 |  |  |  | |  |
| Texas – Iowa | 1.030 | 0.195 | *-0.100* | 1.030 | 0.195 | *0.014* | 1.030 | 0.195 | 0.996 | 0.996 | 0.996 | | *0.113* |
| Iowa – Texas | 0.996\*\*\* | 0.007 |  | 0.996\*\*\* | 0.007 |  | 0.996\*\*\* | 0.007 |  |  |  | |  |
| Texas – Kansas | 0.404 | 0.783 | *-0.014* | 0.404 | 0.783 | *0.008* | 0.438 | 0.767 | - | - | - | | *0.021* |
| Kansas – Texas | 0.743 | 0.485 |  | 0.743 | 0.485 |  | 0.753 | 0.475 |  |  |  | |  |
| Texas – Minnesota | - | - | *-* | -0.735 | 0.339 | *-* | - | - |  | - |  | |  |
| Minnesota – Texas | - | - |  | -0.404 | 0.735 |  | - | - |  |  |  | |  |
| Texas – Missouri | 0.316 | 0.567 | *-0.033* | -0.170 | 0.754 | *0.020* | 0.316 | 0.567 | 0.791 | - | 0.791 | | *0.053* |
| Missouri – Texas | 0.791\*\* | 0.044 |  | 0.529 | 0.299 |  | 0.791\*\* | 0.044 |  |  |  | |  |
| Texas – Nebraska | -0.428 | 0.328 | *-0.003* | -0.256 | 0.726 | *0.011* | -0.428 | 0.328 | - | - | - | | *0.015* |
| Nebraska – Texas | -0.010 | 0.984 |  | 0.224 | 0.761 |  | -0.010 | 0.984 |  |  |  | |  |
| Texas – S. Dakota | - | - | *-* | 0.213 | 0.550 | *-* | - | - | - | 0.766 | - | | *-* |
| S. Dakota – Texas | - | - |  | 0.766\*\* | 0.011 |  | - | - |  |  |  | |  |
| Virginia – Illinois | - | - | *-* | -0.050 | 0.910 | *-* | - | - | - | 0.617 | - | | *-* |
| Illinois – Virginia | - | - |  | 0.617\* | 0.053 |  | - | - |  |  |  | |  |
| Virginia – Iowa | - | - | *-* | -0.643\*\* | 0.023 | *-* | - | - | - | 0.643 | - | | *-* |
| Iowa – Virginia | - | - |  | 0.384 | 0.247 |  | - | - |  |  |  | |  |
| Virginia – Kansas | - | - | *-* | -0.924\*\*\* | 0.001 | *-* | - | - | - | 0.924 | - | | *-* |
| Kansas – Virginia | - | - |  | -1.063\*\*\* | 0.009 |  | - | - |  |  |  | |  |
| Virginia – Minnesota | - | - | *-* | -0.778\*\*\* | 0.001 | *-* | - | - | - | 0.778 | - | | *-* |
| Minnesota – Virginia | - | - |  | -0.639\* | 0.078 |  | - | - |  |  |  | |  |
| (*continued*) | | | | | | | | | | | | | |
| **Table S7.** (*continued*) | | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  | |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* | |
| Virginia – Missouri | -0.886 | 0.017 | *-0.009* | -0.774\*\* | 0.036 | *0.023* | -0.774\*\* | 0.036 | 0.886 | 0.774 | 0.774 | *0.032* | |
| Missouri – Virginia | -0.316 | 0.599 |  | -0.308 | 0.575 |  | -0.308 | 0.575 |  |  |  |  | |
| Virginia – Nebraska | - | - | *-* | -0.600\*\*\* | 0.009 | *-* | - | - | - | 0.600 | - | *-* | |
| Nebraska – Virginia | - | - |  | -0.308 | 0.281 |  | - | - |  |  |  |  | |
| Virginia – S. Dakota | -0.509 | 0.052 | *-0.049* | -0.254 | 0.462 | *0.041* | -0.253 | 0.463 | 0.509 | - | - | *0.090* | |
| S. Dakota – Virginia | -0.185 | 0.611 |  | 0.235 | 0.545 |  | 0.238 | 0.539 |  |  |  |  | |
| Washington – Illinois | 0.668 | 0.190 | *-0.061* | 1.466\*\* | 0.026 | *0.020* | 1.466\*\*\* | 0.026 | 0.800 | 0.959 | 0.959 | *0.081* | |
| Illinois – Washington | 0.800 | 0.013 |  | 0.959\*\*\* | 0.002 |  | 0.959\*\*\* | 0.002 |  |  |  |  | |
| Washington – Iowa | -0.157 | 0.799 | *-0.011* | 0.589 | 0.500 | *0.015* | 0.589 | 0.500 | - | - | - | *0.026* | |
| Iowa – Washington | 0.479 | 0.391 |  | 0.852 | 0.115 |  | 0.852 | 0.115 |  |  |  |  | |
| Washington – Kansas | - | - | *-* | 1.200\* | 0.071 | *-* | - | - | - | 0.980 | - | *-* | |
| Kansas – Washington | - | - |  | 0.980\*\*\* | 0.007 |  | - | - |  |  |  |  | |
| Washington – Minnesota | -0.862 | 0.118 | *-0.024* | -0.862 | 0.118 | *0.005* | -0.521 | 0.466 | - | - | - | *0.029* | |
| Minnesota – Washington | -0.621 | 0.553 |  | -0.621 | 0.553 |  | 0.105 | 0.911 |  |  |  |  | |
| Washington – Missouri | 0.063 | 0.918 | *-0.035* | 0.081 | 0.896 | *0.020* | 0.095 | 0.879 | 0.900 | 0.903 | 0.905 | *0.055* | |
| Missouri – Washington | 0.900 | 0.038 |  | 0.903\*\* | 0.037 |  | 0.905\*\* | 0.036 |  |  |  |  | |
| Washington – S. Dakota | - | - | *-* | 0.546 | 0.135 | *-* | - | - | - | 0.929 | - | *-* | |
| S. Dakota – Washington | - | - |  | 0.929\*\*\* | 0.001 |  | - | - |  |  |  |  | |
| Wyoming – Illinois | - | - | *-* | 0.970\*\*\* | 0.001 | *-* | - | - | - | 0.581 | - | *-* | |
| Illinois – Wyoming | - | - |  | 0.581\*\*\* | 0.001 |  | - | - |  |  |  |  | |
| Wyoming – Iowa | - | - | *-* | 1.036\*\*\* | 0.008 | *-* | - | - | - | 0.851 | - | *-* | |
| Iowa – Wyoming | - | - |  | 0.851\*\*\* | 0.001 |  | - | - |  |  |  |  | |
| Wyoming – Kansas | - | - | *-* | 1.595\*\* | 0.021 | *-* | - | - | - | 0.927 | - | *-* | |
| Kansas – Wyoming | - | - |  | 0.927\*\*\* | 0.001 |  | - | - |  |  |  |  | |
| Wyoming – Missouri | 0.276 | 0.622 | *-0.060* | -0.431 | 0.135 | *0.045* | 1.029\* | 0.070 | 0.681 | - | 0.681 | *0.105* | |
| Missouri – Wyoming | 0.681 | 0.097 |  | 0.064 | 0.841 |  | 0.874\*\*\* | 0.005 |  |  |  |  | |
| Wyoming – S. Dakota | - | - | *-* | 0.819\*\* | 0.031 | *-* | - | - | - | 0.959 | - | *-* | |
| S. Dakota – Wyoming | - | - |  | 0.959\*\*\* | 0.001 |  | - | - |  |  |  |  | |

Note: †to make speed of adjustment parameters of different frequencies comparable we convert them from weekly to biweekly frequency by using following formula for Russia and the USA. *a*parametersfrom the linear VECM are not regime-specific and thresholds are not estimated. Thus, linear VECM estimates are presented in the middle regime column. *b*total adjustment in one regime is calculated as the sum of the absolute value of the respective regime-specific speed of adjustment parameters of the TVECM significant at least 10% level. *c* the band of inaction is given as the difference between the absolute value of the upper and lower threshold. The hyphen (-) = not applicable. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01.

**Table S8.** Results of TVECM and VECM: intraregional analysis †

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* |
| *Black Earth* | | | | | | | | | | | | |
| Belgorod – Kursk | -0.350\*\*\* | 0.004 | *-0.048* | -0.349\*\*\* | 0.004 | *0.032* | -0.350\*\*\* | 0.004 | 0.350 | 0.349 | 0.350 | *0.080* |
| Kursk – Belgorod | 0.109 | 0.479 |  | 0.105 | 0.501 |  | 0.025 | 0.479 |  |  |  |  |
| Belgorod – Lipetsk | - | - | *-* | -0.357\*\*\* | 0.001 | *-* | - | - | - | 0.357 | - | *-* |
| Lipetsk – Belgorod | - | - |  | -0.209\*\* | 0.034 |  | - | - |  |  |  |  |
| Belgorod – Tambov | -0.445\*\*\* | 0.001 | *-0.009* | -0.263\*\*\* | 0.066 | *0.040* | -0.445\*\*\* | 0.000 | 0.445 | - | 0.445 | *0.049* |
| Tambov – Belgorod | 0.053 | 0.602 |  | 0.170 | 0.268 |  | 0.053 | 0.602 |  |  |  |  |
| Belgorod – Voronezh | -0.228 | 0.353 | *-0.068* | -0.088 | 0.594 | *0.109* | 0.228 | 0.353 | 0.581 | 0.162 | 0.581 | *0.177* |
| Voronezh – Belgorod | 0.581\*\*\* | 0.002 |  | 0.162\* | 0.091 |  | 0.581\*\*\* | 0.002 |  |  |  |  |
| Kursk – Lipetsk | - | - | *-* | -0.337\*\*\* | 0.001 | *-* | - | - | - | 0.337 | - | *-* |
| Lipetsk – Kursk | - | - |  | -0.017 | 0.956 |  | - | - |  |  |  |  |
| Kursk – Tambov | 0.024 | 0.855 | *-0.013* | -0.008 | 0.963 | *0.085* | -0.042 | 0.791 | 0.400 | 0.468 | 0.504 | *0.098* |
| Tambov – Kursk | 0.400\*\*\* | 0.001 |  | 0.468\*\*\* | 0.001 |  | 0.504\*\*\* | 0.001 |  |  |  |  |
| Kursk – Voronezh | -0.165 | 0.457 | *-0.087* | -0.264 | 0.186 | *0.136* | 0.028 | 0.931 | 0.326 | 0.311 | 0.721 | *0.223* |
| Voronezh – Kursk | 0.326\*\* | 0.039 |  | 0.311\*\*\* | 0.004 |  | 0.721\*\* | 0.014 |  |  |  |  |
| Lipetsk – Tambov | - | - | *-* | -0.004 | 0.967 | *-* | - | - | - | 0.306 | - | *-* |
| Tambov – Lipetsk | - | - |  | 0.306\*\* | 0.027 |  | - | - |  |  |  |  |
| Lipetsk – Voronezh | -0.039 | 0.786 | *-0.102* | -0.205\*\* | 0.034 | *0.002* | 0.206\*\* | 0.045 | 0.339 | 0.205 | 0.506 | *0.104* |
| Voronezh – Lipetsk | 0.399\* | 0.067 |  | 0.041 | 0.810 |  | 0.506\*\*\* | 0.004 |  |  |  |  |
| Tambov – Voronezh | -0.726\*\*\* | 0.001 | *-0.008* | 0.179 | 0.316 | *0.053* | -0.548 | 0.111 | 0.961 | 0.920 | 0.564 | *0.061* |
| Voronezh – Tambov | 0.235\*\*\* | 0.006 |  | 0.920\*\*\* | 0.006 |  | 0.564 | 0.104 |  |  |  |  |
| (*continued*) | | | | | | | | | | | | |
| **Table S8.** (*continued*) | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* |
| *West Siberia* | | | | | | | | | | | | |
| Kemerovo – Altai | -0.485\*\*\* | 0.002 | *-0.059* | -0.402\*\*\* | 0.005 | *0.039* | -0.402\*\*\* | 0.005 | 0.485 | 0.402 | 0.402 | *0.098* |
| Altai – Kemerovo | -0.074 | 0.685 |  | 0.063 | 0.738 |  | 0.063 | 0.738 |  |  |  |  |
| Kemerovo – Novosibirsk | 0.012 | 0.979 | *-0.097* | -0.236 | 0.309 | *0.123* | -0.145 | 0.630 | - | 0.367 | 0.608 | *0.220* |
| Novosibirsk – Kemerovo | 0.653 | 0.140 |  | 0.367\*\*\* | 0.008 |  | 0.608\*\*\* | 0.015 |  |  |  |  |
| Kemerovo – Omsk | - | - | *-* | -0.309\*\* | 0.027 | *-* | - | - | - | 0.309 | - | *-* |
| Omsk – Kemerovo | - | - |  | 0.304 | 0.170 |  | - | - |  |  |  |  |
| Kemerovo – Tomsk | -0.411\* | 0.073 | *-0.057* | -0.149 | 0.249 | *0.062* | -0.486\* | 0.086 | 0.411 | - | 0.468 | *0.119* |
| Tomsk – Kemerovo | 0.087 | 0.776 |  | 0.269 | 0.312 |  | 0.275 | 0.483 |  |  |  |  |
| Novosibirsk – Altai | -0.401\*\* | 0.047 | *-0.168* | -0.089 | 0.468 | *0.066* | -0.295 | 0.195 | 0.401 | - | - | *0.234* |
| Altai – Novosibirsk | -0.289 | 0.151 |  | -0.137 | 0.289 |  | -0.074 | 0.737 |  |  |  |  |
| Novosibirsk – Omsk | -1.151\*\*\* | 0.001 | *-0.194* | -0.386\*\* | 0.057 | *0.132* | -0.986\*\*\* | 0.001 | - | 0.386 | 0.986 | *0.326* |
| Omsk – Novosibirsk | -0.113 | 0.719 |  | 0.093 | 0.644 |  | -0.026 | 0.938 |  |  |  |  |
| Tomsk – Novosibirsk | -0.229 | 0.407 | *-0.115* | 0.112 | 0.651 | *0.082* | 0.008 | 0.980 | 0.507 | 0.485 | 0.773 | *0.197* |
| Novosibirsk – Tomsk | 0.507\*\* | 0.013 |  | 0.485\*\*\* | 0.001 |  | 0.773\*\*\* | 0.002 |  |  |  |  |
| Tomsk – Altai | -0.074 | 0.751 | *-0.062* | -0.517\* | 0.056 | *0.008* | -0.344 | 0.129 | 0.606 | 0.517 | - | 0.070 |
| Altai – Tomsk | 0.606\*\*\* | 0.005 |  | 0.011 | 0.967 |  | 0.197 | 0.385 |  |  |  |  |
| Tomsk – Omsk | -0.277\*\* | 0.041 | *-0.015* | -0.084 | 0.956 | *0.002* | -0.114 | 0.489 | 0.708 | - | 0.646 | *0.017* |
| Omsk – Tomsk | 0.431\*\* | 0.031 |  | 0.870 | 0.574 |  | 0.646\*\*\* | 0.006 |  |  |  |  |
| Altai – Omsk | -0.590\*\* | 0.020 | *-0.147* | -0.047 | 0.723 | *0.042* | -0.386 | 0.113 | 0.590 | 0.557 | - | *0.189* |
| Omsk – Altai | 0.116 | 0.692 |  | 0.557\*\*\* | 0.002 |  | 0.270 | 0.377 |  |  |  |  |
| Tyumen – Altai | -0.836\*\*\* | 0.001 | *-0.117* | -0.710\*\*\* | 0.003 | *0.007* | -0.714\*\*\* | 0.001 | 0.836 | 1.00 | 0.902 | *0.124* |
| Altai – Tyumen | -0.356\*\*\* | 0.001 |  | 0.303\*\* | 0.021 |  | 0.188\* | 0.052 |  |  |  |  |
| Tyumen – Kemerovo | 0.069 | 0.585 | *-0.063* | 0.064 | 0.626 | *0.056* | 0.064 | 0.626 | 0.508 | 0.531 | 0.531 | *0.119* |
| Kemerovo – Tyumen | 0.508\*\*\* | 0.006 |  | 0.531\*\*\* | 0.007 |  | 0.531\*\*\* | 0.007 |  |  |  |  |
| Tyumen – Novosibirsk | -0.838\*\* | 0.017 | *-0.057* | -0.620\*\* | 0.023 | *0.063* | -0.734\* | 0.081 | 0.838 | 0.620 | 0.734 | *0.120* |
| Novosibirsk – Tyumen | 0.040 | 0.879 |  | 0.281 | 0.135 |  | 0.258 | 0.466 |  |  |  |  |
| (*continued*) | | | | | | | | | | | | |
| **Table S8.** (*continued*) | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* |
| Tyumen – Omsk | -1.068\*\*\* | 0.001 | *-0.089* | -0.869\*\*\* | 0.001 | *0.069* | -0.869\*\*\* | 0.001 | 0.483 | 0.869 | 0.869 | *0.158* |
| Omsk – Tyumen | -0.585\*\* | 0.053 |  | -0.222 | 0.341 |  | -0.221 | 0.341 |  |  |  |  |
| Tyumen – Tomsk | -0.995\*\*\* | 0.001 | *-0.037* | -0.748\*\*\* | 0.001 | *0.081* | 0.779\*\*\* | 0.001 | 0.995 | 0.748 | 0.779 | *0.112* |
| Tomsk – Tyumen | -0.255 | 0.202 |  | 0.097 | 0.683 |  | 0.077 | 0.752 |  |  |  |  |
| *Iowa* | | | | | | | | | | | | |
| Cedar Rapids – Emmetsburg | 0.638 | 0.023 | *-0.028* | 0.638 | 0.023 | *0.038* | 0.638 | 0.023 | - | - | - | *0.066* |
| Emmetsburg – Cedar Rapids | 0.135 | 0.637 |  | 0.135 | 0.637 |  | 0.135 | 0.637 |  |  |  |  |
| Clinton – Cedar Rapids | -0.197 | 0.759 | *-0.008* | -0.005 | 0.994 | *0.018* | -0.197 | 0.759 | - | 0.812 | - | *0.026* |
| Cedar Rapids – Clinton | 0.705 | 0.191 |  | 0.812 | 0.108 |  | 0.705 | 0.191 |  |  |  |  |
| Clinton – Davenport | - | - | *-* | -0.195 | 0.528 | *-* | - | - | - | 0.429 | - | *-* |
| Davenport – Clinton | - | - |  | 0.429 | 0.057 |  | - | - |  |  |  |  |
| Clinton – Emmetsburg | 0.117 | 0.709 | *-0.038* | 0.012 | 0.963 | *0.044* | 0.117 | 0.709 | 0.437 | - | 0.437 | *0.081* |
| Emmetsburg – Clinton | 0.437 | 0.049 |  | 0.287 | 0.150 |  | 0.437 | 0.049 |  |  |  |  |
| Eddyville – Cedar Rapids | -0.522 | 0.075 | *-0.064* | -0.559 | 0.032 | *0.032* | -0.522 | 0.075 | 0.522 | 0.559 | 0.522 | *0.096* |
| Cedar Rapids – Eddyville | 0.218 | 0.449 |  | 0.104 | 0.693 |  | 0.218 | 0.449 |  |  |  |  |
| Clinton – Muscatine | - | - | *-* | 0.138 | 0.843 | *-* | - | - | - | 0.787 | - | *-* |
| Muscatine – Clinton | - | - |  | 0.787 | 0.003 |  | - | - |  |  |  |  |
| Davenport – Cedar Rapids | 0.332 | 0.374 | *-0.123* | -0.421 | 0.031 | *0.052* | 0.332 | 0.374 | 0.726 | - | 0.726 | *0.175* |
| Cedar Rapids – Davenport | 0.726 | 0.002 |  | -0.368 | 0.071 |  | 0.726 | 0.002 |  |  |  |  |
| Davenport – Emmetsburg | -0.306 | 0.047 | *-0.077* | -0.394 | 0.039 | *0.027* | -0.332 | 0.042 | 0.306 | 0.394 | 0.332 | *0.104* |
| Emmetsburg – Davenport | -0.245 | 0.197 |  | -0.360 | 0.134 |  | -0.276 | 0.171 |  |  |  |  |
| Eddyville – Clinton | -0.634 | 0.014 | *-0.051* | -0.634 | 0.014 | *0.024* | -0.634 | 0.014 | 0.634 | 0.634 | 0.634 | *0.075* |
| Clinton – Eddyville | 0.130 | 0.603 |  | 0.130 | 0.603 |  | 0.130 | 0.603 |  |  |  |  |
| Eddyville – Davenport | 0.194 | 0.540 | *-0.079* | -0.671 | 0.005 | *0.036* | -0.683 | 0.004 | 0.715 | 0.671 | 0.683 | *0.115* |
| Davenport – Eddyville | 0.715 | 0.004 |  | -0.123 | 0.707 |  | -0.195 | 0.555 |  |  |  |  |
| Eddyville – Emmetsburg | -0.669 | 0.001 | *-0.076* | -0.627 | 0.006 | *0.028* | -0.578 | 0.012 | 0.669 | 0.627 | 0.578 | *0.103* |
| Emmetsburg – Eddyville | -0.298 | 0.305 |  | -0.337 | 0.275 |  | -0.259 | 0.386 |  |  |  |  |
| (*continued*) | | | | | | | | | | | | |
| **Table S8.** (*continued*) | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* |
| Eddyville – Keokuk | 0.066 | 0.847 | *-0.052* | -0.031 | 0.927 | *0.027* | 0.065 | 0.846 | 0.631 | 0.660 | 0.618 | *0.078* |
| Keokuk – Eddyville | 0.631 | 0.025 |  | 0.660 | 0.017 |  | 0.618 | 0.025 |  |  |  |  |
| Eddyville – Muscatine | -0.531 | 0.104 | *-0.024* | -0.729 | 0.056 | *0.003* | -0.546 | 0.097 | 0.531 | 0.729 | 0.546 | *0.027* |
| Muscatine – Eddyville | 0.447 | 0.126 |  | 0.243 | 0.566 |  | 0.437 | 0.145 |  |  |  |  |
| Keokuk – Clinton | -0.931 | 0.022 | *-0.104* | -0.531 | 0.009 | *0.044* | -0.045 | 0.001 | 0.931 | 0.531 | 0.045 | *0.148* |
| Clinton – Keokuk | -0.755 | 0.290 |  | -0.178 | 0.403 |  | -2.393 | 0.141 |  |  |  |  |
| Keokuk – Davenport | - | - | *-* | -0.637 | 0.017 | *-* | - | - | - | 0.637 | - | *-* |
| Davenport – Keokuk | - | - |  | 0.059 | 0.743 |  | - | - |  |  |  |  |
| Keokuk – Emmetsburg | -0.585 | 0.008 | *-0.144* | -0.401 | 0.023 | *0.030* | -0.426 | 0.012 | 0.585 | 0.401 | 0.426 | *0.174* |
| Emmetsburg – Keokuk | -0.680 | 0.019 |  | -0.233 | 0.215 |  | -0.270 | 0.142 |  |  |  |  |
| Keokuk – Muscatine | -0.823 | 0.006 | *-0.070* | -0.282 | 0.294 | *0.041* | 0.370 | 0.002 | 0.823 | - | - | *0.111* |
| Muscatine – Keokuk | -0.314 | 0.445 |  | 0.010 | 0.969 |  | -2.488 | 0.188 |  |  |  |  |
| Muscatine – Cedar Rapids | -0.554 | 0.157 | *-0.014* | -0.973 | 0.006 | *0.019* | -0.554 | 0.157 | - | 0.973 | - | *0.033* |
| Cedar Rapids – Muscatine | 0.309 | 0.467 |  | -1.316 | 0.080 |  | 0.309 | 0.467 |  |  |  |  |
| Muscatine – Davenport | 0.335 | 0.461 | *-0.094* | -0.600 | 0.008 | *0.018* | -0.600 | 0.008 | 0.570 | 0.600 | 0.600 | *0.113* |
| Davenport – Muscatine | 0.570 | 0.091 |  | -0.119 | 0.645 |  | -0.119 | 0.645 |  |  |  |  |
| Muscatine – Emmetsburg | - | - | *-* | -0.686 | 0.004 | *-* | - | - | - | 0.686 | - | *-* |
| Emmetsburg – Muscatine | - | - |  | -1.048 | 0.012 |  | - | - |  |  |  |  |
| W. Burlington – Cedar Rapids | -0.532 | 0.036 | *-0.014* | -0.676 | 0.048 | *0.032* | -0.532 | 0.036 | 0.532 | 0.676 | 0.532 | *0.046* |
| Cedar Rapids – W. Burlington | -0.023 | 0.931 |  | -0.730 | 0.108 |  | -0.023 | 0.931 |  |  |  |  |
| W. Burlington – Davenport | - | - | *-* | -0.577 | 0.014 | *-* | - | - | - | 0.577 | - | *-* |
| Davenport – W. Burlington | - | - |  | -0.006 | 0.968 |  | - | - |  |  |  |  |
| W. Burlington – Eddyville | -0.191 | 0.576 | *-0.008* | -0.473 | 0.171 | *0.003* | -0.191 | 0.576 | 0.626 | - | 0.626 | *0.011* |
| Eddyville – W. Burlington | 0.626 | 0.031 |  | 0.429 | 0.209 |  | 0.626 | 0.031 |  |  |  |  |
| W. Burlington – Emmetsburg | 0.146 | 0.499 | *-0.044* | 0.170 | 0.410 | *0.049* | 0.146 | 0.499 | 0.331 | 0.335 | 0.331 | *0.094* |
| Emmetsburg – W. Burlington | 0.331 | 0.068 |  | 0.335 | 0.052 |  | 0.331 | 0.068 |  |  |  |  |
| W. Burlington – Keokuk | 5.509 | 0.065 | *-0.051* | -0.111 | 0.796 | *0.025* | -0.070 | 0.872 | - | - | - | *0.076* |
| Keokuk – W. Burlington | -0.359 | 0.012 |  | 0.575 | 0.141 |  | 0.610 | 0.111 |  |  |  |  |
| (*continued*) | | | | | | | | | | | | |
| **Table S8.** (*continued*) | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | lower | middle | upper | band of  inaction *c* |
| W. Burlington – Muscatine | -0.593 | 0.102 | *-0.032* | -0.595 | 0.100 | *0.013* | -0.593 | 0.102 | 0.593 | 0.595 | 0.593 | *0.045* |
| Muscatine – W. Burlington | -0.108 | 0.789 |  | -0.116 | 0.774 |  | -0.108 | 0.789 |  |  |  |  |
| *North Carolina* | | | | | | | | | | | | |
| Candor – Creswell | -0.143 | 0.729 | *-0.081* | -0.276 | 0.339 | *0.032* | -0.214 | 0.492 | 0.655 | - | - | *0.112* |
| Creswell – Candor | 0.655 | 0.107 |  | 0.312 | 0.383 |  | 0.357 | 0.331 |  |  |  |  |
| Cofield – Candor | -0.244 | 0.221 | *-0.097* | -0.047 | 0.799 | *0.029* | -0.244 | 0.221 | - | - | - | *0.126* |
| Candor – Cofield | -0.062 | 0.743 |  | 0.128 | 0.422 |  | -0.062 | 0.743 |  |  |  |  |
| Cofield – Creswell | - | - | *-* | 0.003 | 0.998 | *-* | - | - | - | 0.574 | - | *-* |
| Creswell – Cofield | - | - |  | 0.574 | 0.003 |  | - | - |  |  |  |  |
| Laurinburg – Candor | -0.097 | 0.762 | *-0.038* | -0.097 | 0.762 | *0.006* | -0.316 | 0.279 | - | - | - | *0.045* |
| Candor – Laurinburg | 0.348 | 0.230 |  | 0.348 | 0.230 |  | 0.072 | 0.813 |  |  |  |  |
| Laurinburg – Creswell | -0.647 | 0.010 | *-0.050* | 0.082 | 0.841 | *0.036* | -0.685 | 0.015 | 0.647 | - | 0.685 | *0.086* |
| Creswell – Laurinburg | -0.211 | 0.455 |  | 0.416 | 0.183 |  | -0.138 | 0.674 |  |  |  |  |
| Laurinburg – Roaring River | -0.238 | 0.337 | *-0.075* | -0.252 | 0.324 | *0.003* | -0.515 | 0.039 | - | - | 0.515 | *0.079* |
| Roaring River – Laurinburg | 0.204 | 0.377 |  | 0.150 | 0.540 |  | -0.048 | 0.861 |  |  |  |  |
| Laurinburg – Statesville | 0.126 | 0.717 | *-0.021* | 3.804 | 0.002 | *0.002* | 0.126 | 0.717 | - | - | - | *0.023* |
| Statesville – Laurinburg | 0.254 | 0.397 |  | 0.972 | 0.002 |  | 0.254 | 0.397 |  |  |  |  |
| Roaring River – Candor | -0.284 | 0.448 | *-0.029* | -0.284 | 0.448 | *0.026* | -0.284 | 0.448 | - | - | - | *0.055* |
| Candor – Roaring River | 0.469 | 0.205 |  | 0.469 | 0.205 |  | 0.469 | 0.205 |  |  |  |  |
| Roaring River – Cofield | 0.111 | 0.464 | *-0.070* | 0.183 | 0.296 | *0.028* | 0.111 | 0.464 | - | - | - | *0.098* |
| Cofield – Roaring River | -0.289 | 0.133 |  | -0.206 | 0.316 |  | -0.289 | 0.133 |  |  |  |  |
| Roaring River – Creswell | - | - | *-* | -0.066 | 0.997 | *-* | - | - | - | 0.630 | - | *-* |
| Creswell – Roaring River | - | - |  | 0.630 | 0.007 |  | - | - |  |  |  |  |
| Roaring River – Statesville | -0.194 | 0.484 | *-0.014* | -0.212 | 0.441 | *0.003* | -0.194 | 0.484 | - | - | - | *0.017* |
| Statesville – Roaring River | 0.306 | 0.307 |  | 0.275 | 0.363 |  | 0.306 | 0.307 |  |  |  |  |
| Statesville – Candor | -0.260 | 0.510 | *-0.024* | -0.232 | 0.553 | *0.015* | -0.260 | 0.510 | - | - | - | *0.039* |
| Candor – Statesville | 0.120 | 0.755 |  | 0.139 | 0.710 |  | 0.120 | 0.755 |  |  |  |  |
| (*continued*) | | | | | | | | | | | | |
| **Table S8.** (*continued*) | | | | | | | | | | | | |
| price pair | lower regime | |  | middle regime / VECM parameters *a* | |  | upper regime | | total adjustment*b* | | |  |
| sp. adj. () | p-value | threshold  () | sp. adj. () | p-value | threshold  () | sp. adj. () |  | lower | middle | upper | band of  inaction *c* |
| Statesville – Cofield | -0.161 | 0.409 | *-0.057* | -0.161 | 0.409 | *0.018* | -0.161 | 0.409 | - | - | - | *0.076* |
| Cofield – Statesville | 0.052 | 0.775 |  | 0.052 | 0.775 |  | 0.052 | 0.775 |  |  |  |  |
| Statesville – Creswell | - | - | *-* | -0.021 | 0.978 | *-* | - | - | - | 0.596 | - | *-* |
| Creswell – Statesville | - | - |  | 0.596 | 0.016 |  | - | - |  |  |  |  |

Note: † to make speed of adjustment parameters of different frequencies comparable we convert them from weekly to biweekly frequency by using following formula for Iowa and North Carolina. Parameters for North Caucasus and West Siberia are by itself estimated on biweekly level. *a*parametersfrom the linear VECM are not regime-specific and thresholds are not estimated. Thus, linear VECM estimates are presented in the middle regime column. *b*total adjustment in one regime is calculated as the sum of the absolute value of the respective regime-specific speed of adjustment parameters of the TVECM significant at least 10% level. *c* the band of inaction is given as the difference between the absolute value of the upper and lower threshold. The hyphen (-) = not applicable. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01.

**Table S9.** Additional production potential in Russia at the regional level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Economic region | Sown  area | Observed yield | Yield  gap | Abandoned land | Intensification 80% | Recultivation 15% | Intensification 80% & recultivation 15% |
| Measurement unit | Mio ha | t/ha | t/ha | Mio ha | Mio t (% of total) | Mio t (% of total) | Mio t (% of total) |
| Column | A | B | D | E | F = (A x D) x 0.8 | G = (B x E) x 0.15 | H = F + G |
| Source | Swinnen *et al*. (2017) | Swinnen *et al*. (2017) | Swinnen *et al*. (2017) | Lesiv *et al*. (2018) | own  calculation | own  calculation | own  calculation |
| Black Earth | 2.21 | 2.95 | 1.99 | 2.19 | 8.69 (13%) | 0.96 (7%) | 4.10 (9%) |
| Central | 1.37 | 2.14 | 3.04 | 9.53 | 5.51 (8%) | 3.00 (21%) | 6.20 (14%) |
| North Caucasus | 5.13 | 2.52 | 2.75 | 4.39 | 17.25 (26%) | 1.70 (12%) | 6.75 (15%) |
| Ural | 4.54 | 1.33 | 2.56 | 10.47 | 12.21 (18%) | 2.01 (14%) | 10.66 (24%) |
| Volga | 3.75 | 1.78 | 1.56 | 8.76 | 10.99 (16%) | 2.29 (16%) | 7.02 (16%) |
| West Siberia | 3.76 | 1.49 | 2.13 | 7.73 | 5.98 (9%) | 1.13 (8%) | 5.02 (11%) |
| Other regions | 1.66 | 1.90 | 2.56 | 13.08 | 5.97 (9%) | 3.37 (23%) | 4.71 (11%) |
| **Ural & West Siberia** | **8.30** | **1.41** | **2.35** | **18.20** | **18.19 (27%)** | **3.14 (22%)** | **15.68 (35%)** |
| Total Russia | 22.43 | 1.99 | 2.47 | 56.14 | 66.60 (100%) | 14.46 (100%) | 44.47 (100%) |

Note: Data shown in columns A–E is provided by Florian Schierhorn.

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