How well is the Russian Wheat Market Functioning? A Comparison with the Corn Market in the USA

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Abstract

Given Russia's leading position in the world wheat trade, how well its grain markets function becomes very important question to evaluate the state of future global food security. We use a threshold vector error correction model to explicitly account for the influence of trade costs on price relationships in the grain markets of Russia and the USA. In addition, we study impact of market characteristics on regional wheat market integration. Empirical evaluation shows that distance between markets, interregional trade flows, export orientation, export tax and export ban all have a significant impact on the magnitude of wheat market integration.

Keywords: regional market integration, threshold vector error correction model, Russia, USA, export ban

JEL classification: C22, C33, C34, P52, Q13, Q18

1 Introduction

In recent years Russia has advanced from a grain importing country to one of the primary grain exporting countries. Russia could further boost its grain production by increasing production efficiency and to a limited extend by re-cultivating formerly abandoned agricultural land. Therefore, Russia could play a large role for future global food security (Lioubimtseva and Henebry, 2012). Against this background, how well Russia's grain markets function becomes very important question to evaluate the state of future global food security.

Our research contribution in understanding regional wheat market performance within Russia is fourfold. First, we examine to what degree and how fast are price shocks in one region transmitted to the other regions. Identifying the patterns of price developments is critically important given that the Russian grain market is characterized by strong production volatility resulting from extreme weather events which are expected to increase with climate change. Consequently, interregional grain trade is of high importance to equilibrate grain supply and demand within Russia. Nonetheless, grain market transport and storage infrastructure is deficient in several regions and price peaks are repeatedly observed on regional markets, exceeding even the world market price.

As our second question, we investigate the effects of the wheat export ban 2010/11 on regional price relationships to shed further light on the domestic price effects of export controls. Russia has a history of restricting the exports of wheat to the world market when domestic wheat prices peak. Export controls have strong negative effects on grain production and hamper further development of the grain sector (Götz et al. 2016). Frequently changing export policy environment further adds to market uncertainties in Russia.

Third, to assess how well the Russian market is functioning we conduct a comparative price transmission analysis for the corn market of the USA which is also characterized by large distances, strong variation in regional production and high interregional trade flows. We assume that the corn market of the USA is one of the most efficient grain markets in the world characterized by well-developed transport and storage infrastructure and high market transparency, serving as a benchmark for the Russian wheat market in this study.

Fourth, we identify characteristics that affect functioning of the Russian wheat markets and study their impact on the degree of market integration only in Russia, and as well as in comparison to the USA. In this study we identify functional relationship between market integration and distance, trade costs, interregional trade flows, export orientation and export control measures.

The remainder of this paper is organized as follows. In the next Section 2, we discuss methodological approaches and data properties, which is followed by the review of outcomes of model estimations in Section 3. In the final Section 4, concluding remarks are summarized.

2 Methodological framework and data properties

Methodology and estimation technique

We answer first three questions using a non-linear model of price transmission. In a well-functioning, efficient market price shocks in one region are quickly transmitted to the other regions inducing interregional trade flows when price differences exceed trade costs (Fackler and Goodwin, 2001). Therefore, the adjustment to price shocks is an essential characteristic of the functioning of markets. Also, with a well-developed transport and storage infrastructure, regional prices differ at most by the costs of trade between those regions. Thus, an efficient market could contribute to cushioning price increasing effects of regional harvest shortfalls and prevent that prices increase beyond the world market price.

Regionally integrated markets are related through a long-run equilibrium parity, which we characterize by long-run price transmission elasticities estimated in the cointegration equation. Price transmission elasticities characterize how strongly are price shocks transmitted from one region to another. Given wheat prices P_t^1 and P_t^2 for each regional market pair, the respective long-run cointegration relationship can be expressed as follows:

$$P_t^1 = \alpha + \beta P_t^2 + \varepsilon_t \qquad (1)$$

Where P_t^1 and P_t^2 are nonstationary price series expressed in natural logarithm and ε_t denotes stationary disturbance term; α and β are interpreted as intercept and long-run price transmission elasticity, respectively, characterizing the magnitude of the transmission of price shocks from one market to another. Regression equation is estimated by the ordinary least squares method.

Usually, prices diverge from a long-run equilibrium relationship from time to time. Threshold vector error correction model (TVECM) is designed to examine how fast prices converge back to the equilibrium state in the short-run. We adopt a non-linear 3-regime TVECM with 2 thresholds developed by Greb et al. (2013) also to account for the influence of trade costs, which are highly relevant to the Russian wheat market.

A three-regime TVECM is illustrated in equation (2). The vector of dependent variables $\Delta P_t = (\Delta P_t^1,\ \Delta P_t^2)$ denotes the difference between prices in periods t and $t-1$ for both markets in question. As the independent variables, ε_{t-1}, error correction term, or alternatively, lagged residuals from equation (1) is taken to represent the price deviation from the long-run price equilibrium. Additionally, $\sum_{m=1}^{M} \Delta P_{t-m}$ term is the sum of price differences lagged by period *m* to correct residual correlation, and ω_t denotes a white-noise process with expected value $E(\omega_t) = 0$ and covariance matrix $Cov(\omega_t) = \Omega \in (\mathbb{R}^+)^{2\times 2}$.

$$\Delta P_t = \begin{cases} \rho_1 \varepsilon_{t-1} + \sum_{m=1}^{M} \Theta_{1m} \Delta P_{t-m} + \omega_t\,, & if\ \varepsilon_{t-1} \le \tau_1\ (Lower) \\ \rho_2 \varepsilon_{t-1} + \sum_{m=1}^{M} \Theta_{2m} \Delta P_{t-m} + \omega_t\,, & if\ \tau_1 < \varepsilon_{t-1} \le \tau_2\ (Middle) \\ \rho_3 \varepsilon_{t-1} + \sum_{m=1}^{M} \Theta_{3m} \Delta P_{t-m} + \omega_t\,, & if\ \tau_2 < \varepsilon_{t-1}\ (Upper) \end{cases} \quad (2)$$

The short-run dynamics are characterized by the speed of adjustment parameter (ρ_k) and the coefficients of the price differences (Θ_{km}) lagged by *m*-periods with *k* referring to a regime. All parameters may vary by regime with *k=1 … 3*.

We employ novel regularized Bayesian technique to identify estimates of threshold parameters, which govern the regime switch and restricted maximum likelihood method to estimate model variable coefficients (Greb et al., 2013).

Having completed price transmission analysis, next we combine price transmission elasticities with various market characteristics in reduced-form regression analysis to identify causes of the difference in the degree of market integration. We posit that transportation costs (approximated by distance), interregional trade flows, export orientation and trade policy measures have a significant impact on the degree of market integration.

We start to conduct econometric analysis first for the Russian markets only. For each regional market pair $i = 1, \ldots, 15$ in time $t = 2007/08, \ldots, 2011/12$ we estimate following panel data model:

$$\boldsymbol{\Psi}_i = \vartheta_0 + \vartheta_1 \boldsymbol{\mathcal{V}}_{it} + \vartheta_2 \boldsymbol{\mathcal{D}}_{it} + \vartheta_3 \boldsymbol{\mathcal{X}}_{it} + \lambda_1 \boldsymbol{T}_t + \lambda_2 \boldsymbol{\mathcal{B}}_t + \boldsymbol{\mu}_i + \boldsymbol{\xi}_{it} \quad (3)$$

Where $\boldsymbol{\Psi}_{it}$ is estimate of long-run price transmission coefficient from cointegration equation (1). $\boldsymbol{\mathcal{V}}_{it}$ and $\boldsymbol{\mathcal{D}}_{it}$ measures total interregional wheat trade and average kilometers covered by the means of railway between regions, respectively. $\boldsymbol{\mathcal{X}}_i$ takes value 1 if a region is an exporter to the world, otherwise equals to 0; and $\boldsymbol{T}_t$ and $\boldsymbol{\mathcal{B}}_t$ are indicator variables capturing the effect of policy measures on market integration in marketing years 2007/08 (export tax) and 2010/11 (export ban), respectively. $\boldsymbol{\mu}_i$ is region-specific unobserved heterogeneity.

For the sake of comparability between Russia and the USA, equation (3) is adjusted to the cross-sectional data format by fixing $\mathrm{t} = 2009/10$ when trade was freely possible in Russia and adding 63 more observations for the USA. Tobit model is fitted to the sample of $i = 1, \ldots, 78$ observations in the following reduced-from equation:

$$\boldsymbol{\Psi}_i = \vartheta_0 + \vartheta_1 \boldsymbol{\mathcal{V}}_i + \vartheta_2 \boldsymbol{\mathcal{D}}_i + \vartheta_3 \boldsymbol{\mathcal{X}}_i + \lambda_0 \boldsymbol{\mathcal{R}}_i + \lambda_1 \boldsymbol{\mathcal{V}}_i \boldsymbol{\mathcal{R}}_i + \lambda_2 \boldsymbol{\mathcal{D}}_i \boldsymbol{\mathcal{R}}_i + \lambda_3 \boldsymbol{\mathcal{X}}_i \boldsymbol{\mathcal{R}}_i + \boldsymbol{\xi}_{it} \quad (4)$$

Where $\boldsymbol{\mathcal{V}}_{it}$, $\boldsymbol{\mathcal{D}}_{it}$, and $\boldsymbol{\mathcal{X}}_i$ again have the same meaning as in (3), $\boldsymbol{\mathcal{R}}_i$ is a dummy variable that equals to 1 if a market is located in Russia**.** It is natural that we remove export policy dummies $\boldsymbol{T}_t$ and $\boldsymbol{\mathcal{B}}_t$ from equation (3). By introducing interaction terms we test conditional hypothesis that determinants of market integration have a different effect in Russia rather than in the USA.

Data and its properties

To estimate our price transmission model, we use the data set of weekly wheat prices for 6 grain producing economic regions observed for five years between 2007/08 and 2011/2012. This data is collected by the Russian Grain Union and is not publicly available. The quoted prices are paid by traders to farmers on the basis of ex-works contracts. From this database, we construct 15 market pairs in total by combining each market with all other five regional markets in Russia.

Our data set comprises regional data for regions North Caucasus, Black Earth, Central, Volga, Urals and West Siberia. The regional map is given in Figure 1. North Caucasus, Black Earth, Volga, West Siberia and Urals usually supply their production excess to other markets. Central region with capital city Moscow is the primary wheat deficit region, which heavily depends on external domestic supplies. By contrast, North Caucasus, the only region in Russia with its high-capacity sea terminals, supplies primarily to the world markets, while its role in the domestic trade is rather limited. Differing, Urals and West Siberia are far away from not only the world market, with the distance to the Black Sea ports amounting up to 4000 km, but also the grain consumption regions within Russia. In particular, Moscow is about 2000-3000 km apart. Due to outdated and insufficient transport infrastructure, Urals and West Siberia are not well connected neither world market nor the consumption centres.

To run comparisons with the USA, we employ weekly corn prices for 16 states observed between marketing years 2008/09 and 2010/11 (source: USDA, 2016). Overall, this dataset generates 63 market pairs, which re construct by pairing 7 markets from the major producing ‘Corn Belt’ area states with the other 9 markets mostly from net-consumer states.

Given that wheat markets in Russia were highly turbulent over the recent decade, we notice that the regional price relationships are not stable, but rather differ from marketing year to marketing year. For example, the price of North Caucasus is in some period higher and in other periods lower than in the other regions. Also, the interregional trade flows are highly volatile. This implies that the interregional price relationships, which are depicted in the price transmission model, are highly unstable, and thus parameter estimates may also not be constant. To tackle this issue, we estimate the price transmission model based only on one marketing year sample which is characterized by relatively stable price relationships. There is no need for such treatment for the USA price series.

Before we begin with the price transmission analysis we test the properties of our data series. In particular, we apply Augmented Dickey-Fuller test (Dickey and Fuller, 1981) to confirm non-stationary nature of individual price series (results, not reported here, entirely agree with the test hypothesis). Once we accomplish this exercise, next step is to examine if prices are cointegrated, i.e. if long-run relationship between them can be established. We apply three cointegration tests to explore linear (Johansen, 1988) and threshold cointegration (Hansen and Seo, 2002; Larsen, 2012). Test results (not reported here to save space) indicate that in the majority of the cases cointegration is confirmed. In addition, number of non-linearly cointegrated market pairs significantly exceeds the total number of linearly cointegrated ones. We consider this result as a strong evidence for the existence of threshold effects. We explicitly account for threshold effects in the price transmission analysis by choosing a 3-regime-TVECM for our analysis of price transmission between regional wheat markets in Russia and in comparison with the USA.

In addition, to account for market characteristics, we supplement our dataset with the weekly amounts of grains transported by train between all grain producing regions of Russia as a measure for interregional grain trade flows (source: Rosstat, 2014). From the same dataset we calculate quantity weighted kilometers between two paired regions to account for the distance. Equivalent state-level data for the USA is extracted from Carload Waybill Samples (Source: Surface Transportation Board, 2016).

3 Results

Parameters of the long-run price equilibrium regression

In this section, we discuss estimation results of price transmission analysis for Russia for the marketing year 2009/10, when trade was freely possible, and in the marketing year 2010/11, when Russian government imposed export ban. Table 1 presents the parameter estimates of the long-run price equilibrium regression. For the marketing year 2009/10 results suggest that the long-run price transmission parameter decreases and the intercept parameter increases with increasing distance between the regions. This corresponds with the Law of One Price according to which markets are perfectly integrated if the intercept of the long-run price equilibrium is equal to zero and the slope parameter is equal to one.

In particular, long-run price transmission is strongest between the neighbouring regions Central and Black Earth (0.940) and lowest between North Caucasus and West Siberia (0.132), the two grain producing regions which are the most distant to each other. Our results also suggest that North Caucasus is the least integrated with the other grain producing regions of Russia. North Caucasus is the only major grain producing region with direct access to the world grain market. Thus, different to the other grain producing regions, North Caucasus is also strongly influenced by the world market conditions explaining its rather low integration in the Russian regional grain markets.

For the marketing year 2010/11, when several regions experienced severe droughts and exports to the world market were forbidden by an export ban, the slope coefficient increases and the intercept parameter decreases compared to 2009/10 for 13 out of the 15 price pairs. Obviously, the domestic Russian grain market is characterized by stronger market integration during the export ban.

Estimated parameters of the TVECM

Selected parameters of the 3-regime TVECM, which is estimated for the 15 market pairs separately for the marketing years 2009/10 and 2010/11 are presented in Tables 2a and Table 2b. It becomes evident that the vast majority of observations are attributed to the middle regime for 12 out of 15 regional price pairs in 2009/10. This means that the error correction term between regional market pairs is usually smaller than the absolute value of the lower and upper threshold, providing evidence for strong market integration. In 2010/11 the number of market pairs for which the majority of observations lays in the middle regime increases to 14 out of the 15 market pairs. This can be interpreted as evidence of the strengthened integration of regional markets during the export ban.

Another attribute to characterize market integration is the size of the band of inaction, difference between the absolute value of the upper and lower threshold. The average size of the band of inaction is significantly lower in the marketing year 2009/10 amounting to 0.07 compared to the marketing year 2010/11 amounting to 0.12. This can be explained by the increase of the size of thresholds, which are proxy for the transaction costs. These results suggest that interregional trade costs increased in 2010/11 compared to 2009/10. Information provided by the Russian Grain Union confirms these results. First, the railway transport costs were increased by 10% by the government in 2010/11 compared to 2009/10. Further, the destinations of interregional grain trade flows changed during the export ban and grain trade flows were even reversed. Traders had to extend their business to other regions and could not make use of their established business contacts. Thus, transaction costs of trade increased strongly by increasing trade risk associated with a high level of fraud and high risk of contract enforcement.

The influence of distance is also reflected in the size of the regime-specific speed of adjustment parameters. We find 8 price pairs for 2009/10 and 12 price pairs for 2010/11 out of the 15 price pairs each for which the speed of adjustment parameters and the total adjustment is higher in at least one of the outer regimes (lower and upper regime) compared to the middle regime. This confirms the theory underlying threshold models applied in spatial price transmission, according to which the speed at which deviations from the long-run price equilibrium are corrected, is higher if the price deviations exceed the thresholds. The regime-specific speed of adjustment parameters are increasing for at least one regime in 13 out of 15 cases in 2010/11 compared to 2009/10, confirming once again that the integration of the regional wheat markets was strengthened during the export ban.

Comparison with the corn market in the USA

To assess how well the regional wheat markets functions in Russia, we conduct an analysis of the integration of the corn markets in the main grain producing regions of the USA. In general, compared to Russia, transportation logistics function more efficiently and delivery costs are much lower in the USA.

We depict all comparisons concerning the price transmission analysis on the different panels of Figure 2. For the sake of comparability, we consider results of price transmission analysis for Russian markets in the marketing year 2009/10 to compare it with the USA. Box-plot of long-run price transmission elasticities on Panel a, Figure 2 shows that price transmission is typically lower in Russia compared to the USA. Median coefficient is 0.43 in Russia and 0.93 in the USA, respectively. In addition, price transmission coefficients are more heterogeneous ranging between 0.13 and 0.97 in Russia, while it has modest variation in the USA changing from 0.72 to 1.10.

Further, eliminating of short-run price disequilibrium is more time-consuming in Russia compared with the USA (Panel b). In terms of median values, markets in the USA eliminate 27% of any disequilibrium in one week, while just 21% is corrected in Russia. For comparison, maximum observed speed of adjustment in the USA is 0.72 between California and Iowa, the leading consumption centre and the largest production region, respectively. Whereas the highest speed of adjustment in Russia (0.38) is obtained between two neighbouring regions Central and Black Earth, which is the main supplier of wheat to Moscow in Central region.

A similar pattern is observed when comparing threshold estimates between Russian and the USA price pairs (Panel c). Even though median values are very similar (0.06 in Russia and 0.056 in USA) difference in the spread of threshold values are much more noticeable for Russia. Band of inaction values are higher and range in between 0.01 and 0.11 in Russia, whereas it varies from 0.005 to 0.09 in the USA.

Determinants of market integration

Results of a formal analysis of market characteristics are given in Table 3. First we discuss how those characteristics influence market integration only in the Russian wheat markets. We use random effects estimator to estimate panel data model as Hausman specification test (1978) favours the use of random effects over fixed effects estimation.

The results show that markets which are enrolled into the intensive trade with each other tend to be more integrated than markets which lack such linkages. In particular, increase in railway traded wheat volumes by 100 thousand tonnes is associated with the 2% increase in long-run price transmission parameter.

The estimations also show that closer markets are more strongly integrated than markets that are far away from each other. For instance, if we consider capital city Moscow as a point of reference and compare two markets in terms of proximity to Moscow, then the one which is located 1000 km closer to the capital city will show greater magnitude of price transmission by 0.06 points than another market which is more distant from Moscow.

As expected, exporting region North Caucasus, which accounts for the lion's share of total Russian wheat export, demonstrates very low level of market integration (on average by 27%, i.e. 0.27 points) compared to other regions in Russia. Since North Caucasus is greatly influenced by world market conditions, it is expected that prices will follow less to regional market developments in Russia.

Further, estimates of export policy measures generally confirm their effectiveness in terms of enforcing regional market integration. An increase in price transmission parameter by 0.13 points in 2010/11 could be attributed to the implementation of export ban. Similarly, prohibitive export tax policy also proved to have significant and positive impact on market integration. Particularly, regional markets reported higher integration by 0.22 points during marketing year 2007/08. This can be explained by the decrease of influence of the world market conditions on domestic price formation particularly in those regions, which are usually involved in grain export to the world market. Thus, the influence of the common domestic factors increases, particularly in the export-oriented regions which strengthens their integration in the domestic market.

Next, comparing Russian regional markets with the USA, Tobit model estimation in Table 3 shows that, regional wheat markets in Russia overall are not as well-integrated as in the USA. Intercept term, accounting for country effects, suggests that regional price transmission is lower by 17% in Russia compared to the USA. Lower integration of wheat markets in Russia parallels fundamental differences between Russia and the USA that exist due to the different market structures and efficiency to function their grain markets.

Though interregional grain trade still positively contributes to enforcing market integration in Russia (coefficient is 0.03), parameter estimate on traded volumes in the USA is highly statistically insignificant, suggesting that we cannot reject the hypothesis that physical trade does not have an important role in enforcing market integration in the USA. We consider this result in favour with the idea that information flows are more important for market integration in the USA than in Russia, where wheat market participants in general lack a practice in using modern technologies to get information on alternative market opportunities throughout the country and beyond.

Yet again, distance has negative influence on market integration in both countries, but its impact is more pronounced in Russia compared to the USA. More concretely, increase of distance between markets by 1000 km translates into decreased price transmission coefficient by 0.14 points in Russia and 0.10 points in the USA, respectively. This finding echoes the core aspect of the Law of One price according to which transportation costs play a central role in examining whether market prices follow an interrelated pattern of dynamics.

Further, if a region exports to the world markets in the USA, this strengthens integration of that region with the other domestic markets by 7%. We interpret this result as an indicator that in the USA, market participants use price information from exporting regions as a reference to negotiate their own trade transactions. However, the effect is opposite and much stronger in Russia (estimated coefficient is -0.36). If a market, such as North Caucasus, exports to the world this leads higher isolation of that exporting region from domestic price developments compared to other regions that do not have access to the world markets.

4 Conclusions

In this paper we have investigated the regional price relationships between the primary grain production regions of Russia to assess the efficiency of the Russian wheat market and have compared them to results for the corn market of the USA.

In general, the results of the price transmission analysis for Russia demonstrate high variation in the level of market integration across regions. Price pairs involving North Caucasus, exporting region with direct access to the world markets, are characterized by particularly low long-run price transmission elasticity, speed of adjustment parameters and total adjustment, demonstrating that the influence of the world market price is strongest in the exporting region North Caucasus, which reduces its regional integration in the Russian wheat market.

In a large country like Russia, distance between the grain producing regions has strong influence on their price relationships. In particular, the band of inaction and the upper and the lower threshold increase with distance between the regions of the price pairs, whereas the long-run price transmission elasticity, the speed of adjustment parameter and the total adjustment decrease with distance. The speed of adjustment parameters and total adjustment are highest for neighbouring regions.

Our results suggest that the integration of the regional wheat markets strengthened during the wheat export ban in 2010/11. In particular, price transmission elasticities and regime-specific speed of adjustment parameters increased in 2010/11 compared to 2009/10 for many price-pairs. Further, we find that the size of thresholds and the band of inaction increasing in 2010/11 compared to 2009/10. We trace this back to increasing transport costs and also increasing trade risk of interregional grain transactions. The increasing trade risks results from the change in export destinations requiring to involve new trade partners. These results confirm that in general the risk of business is particularly high in Russia due to a high degree of fraud and the difficulties to enforce contracts.

The comparison of the long-run price transmission parameter of the Russian wheat market with the results for the corn market of the USA makes evident that price transmission heterogeneity is substantially higher in Russia compared to the USA. Furthermore, TVECM estimations show that thresholds are larger in Russia and price deviations are more quickly eliminated in the USA.

Our results on the determinants of market integration suggest that export tax 2007/08 and export ban in 2010/11 clearly increased domestic market integration through isolating domestic markets from the influence of the world markets. Results also show that physical trade contributes to increased market integration in Russia, but its influence is insignificant for the USA. Alternatively, due to the presence of higher trade costs more distant markets are more likely to have lower magnitude of price transmission than closer markets in both countries, but this impact is much stronger in Russia. Findings on how exporting regions are integrated with regional markets again confirm that export-oriented region North Caucasus is less strongly integrated with domestic markets in Russia, whereas it has opposite effect in the USA.

Our study offers several important implications in terms of trade policy and food security. First, strengthening market integration between the grain production regions could contribute to decrease price volatility within the regions of Russia. If price signals were faster transmitted from deficit to surplus regions, and the transaction costs of trade were decreased, incentives for interregional trade from surplus to the actual deficit regions would be strengthened and contribute to cushion the price increasing effects of regional production shortfalls. This in turn would reduce the incentives for the government to implement export controls on grain market which in the long-run strongly negatively affect the further development of the grain sector.

5 References

Dickey, D. A., and Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica*, 49 (4): 1057-1072.

Fackler, P. and Goodwin, B. (2001). Spatial price analysis. In Gardner, B., Rausser, G. (eds), *Handbook of Agricultural Economics*. Amsterdam: Elsevier, 971-1024.

Götz, L., Djuric, I. and Nivievskyi, O. (2016). Regional price effects of extreme weather events and wheat export controls in Russia and Ukraine. *Journal of Agricultural Economics*, 67 (3): 741-763.

Greb, F., von Cramon-Taubadel, S., Krivobokova, T. and Munk, A. (2013). The estimation of threshold models in price transmission analysis. *American Journal of Agricultural Economics*, 95 (4): 900–916.

Hansen, B. and Seo, B. (2002). Testing for two-regime threshold co-integration in vector error-correction models. *Journal of Econometrics*, 110 (2): 293–318.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12 (2-3): 231-254.

Larsen, B. (2012). *A Threshold Cointegration Analysis of Norwegian Interest Rates*. Master Thesis, University of Tromsø.

Lioubimtseva, E. and Henebry, G. (2012). Grain production trends in Russia, Ukraine and Kazakhstan: New opportunities in an increasingly unstable world? *G.M. Front. Earth Sci*. 6 (2): 157–166.

Rosstat (2014). Federal State Statistics Service, www.gks.ru

Surface Transportation Board (2016). Carload Waybill Samples, www.stb.gov

United States Department of Agriculture (2016). Agricultural Marketing Service, ww.marketnews.usda.gov

6 Appendix

Figure 1: Map of economic regions in the Russian Federation

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Table 1: Parameters of the long-run price equilibrium regression, OLS estimation, 2009/10 and 2010/11

Price pairs			**Slope parameter**			**Intercept parameter**	
Dependent variable	**Independent variable**	**Distance (km)**	**2009/10**	**2010/11**	**% change**	**2009/10**	**2010/11**
Central	**Black Earth**	526	0.940	0.917	-2	0.519	0.733
Central	**Volga**	801	0.698	0.824	18	2.525	1.538
Central	**Urals**	2044	0.432	0.670	55	4.699	2.590
Central	**West Siberia**	3346	0.358	0.589	65	5.346	3.654
North Caucasus	**Black Earth**	870	0.333	0.573	72	5.672	3.646
North Caucasus	**Central**	1300	0.346	0.642	86	5.557	3.037
North Caucasus	**Volga**	1708	0.267	0.543	103	6.225	3.896
North Caucasus	**Urals**	2682	0.156	0.443	184	7.132	4.752
North Caucasus	**West Siberia**	3984	0.132	0.392	197	7.340	5.262
Black Earth	**Volga**	1035	0.740	0.890	20	2.153	0.959
Black Earth	**Urals**	2027	0.469	0.760	62	4.366	2.052
Black Earth	**West Siberia**	3329	0.388	0.636	64	5.071	3.248
Volga	**Urals**	1235	0.677	0.844	25	2.645	1.326
Volga	**West Siberia**	2537	0.571	0.717	26	3.575	2.553
Urals	**West Siberia**	1310	0.833	0.834	0	1.452	1.590

Note: All parameters are significant at a level lower than 1%.
Source: Own estimations.

Table 2a: Results of TVECM, 2009/10

	Price pair	**Lower regime**			**Middle regime**			**Upper regime**		**Total adjustment [Number of obs.]**			
	Dependent – indep. variable	ρ_1	**[Pvalue]**	**Lower Thresh.**	ρ_2	**[Pvalue]**	**Upper Thresh.**	ρ_3	**[Pvalue]**	**Lower**	**Middle**	**Upper**	**Band of inaction**
1	**Central - Black Earth**	-0.212	[0.360]	**-0.021**	-0.208	[0.336]	**0.018**	**-0.353**	[0.089]	**0.340**	**0.364**	**0.733**	**0.039**
	Black Earth - Central	**0.340**	[0.072]		**0.364**	[0.035]		**0.380**	[0.015]	[7]	[40]	[1]	
2	**Central - Volga**	-0.100	[0.291]	**-0.013**	-0.207	[0.337]	**0.003**	-0.147	[0.168]	**-**	**-**	**-**	**0.016**
	Volga - Central	0.121	[0.264]		-0.180	[0.408]		-0.081	[0.494]	[17]	[12]	[19]	
3	**Central -Urals**	-0.029	[0.757]	**-0.047**	-0.149	[0.259]	**0.029**	**-0.173**	[0.030]	**0.310**	**-**	**0.173**	**0.076**
	Urals - Central	**0.310**	[0.004]		0.179	[0.214]		0.100	[0.233]	[17]	[18]	[13]	
4	**Central - West Siberia**	-0.039	[0.646]	**-0.062**	-0.102	[0.311]	**0.021**	**-0.166**	[0.014]	**0.260**	**-**	**0.166**	**0.083**
	West Siberia - Central	**0.260**	[0.041]		0.082	[0.574]		-0.005	[0.955]	[12]	[17]	[19]	
5	**North Caucasus - Black Earth**	**-0.207**	[0.041]	**-0.021**	**-0.207**	[0.041]	**0.020**	**-0.207**	[0.041]	**0.207**	**0.207**	**0.207**	**0.041**
	Black Earth - North Caucasus	-0.018	[0.809]		-0.018	[0.809]		-0.018	[0.809]	[14]	[16]	[18]	
6	**North Caucasus - Central**	**-0.300**	[0.025]	**-0.030**	**-0.216**	[0.088]	**0.020**	-0.168	[0.136]	**0.300**	**0.216**	**-**	**0.050**
	Central - North Caucasus	**-0.152**	[0.187]		0.114	[0.299]		-0.031	[0.744]	[7]	[24]	[16]	
7	**North Caucasus - Volga**	**-0.167**	[0.078]	**-0.038**	-0.177	[0.136]	**0.012**	**-0.153**	[0.060]	**0.167**	**-**	**0.153**	**0.050**
	Volga - North Caucasus	-0.107	[0.276]		-0.074	[0.569]		-0.091	[0.328]	[4]	[26]	[18]	
8	**North Caucasus - Urals**	0.041	[0.684]	**-0.036**	-0.029	[0.820]	**0.024**	-0.064	[0.379]	**-**	**-**	**-**	**0.060**
	Urals - North Caucasus	0.176	[0.132]		0.154	[0.284]		0.081	[0.360]	[11]	[21]	[16]	
9	**North Caucasus - West Siberia**	-0.116	[0.146]	**-0.049**	**-0.125**	[0.036]	**0.029**	**-0.125**	[0.036]	**-**	**0.125**	**0.125**	**0.078**
	West Siberia - North Caucasus	-0.010	[0.926]		0.057	[0.573]		0.057	[0.573]	[6]	[29]	[13]	
10	**Black Earth - Volga**	**-0.094**	[0.086]	**-0.046**	**-0.146**	[0.052]	**0.011**	**-0.094**	[0.086]	**0.094**	**0.146**	**0.094**	**0.057**
	Volga - Black Earth	0.022	[0.781]		-0.003	[0.979]		0.022	[0.781]	[8]	[26]	[14]	
11	**Black Earth - Urals**	0.063	[0.318]	**-0.059**	0.063	[0.318]	**0.031**	0.005	[0.928]	**0.295**	**0.295**	**0.193**	**0.090**
	Urals - Black Earth	**0.295**	[<0.001]		**0.295**	[<0.001]		**0.193**	[0.016]	[10]	[28]	[10]	
12	**Black Earth - West Siberia**	-0.007	[0.898]	**-0.087**	-0.069	[0.208]	**0.025**	-0.049	[0.375]	**-**	**-**	**-**	**0.112**
	West Siberia - Black Earth	0.106	[0.229]		0.015	[0.859]		0.016	[0.849]	[6]	[26]	[16]	
13	**Volga - Urals**	-0.160	[0.203]	**-0.058**	-0.019	[0.858]	**0.038**	**-0.297**	[0.014]	**0.210**	**0.200**	**0.297**	**0.096**
	Urals - Volga	**0.210**	[0.067]		**0.200**	[0.043]		0.120	[0.245]	[8]	[33]	[7]	
14	**Volga - West Siberia**	-0.141	[0.274]	**-0.056**	**-0.201**	[0.035]	**0.035**	**-0.288**	[0.004]	**-**	**0.201**	**0.288**	**0.091**
	West Siberia - Volga	0.216	[0.125]		0.098	[0.228]		-0.026	[0.763]	[4]	[38]	[6]	
15	**Urals - West Siberia**	**-0.206**	[0.072]	**-0.027**	-0.186	[0.183]	**0.012**	-0.206	[0.141]	**0.206**	**-**	**-**	**0.039**
	West Siberia - Urals	0.213	[0.157]		0.167	[0.324]		0.011	[0.951]	[11]	[22]	[15]	

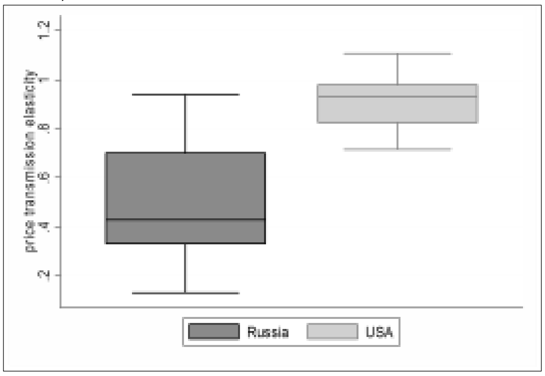
Table 2b: Results of TVECM, 2010/11

	Price pair	Lower regime			Middle regime			Upper regime		Total adjustment [Number of obs.]			
	Dependent – indep. variable	ρ_1	**[Pvalue]**	**Lower Thresh.**	ρ_2	**[Pvalue]**	**Upper Thresh.**	ρ_3	**[Pvalue]**	**Lower**	**Middle**	**Upper**	**Band of inaction**
1	**Central - Black Earth**	0.018	[0.964]	**-0.022**	**-0.437**	[0.096]	**0.014**	-0.272	[0.369]	**0.587**	**0.437**	**-**	**0.036**
	Black Earth - Central	**0.587**	[0.098]		0.022	[0.915]		0.301	[0.243]	[6]	[36]	[6]	
2	**Central - Volga**	**-0.690**	[0.005]	**-0.018**	-0.290	[0.161]	**0.008**	-0.168	[0.334]	**0.690**	**-**	**-**	**0.026**
	Volga - Central	-0.142	[0.568]		0.117	[0.566]		0.178	[0.292]	[8]	[27]	[13]	
3	**Central -Urals**	**-0.457**	[<0.001]	**-0.095**	0.042	[0.524]	**0.058**	-0.039	[0.826]	**0.457**	**-**	**0.304**	**0.153**
	Urals - Central	-0.017	[0.873]		0.084	[0.171]		**0.304**	[0.078]	[3]	[41]	[4]	
4	**Central -West Siberia**	**-0.329**	[0.007]	**-0.105**	**0.118**	[0.061]	**0.054**	0.158	[0.131]	**0.329**	**-0.118**	**0.274**	**0.159**
	West Siberia - Central	0.040	[0.772]		0.028	[0.764]		**0.274**	[0.042]	[3]	[38]	[7]	
5	**North Caucasus - Black Earth**	**-0.244**	[0.054]	**-0.090**	**-0.264**	[0.035]	**0.038**	-0.217	[0.121]	**0.244**	**0.264**	**-**	**0.128**
	Black Earth - North Caucasus	-0.014	[0.846]		-0.075	[0.171]		0.008	[0.921]	[2]	[38]	[8]	
6	**North Caucasus - Central**	**-0.239**	[0.010]	**-0.032**	-0.385	[0.397]	**0.004**	**-0.242**	[0.009]	**0.129**	**-**	**0.129**	**0.036**
	Central - North Caucasus	**-0.110**	[0.094]		0.308	[0.154]		**-0.113**	[0.089]	[16]	[14]	[18]	
7	**North Caucasus - Volga**	**-0.308**	[0.049]	**-0.046**	**-0.315**	[0.075]	**0.007**	**-0.260**	[0.066]	**0.054**	**0.315**	**0.103**	**0.053**
	Volga - North Caucasus	**-0.254**	[0.009]		0.033	[0.748]		**-0.157**	[0.042]	[10]	[23]	[15]	
8	**North Caucasus - Urals**	**-0.323**	[0.002]	**-0.099**	**-0.323**	[0.002]	**0.085**	**-0.328**	[0.098]	**0.323**	**0.323**	**0.328**	**0.184**
	Urals - North Caucasus	-0.036	[0.365]		-0.036	[0.365]		-0.149	[0.210]	[4]	[40]	[4]	
9	**North Caucasus - West Siberia**	**-0.381**	[<0.001]	**-0.053**	**-0.370**	[0.011]	**0.038**	**-0.453**	[0.003]	**0.381**	**0.370**	**0.453**	**0.091**
	West Siberia - North Caucasus	-0.048	[0.536]		0.013	[0.921]		-0.134	[0.335]	[10]	[29]	[9]	
10	**Black Earth - Volga**	-0.139	[0.371]	**-0.029**	-0.139	[0.404]	**0.008**	-0.126	[0.401]	**-**	**-**	**-**	**0.037**
	Volga - Black Earth	0.012	[0.948]		-0.056	[0.766]		-0.008	[0.963]	[6]	[22]	[20]	
11	**Black Earth - Urals**	**-0.271**	[0.011]	**-0.103**	0.020	[0.780]	**0.076**	**-0.322**	[0.003]	**0.271**	**-**	**0.322**	**0.179**
	Urals - Black Earth	-0.063	[0.500]		0.039	[0.518]		-0.123	[0.184]	[2]	[44]	[2]	
12	**Black Earth - West Siberia**	**-0.246**	[0.008]	**-0.107**	0.041	[0.430]	**0.071**	-0.063	[0.657]	**0.246**	**-**	**-**	**0.178**
	West Siberia - Black Earth	-0.150	[0.186]		0.104	[0.126]		0.003	[0.984]	[2]	[44]	[2]	
13	**Volga - Urals**	**-0.194**	[0.027]	**-0.107**	-0.092	[0.163]	**0.069**	**-0.225**	[0.027]	**0.194**	**-**	**0.225**	**0.176**
	Urals - Volga	-0.018	[0.812]		0.015	[0.791]		-0.043	[0.624]	[2]	[43]	[3]	
14	**Volga - West Siberia**	-0.104	[0.170]	**-0.105**	0.041	[0.529]	**0.046**	0.105	[0.439]	**-**	**-**	**0.418**	**0.151**
	West Siberia - Volga	0.032	[0.679]		0.061	[0.376]		**0.418**	[0.005]	[4]	[37]	[7]	
15	**Urals - West Siberia**	0.053	[0.513]	**-0.061**	0.039	[0.619]	**0.029**	0.039	[0.619]	**0.318**	**0.300**	**0.300**	**0.090**
	West Siberia - Urals	**0.318**	[0.012]		**0.300**	[0.020]		**0.300**	[0.020]	[3]	[36]	[9]	

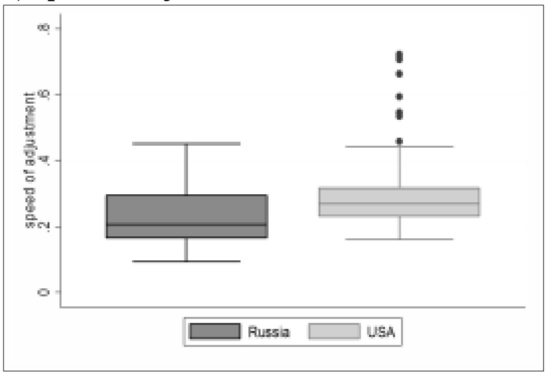
Note: Total adjustment in one regime is calculated as the sum of the absolute value of the respective regime-specific speed of adjustment parameters of the TVECM. The band of inaction is given as the difference between the absolute value of the upper and lower threshold.
Source: Own estimations.

Figure 2: Boxplot comparisons of estimated cointegration model and TVECM parameters in Russia 2009/10 and the USA 2008/11

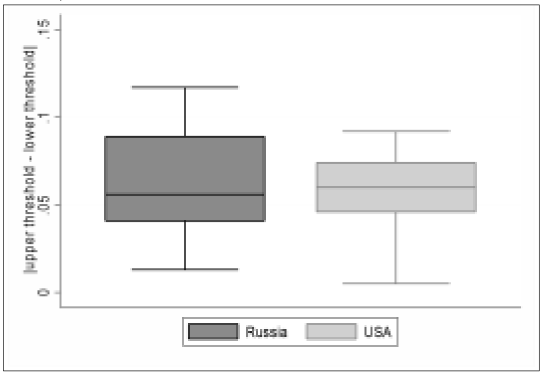
a) Price transmission elasticities



b) Speed of adjustment



c) Band of inaction



Source: Own estimations.

Table 3: Random effects linear multivariate and Tobit regression results: analysis of the determinants of market integration

	Random Effects model		Tobit model			
	Russia		Russia		USA	
Independent variables	**Coef.**	**b. SE**	**Coef.**	**b. SE**	**Coef.**	**b. SE**
Traded volume *(100 thousand tonnes)*	0.021**	0.010	0.032***	0.007	-0.001	0.001
Distance *(100 km)*	-0.006*	0.004	-0.014***	0.003	-0.010***	0.001
Exporter *(to the world markets)*	-0.270***	0.066	-0.363***	0.040	0.073***	0.015
Export ban *(year 2010/11)*	0.133***	0.047				
Export tax *(year 2007/08)*	0.223**	0.052				
Constant	0.718***	0.076	0.826***	0.062	0.999***	0.016
Observations	61		78			
F-test (8, 70)			3486.54*** (Prob > F = 0.000)			
Wald $\chi^2(5)$	57.40***	(Prob >χ^2=0.000)				
Breusch-Pagan LM test	4.51	(Prob >χ^2=0.034)				
LR test of homoscedasticity $\chi^2(14)$	26.51	(Prob >χ^2=0.022)				
Hausman $\chi^2(4)$	0.28	(Prob >χ^2=0.991)				
$\hat{\sigma}_v$	0.15					
$\hat{\sigma}_u$	0.09					

Note: *, **, *** indicate statistical significance at 10, 5 and 1%, respectively. b. SE is bootstrap standard error.
Source: Own estimations.