HOW WELL IS THE RUSSIAN WHEAT MARKET FUNCTIONING? A COMPARISON WITH THE CORN MARKET IN THE USA

Miranda Svanidze, Linde Götz

Svanidze@iamo.de

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany

2017

Paper prepared for presentation at the 57th annual conference of the GEWISOLA (German Association of Agricultural Economists) and the 27th annual conference of the ÖGA (Austrian Society of Economics) "Bridging the Gap between Resource Efficiency and Society's Expectations in the Agricultural and Food Economy" Munich, Germany, September 13 – 15, 2017

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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 and distance 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, grain markets, Russia, USA, export ban.

1 Introduction

In recent years Russia has advanced from a grain importing country to one of the primary grain exporting countries. In 2016/17 Russia is forecasted to become the largest wheat exporter in the world (Interfax 2016).

Russia could further boost its grain production by increasing production efficiency and also by re-cultivating formerly abandoned agricultural land. According to OECD/FAO (2012) global grain production needs to increase by 30% to satisfy global demand for cereals which will reach 3 billion tons by 2050. Russia could play a large role for future global food security (Lioubimtseva and Henebry, 2012). This requires not only Russia's large additional grain production potential to be mobilized but also that grain markets are functioning well enabling that the grain exporting potential is mobilized as well.

This study aims to address the research question how well the Russian grain market is functioning, a question which has not been addressed in the literature before. Following a price transmission approach we are focusing on the primary grain producing regions and investigate the integration of the regional grain markets. To what degree and how fast are price shocks in one region transmitted to the other regions?

This is an important question 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. Favourable production conditions and thus relatively high yields can be observed in some regions but relatively low yields in other regions at the same time. Therefore, 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.

In a well-functioning, efficient market, with a well-developed transport and storage infrastructure, regional prices differ at most by the costs of trade between those regions. Also, 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). Thus, an efficient market could also contribute to cushioning price increasing effects of regional harvest shortfalls and prevent that prices increase beyond the world market price.

However, Russia has a history of restricting the exports of wheat to the world market when domestic wheat prices peak. 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. This is an addition to Götz et al. 2013, 2016 which focus on the export controls' effects on the integration in the world market.

We address both research questions in a price transmission framework. We apply a threshold vector error-correction model (TVECM) to explicitly account for the influence of distance and use a Bayesian estimator suggested by Greb et al. (2013) as an alternative to the conventional maximum likelihood approach (Hansen and Seo, 2002; Lo and Zivot, 2001).

Highly integrated markets characterized by strong price relationships with fast transmission of price changes between the regions are usually interpreted as evidence for well-functioning markets. However, the Russian wheat market is characterized by extremely large distances of up to 4000 km which certainly negatively affects market integration.

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.

The remainder of this paper is organized as follows. In the next section, we discuss market conditions and the consequences of the export ban 2010/11 for wheat trade in Russia. This is followed by the review of major literature sources. The detailed presentation of econometric model is given in the section on methodology and estimation. Data section 5 focuses on the properties and preliminary assessment of time series used in analysis. In the results section6, we discuss outcomes of model estimation. The results for the Russian wheat market are compared to the results for the corn market of the USA presented in section 7. In the final section 8, concluding remarks are given.

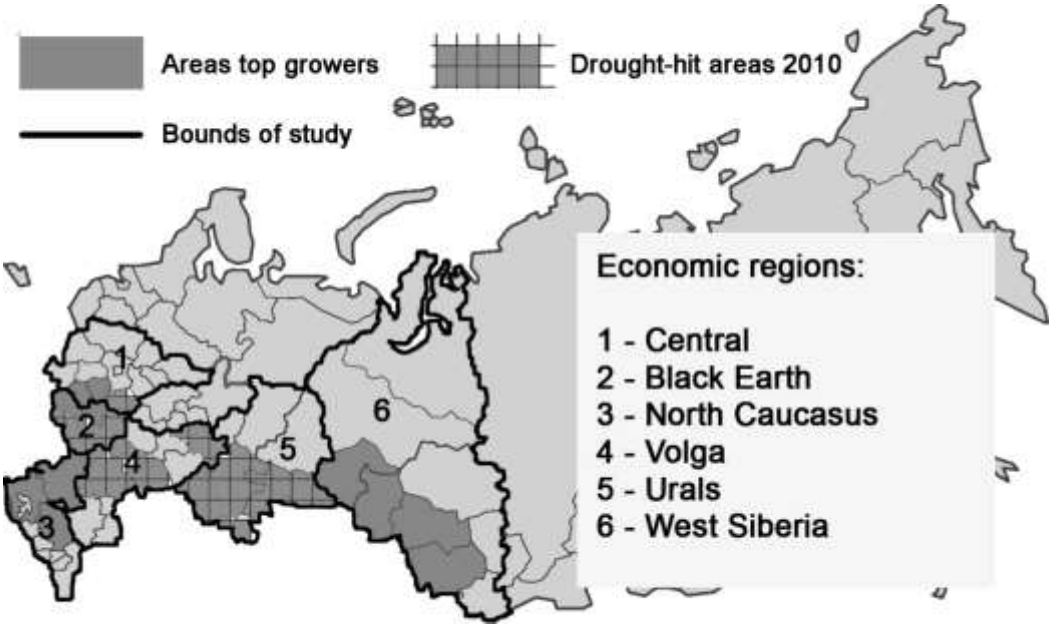
2 Characteristics of the Russian wheat markets

2.1 Regional wheat production and harvest shortfall

Wheat production in Russia is concentrated on a limited, yet spatially protracted area. Two large regional production clusters emerge depending on both the type of culture and the area of cultivation. The winter wheat cluster covers Southwest of Russia stretching from the Black Sea to Volga. Yields in this area amount to 3 tons per hectare on average (2006-2010). The spring wheat cluster spans over Urals and West Siberia. In contrast to winter wheat, spring wheat is much less productive with yields amounting to 1.7 tons per hectare on average (2006-2010).

During the last decade, 2010 marks as the year when Russian grain markets witnessed exeptionally low production. Drought in 2010 affected the key crop growing areas in Russia (Figure 1), whcih resulted in the unusually low harvest and export-respricting policies by the government.

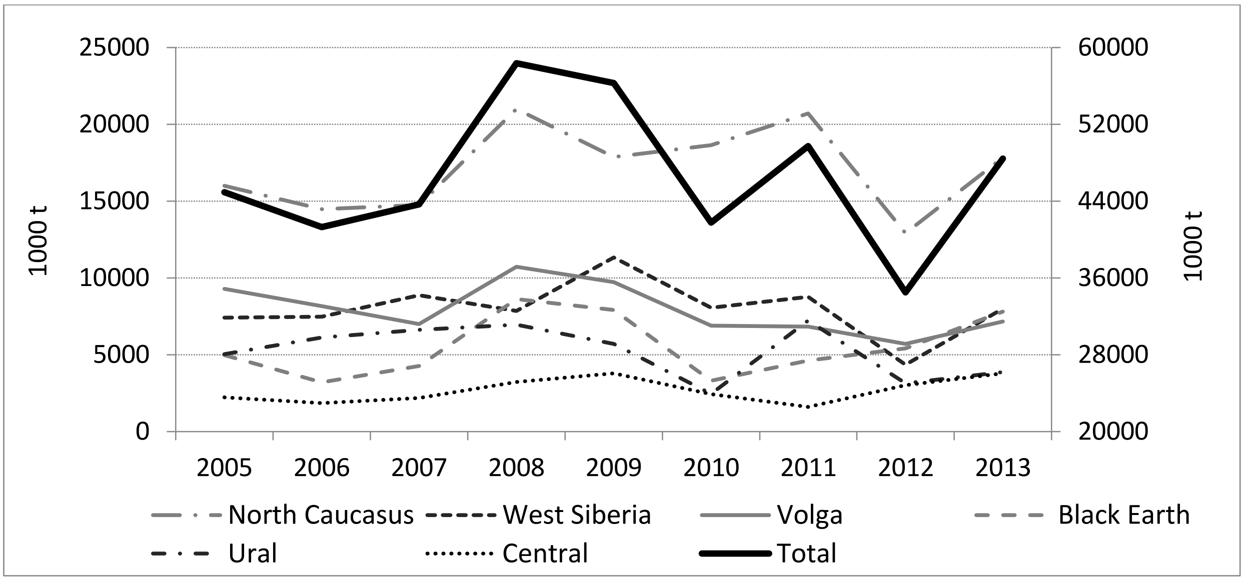
Figure 1. Map of crop-growing regions affected by drought in 2010



Source: Own illustration.

In general, the size of wheat production in the major grain production regions differs strongly. As can be seen from Figure 2, wheat production is highest in North Caucasus, with an annual production varying between 12 and 22 million tons in the period 2005-2013. This is followed by Volga and West Siberia (with wheat production varying between 4 and 11 million tons in each region), Black Earth (between 3 to 9 million tons), Urals (between 2 to7 million tons) and Central (2-4 million).

Figure 2. Regional wheat production development in Russia



Source: Götz et al. 2016

In addition, the variation of wheat production within a region is also extremely high. Table 1 gives regional wheat production as the average of wheat production in the previous three years. It becomes evident that for example in the Volga region, wheat production varied between 34% and 143% in the marketing years 2005/6 to 2012/13. Weather conditions are a key determinant of the quantity of wheat production. Due to large distances, the production regions are affected by different climatic and weather conditions.

Table 1: Regional wheat production developments Russia (2005-2013), in % of the average of previous 3 years

	2005/6	2006/07	2007/08	2008/9	2009/10	2010/11	2011/12	2012/13
North Caucasus	126	112	98	139	107	104	108	68
Central	109	100	117	160	159	81	79	97
Black Earth	120	97	117	187	136	46	86	96
Volga	112	103	98	143	109	34	81	84
West Siberia	93	98	114	99	140	86	96	46
Ural	91	118	125	117	87	38	144	61

Source: Götz et al. 2016

This implies that favorable production conditions and thus relatively high yields might be observed in some regions but relatively low yields in other regions at the same time. For example, grain production was even by 4% above average in North Caucasus in the marketing year 2010/11, whereas the regions Volga, Urals and Black Earth were severely hit by the drought with grain production 66%, 62% and 54% below average, respectively.

2.2 Regional wheat trade and transportation costs

The Russian wheat producing regions can be classified into surplus and deficit areas. The former includes North Caucasus, Black Earth, Volga, West Siberia and Urals, which usually supply their production excess to other markets. Central region with Moscow is the primary wheat deficit region, which heavily depends on external supplies. Central mostly imports wheat domestically from the regions Black Earth, Volga, Urals and West Siberia. By contrast, North Caucasus supplies primarily to the world markets, while its role in the domestic trade is rather limited. Due to the presence of high-capacity sea terminals, North Caucasus also serves as a gate-market for the other grain producing regions, particularly Volga and Black Earth, to export wheat to the world market. 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 centers.

However, due to the large variation in grain production, the size of trade flows between surplus and deficit regions may vary strongly.

Trains and trucks are the two primary means of wheat transportation in Russia. Trains are mostly used when the transport distance between regions exceeds 1000 kilometers, while trucks are often preferred on shorter routes.

As production areas cover large territory, the influence of transport infrastructure is crucial for the distribution of wheat. The quality of transport infrastructure strongly differs between regions. For instance, the density of the railway network is highest in the European part of Russia, whereas it is much lower in Urals and West Siberia. It is reported that excessive crops are often difficult to transport beyond West Siberia as the only railway track connecting the area to the rest of the country has low throughput capacity and is shared by many other industries (Scherbanin, 2012). In addition, grain traders regularly complain that the number of grain wagons in peak seasons does not suffice (Gonenko, 2011).

The estimated values of the railway delivery fees for selected market pairs in 2010 are presented in Table 2. It should be pointed out that the delivery fee captures only parts of the full transport costs. Other expenses may include storage fees, transportation between the railway station and the grain processing facility, insurance premium etc. The share of the delivery fee in the total transport costs varies significantly amounting to 30% to 70% of transport costs.

Table 2. Costs of wheat transportation between the selected locations in 2010

Pair of markets	Station of origin	Station of destination	Distance (km)	Delivery fee (RUB/ton)	Delivery fee (USD/ton)
North Caucasus-Black Earth	Kavkaz	Voronezj	870	781	26

North Caucasus-Central	Kavkaz	Moscow	1300	1165	39
North Caucasus-Volga	Kavkaz	Kazan'	1708	1328	45
Volga-Central	Kazan'	Moscow	812	752	25
Urals-Central	Kurgan	Moscow	2037	1498	50
West Siberia-North Caucasus	Novosibirsk	Kavkaz	3800	2576	86
West Siberia-Central	Novosibirsk	Moscow	3350	2147	72

Note: Delivery fee is recognized as a charge due to be paid for the rent of one wagon (measured in RUB/ton). The value of delivery fee is estimated using an online calculator provided by the Russian railways on August 06, 2010 when trade was freely possible. These estimates correspond to the amount of wheat which is simultaneously transferred in a group of 100 wagons. Therefore, they may slightly vary if the actual number of wagons included in the group differs.

Source: Own illustration, data: Rosstat 2015.

3 Literature review

This paper adds to the strand of literature focusing on spatial price relations between regional agricultural markets.

Goodwin and Piggott (2001) first introduced threshold co-integration in the spatial price transmission literature. They analyse spatial price links between regional corn and soybean markets in North Carolina using a two-regime threshold autoregressive (TAR) model. They find that thresholds are proportionally related to transaction costs, which increase with distance between the markets. Their study confirms the presence of non-linear adjustment of prices to deviations from the long-run price equilibrium between two locations. In particular, price adjustment is hardly confirmed if regional price differences are smaller than transaction costs. On the contrary, large price differentials induce adjustment of regional prices to their price equilibrium, which increases with proximity of the markets. Additionally, the authors utilize a three-regime threshold vector error-correction model (TVECM) to account for changes in the direction of trade flows. However, model results do not find evidence that a reversal in trade direction alters the speed of price adjustments to its spatial price equilibrium.

Several methods have been developed to correctly identify the optimal threshold parameter. Chan (1993) offers the method of threshold selection that gained recognition in the context of the TAR model. According to this approach, the optimal threshold is to be chosen from the set of residuals retrieved from the long-run equilibrium regression. The residuals are sorted using results of sum of squared errors (SSE), and the residual with the lowest SSE is selected as a threshold. Hansen and Seo (2002) use values of error-correction terms (ECTs) to determine possible threshold adjustment in a two-regime TVECM. They pair ECTs with corresponding values of the co-integrating vector to construct a two-dimensional grid and then estimate this grid with maximum likelihood. The pair that yields the lowest value of the concentrated likelihood function is determined to contain the optimal threshold parameter. These procedures are criticized for the reliance on an arbitrarily chosen trimming parameter which is used to ensure that the model parameters of each regime are estimated based on a minimum number of observations. According to Greb et al. (2014) the selection of the trimming parameter might lead to the exclusion of the true value of a threshold from the threshold parameter space and, as a consequence, to unreliable threshold values and model parameter estimates.

Balcombe et al. (2007) offer an alternative framework to estimate the parameters of generalized threshold error-correction model on the basis of classic Bayesian theory. They apply this model to monthly wheat, maize and soya prices for the United States, Argentina and Brazil. Results suggest that the new method is capable of addressing the problem of identification of model parameters that often pertains to the maximum likelihood approach. This problem results from the jagged nature of the maximum likelihood function implying that the function cannot be evaluated using traditional differentiation methods. By contrast, classic Bayesian analysis offers special computational algorithms which allow estimating the parameters without using the irregular maximum likelihood function.

Greb et al. (2014) use a methodologically similar empirical Bayesian paradigm to develop a threshold estimator in the context of generalized threshold models. However, in comparison to the Bayesian approach followed in Balcombe et al. (2007), they tend to reduce the application of so-called non-informative priors. According to Greb et al. (2014), certain prior values should be assigned to the model parameters to make the estimation procedure possible, but in the absence of any preliminary information this assignment becomes rather arbitrary and may influence the final estimates. To avoid this outcome, they start with selected priors obtained from maximum likelihood estimation. Additionally, the empirical Bayesian analysis requires no trimming parameter to achieve the desired distribution of observations across regimes. Greb et al. (2013) exploit this approach and compare it to the maximum likelihood procedure to revisit the study of Goodwin and Piggott (2001). Applying three-regime TVECM, they conclude that the Bayesian estimator identifies larger thresholds and wider inaction bands compared to the maximum likelihood counterpart. Moreover, they also find more evidence in support of asymmetric adjustment that takes place, potentially, due to changes in the direction of trade.

Our study also contributes to the growing price transmission literature on the domestic price effects of export controls. The effects of wheat export controls in Russia were previously addressed within a price transmission approach by Götz et al. (2016) and Götz et al. (2013). Both studies focus on the relationship between the world market price and the domestic prices in order to identify the price dampening effect of the export controls. Götz et al. (2013) investigate domestic price effects of the export tax in Russia during 2007/8 within a MSECM approach. They find compared to Ukraine a rather low price dampening effect amounting to 25%. Results of Götz et al. (2016) suggest a strong heterogeneity of the price dampening effect of the wheat export ban 2010/11 in Russia, varying between 67% and 35% in the major grain producing regions.

Differing, this study investigates how the export ban 2010/11 impacts price relationships between the grain producing regions of Russia themselves. A further novelty of our approach is that we use a TVECM in order to capture the possible effects of the export ban on trade costs. Also, we are supplementing the regional price data with interregional trade flow data to facilitate interpretation of our model results.

A regional perspective is also followed by Baylis et al. (2014) which investigate the export ban for wheat and rice implemented in India 2007-2011. They take into account integration between the world and domestic markets, but also explicitly focus on price relations between the regions of India. The analysis is based on regional price data for producing, consuming and port markets and the world market price. Using a linear VECM and a TVECM, they investigate cointegration and integration for the time period when trade was freely possible and compare it to when the export ban was implemented. They find for rice all port markets integrated with the world market during the export ban period as well as when trade is freely possible. Though, no cointegration of the port markets and the world market for wheat is observed during the export ban. However, more domestic market price pairs are integrated during the export ban for rice but less for wheat, when compared to the free trade regime.

4 Methodological framework and data properties

4.1 Measurement of market integration

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. Long-run price equilibrium is given as:

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

where P_t^1 and P_t^2 are natural logarithm of prices at time t for every regional market pair, ε_t denotes stationary disturbance term. α denotes intercept and β is coefficient of the long-run price transmission elasticity, 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, market prices are tend to diverge from the long-run equilibrium parity from time to time. Threshold vector error correction model (TVECM) is designed to examine how fast prices converge back to the equilibrium 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 $Cov(\omega_t) = \Omega \in (\mathbb{R}^{+})^{2\times 2}$.

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

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*.

Price observations are attributed to a certain regime depending on the size of the ECT. The 3-regime TVECM is based on the assumption that two thresholds exist corresponding to the costs of trade in both directions, i.e. from one market to the other and vice versa. Price observations for which the ECT is smaller than threshold τ_1 are attributed to the lower regime, whereas price observations with an ECT larger than threshold τ_2 are assigned to the upper regime 3. The threshold is considered a proxy for transaction costs of wheat trade between the two respective markets. If the ECT is of the size smaller than threshold τ_2 but larger than threshold τ_1, the observations are allocated to the middle regime. Within this regime, the difference between the prices of two regions are smaller than transaction costs of trade.

The speed of adjustment refers to the time period required by the price of a certain market to correct a deviation from the long-run equilibrium between the two markets. The speed of adjustment may differ between the regimes. Prices in two spatially separated markets may be related by trade arbitrage only if the price differences are at least as high as trade costs. This is given for price observations which are attributed to the upper and lower regime in a 3-regime TVECM. However, prices may be related but at a lower degree even if the price differences are smaller than transaction costs, corresponding to the middle regime in a 3-regime TVECM, via information flows or third markets (Stephens et al., 2012).

There are several conditions that should be satisfied to ensure the stability of the system in (1). First of all, the speed of adjustment parameters in one specific regime should be of opposite sign reflecting that markets return to their equilibrium path in the long-run. From (1) it follows that both markets can be treated as dependent simultaneously such that in each regime $\Delta P_{1,t} = \rho_{k1} \gamma' P_{t-1}$ and $\Delta P_{2,t} = \rho_{k2} \gamma' P_{t-1}$. Convergence is achieved if $\rho_{k1} \leq 0$ and $\rho_{k2} \geq 0$. Given this restriction, it is considered sufficient that at least one adjustment parameter in a specific regime is found significant. Secondly, the difference between the two speed of adjustment prameters of the outer regimes should fall in the following interval $0 < \rho_{k2} - \rho_{k1} < 1$. The last restriction corresponds to price fluctuations decaying gradually (Greb et al., 2013).

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).

The presented model is estimated by two methods and within three steps. First, the long-run price equilibrium in equation (1) is estimated by ordinary least squares (OLS) method. We retrieve the error term which enters the TVECM lagged by one period as the ECT variable. Second, the threshold parameters in equation (2) are identified by using the regularized Bayesian technique. Third, the short-run and long-run price transmission parameters of equation (2) are estimated by implementing restricted maximum likelihood method.

Compared to maximum likelihood method that utilizes maximization, the selection of thresholds on the basis of RB estimator is done using integral calculus. According to Greb et al. (2014), integration might be more natural to use in TVECM as it provides a means to account for inherent variability of the estimates. A function to choose optimal threshold values over the grid of ECTs is called posterior median and constructed as follows:

$$\int_{\min(\gamma' P_t)}^{\hat{\tau}_{iRB}} P_{RB}(\tau_i|\Delta P, X)d\tau_i = 0.5\,,\ for\ i = 1,2 \quad (2')$$

where X is a $n \times d$ matrix that compactly stacks together columns of ECTs and values of lagged terms. $P_{RB}(\tau|\Delta P, X)$ is well defined across the space of all possible threshold parameters $\mathrm{T} = \{\tau_1,\tau_2 | \min(\gamma' P_t) < \tau_1 < \tau_2 < \max(\gamma' P_t)\}$. In the previous expression, τ_1 and τ_2 are optimal thresholds that separate the space into three regimes and satisfy $\tau_1 < 0 < \tau_2$. Computation is based on a prior $P_{RB}(\tau|X) \propto I(\tau \in T)$ for τ, where $I(\cdot)$ is an indicator function providing switching between regimes.

Upon identification of the optimal thresholds, the additional parameters of the TVECM are estimated. We use the restricted maximum likelihood framework implemented as a part of mixed-effects modeling in R. Each regime is estimated independently, given the values of thresholds (Gałecki and Burzykowski, 2013).

4.2 Identification of the determinants of market integration

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 differences in the degree of market integration. We posit that distance and orientation of wheat production region on export have a significant impact on the degree of market integration.

We conduct econometric analysis using Tobit model, which is fitted to the sample containing data on regional market pairs in Russia and the USA. Model is given in the following reduced-from equation:

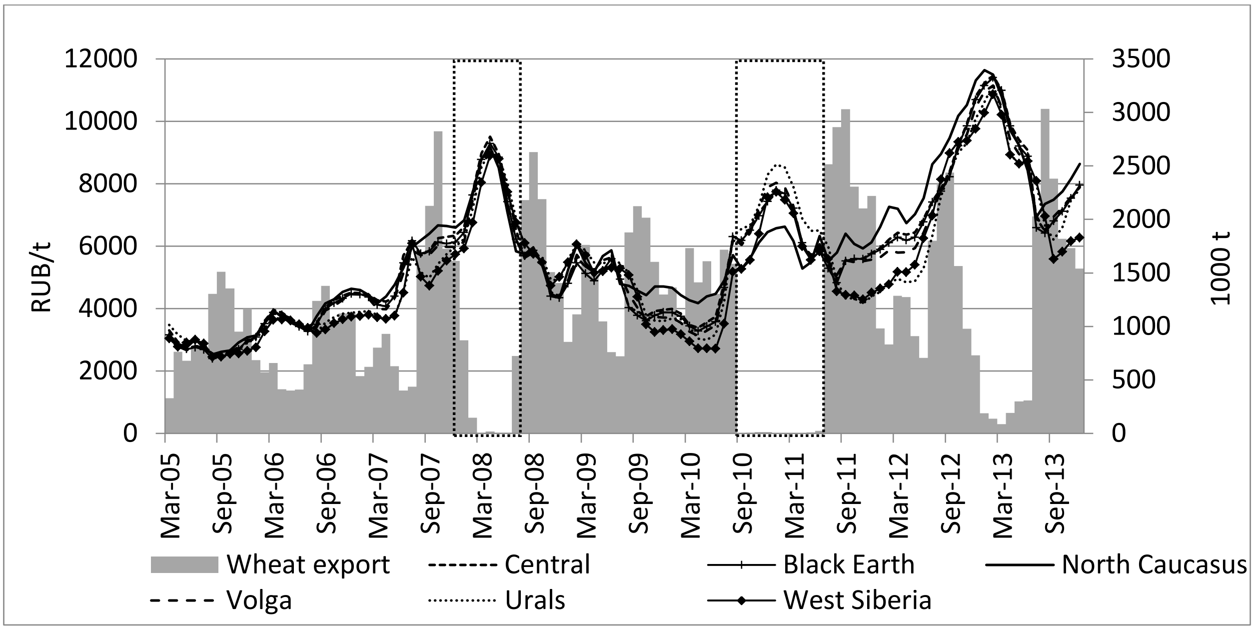
$$\boldsymbol{\Psi}_i = \vartheta_0 + \vartheta_2\boldsymbol{\mathcal{D}}_i + \vartheta_3\boldsymbol{\mathcal{X}}_i + \lambda_0\boldsymbol{\mathcal{R}}_i + \lambda_2\boldsymbol{\mathcal{D}}_i\boldsymbol{\mathcal{R}}_i + \lambda_3\boldsymbol{\mathcal{X}}_i\boldsymbol{\mathcal{R}}_i + \boldsymbol{\xi}_i \quad (3)$$

Where $\boldsymbol{\Psi}_i$ is an estimate of the long-run price transmission elasticity from cointegration equation (1) in Russia and the USA. $\boldsymbol{\mathcal{D}}_i$ measures average distance in kilometers between different economic regions in Russia and between states in the USA. $\boldsymbol{\mathcal{X}}_i$ is an indicator variable and takes value 1 if a region is an exporter to the world market, and equals to 0 otherwise. $\boldsymbol{\mathcal{R}}_i$ is a dummy variable that equals to 1 if a observation refers to the markets in Russia and 0 – if in the USA. By introducing interaction terms with country dummy variable $\boldsymbol{\mathcal{R}}_i$, we test conditional hypothesis that market characteristics have different effect on market integration in Russia compared to the USA.

5 Data sets and data properties

To estimate our price transmission model, we use a unique dataset of weekly prices of wheat of class three (Ruble/ton), the most widely traded type of wheat for human consumption in the Russian domestic market. 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. Our data set comprises regional data for the six economic grain producing regions North Caucasus, Black Earth, Central, Volga, Urals and West Siberia and contains 468 observations (January 2005 until December 2013) (Figure 3). From this database, we construct 15 market pairs in total by combining each market with all other five regional markets in Russia.

Figure 3: Development of regional wheat prices in Russia in 2005-2013



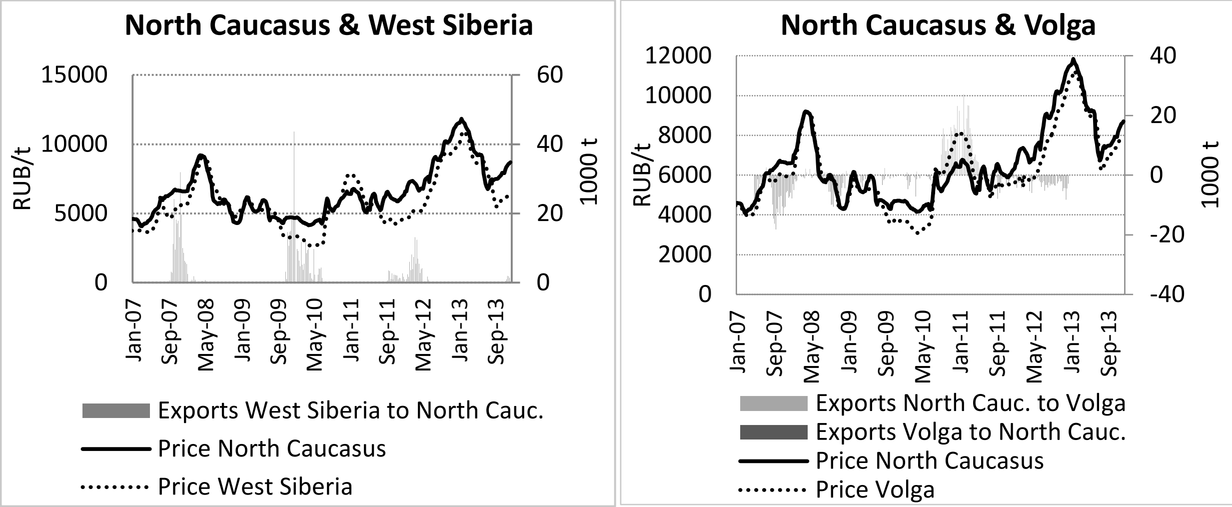
Note: The area with dashed line on the graph covers the period of export tax (Nov 2007 - May 2008) and export ban (Aug 2010 - Jul 2011).

Source: Own illustration, data: Russian Grain Union (2014), GTIS (2013).

In addition, we use weekly amounts of grains transported by train between all grain producing regions of Russia as a measure for interregional grain trade flows (source: Rosstat 2015). This data is used as additional information to build the model framework and to interpret results. As an example, Figure 4 gives the price relationship between the regions North Caucasus and Volga as well as North Caucasus and West Siberia (2007-2013) and the corresponding interregional grain trade flows transported by train.

However, Figure 4 makes evident that the regional price relationships are not stable, but rather differ from marketing year to marketing year. In particular, 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 on one marketing year only which is characterized by relatively stable price relationships.

Figure 4: Regional wheat price relationships and interregional trade flows



Sources: Own illustration, data: Russian Grain Union (2014).

In particular, to assess strength of market integration in Russia, we use regional price observations of the marketing year 2009/10, when trade was freely possible, as our data base. Also, to investigate the impact of the drought and the export ban, we estimate the price transmission model based on the price data for the marketing year 2010/11 and compare the parameter estimates with those obtained based on the 2009/10 price data. Both data sets comprise 52 observations each.

We use estimate long-run price transmission coefficients from free-trade regime in 2009/10 as a dependent variable to identify determinants of market integration on the next stage. In addition, we employ equivalent state-level corn prices for 16 states observed between marketing years 2008 and 2011 (source: USDA AMS, 2016) to get an estimate of long-run price transmission coefficients for markets in the USA. Each price series contain 156 observations on the weekly basis. Overall, this dataset generates 63 market pairs, which we construct by pairing 7 markets from the major producing 'Corn Belt' area states with the other 9 markets mostly from net-consumer states.

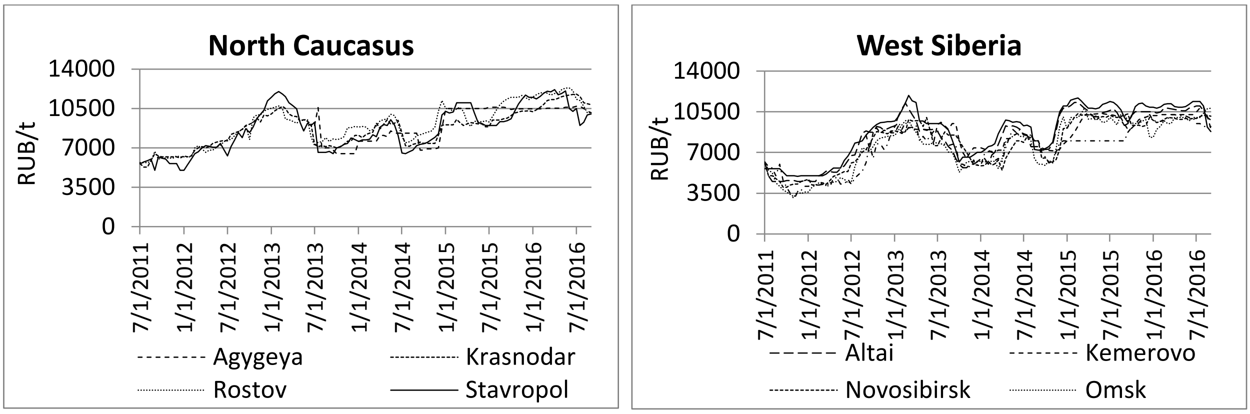
In order to identify determinants of the market integration, we supplement our dataset with the weekly amounts of grains transported by train between all grain producing regions of Russia as a measure for interregional grain trade flows (source: Rosstat, 2015).

Except for identifying how various market characteristics affect market functioning in Russia and the USA, we also conduct comparative price transmission analysis to evaluate how markets function in Russia compared to the USA, which serves as a benchmarch for the most efficient grain market in our analysis.

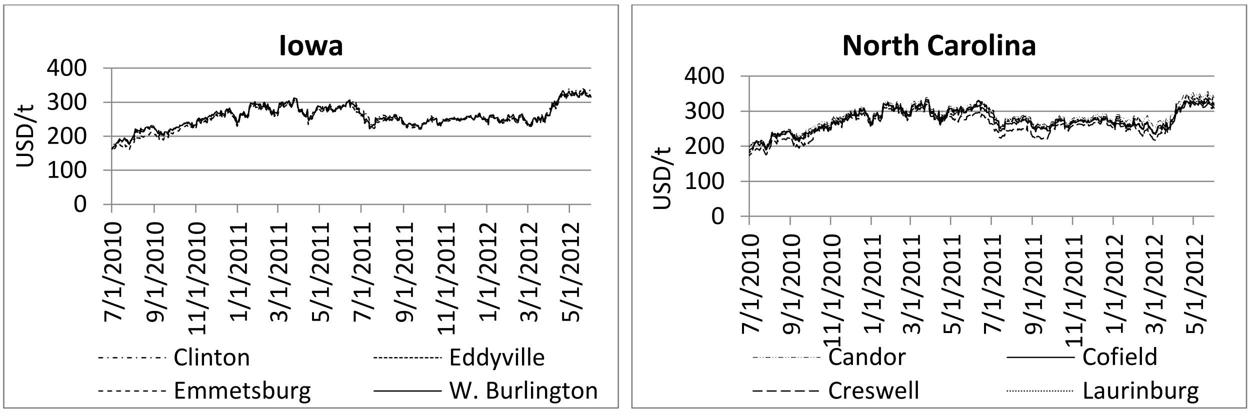
Comparative price transmission analysis is conducted based on within-regional price relationships. We select North Caucasus and West Siberia as a unit of analysis in Russia (source: Ministry of Agriculture of Russia, 2016) and compare it with the USA markets in Iowa and North Carolina. Figure 5 shows price developments in local markets of North Caucasus and West Siberia.

Figure 5: Development of selected regional wheat prices in North Caucasus and West Siberia in Russia (a), and Iowa and North Carolina, in the USA (b)

a) Russia



b)



Note: Prices are by-weekly in Russia and daily in the USA. For graphical representation we select only four market in each region.

Sources: Own illustration, data: Ministry of Agriculture of Russia (2016), GeoGrain and Nick Piggott, 2016. Own illustration.

North Caucasus is production region which has good access to the ports and is very active on the world market, while West Siberia – another wheat production region – is mainly active on domestic wheat trade due to its large distances and geopraphical separation from the world markets (Figure 6).

Figure 6. Map of crop-growing regions in North Caucasus and West Siberia

Source: Own illustration.

We include price series from four winter wheat growing areas in the North Caucasus region such as Agygeya, Krasnodar, Rostov and Stavropol. In general, price data for local markets in this region is available from January, 2010 to September, 2016 and consists of 161 by-weekly observations in total. Exception is Agygeya with its price series starting from June, 2013 and accounting for 79 observations altogether.

West Siberia, which is the leading spring wheat production region in Russia and advanced grain milling facilities, is represented by six local markets in this study. Out of them, Novosibirsk, Altai, Omsk and Tyumen are categorized as production regions and Tomsk and Kemerovo are net-consuming regions. Price series for Altai, Tomsk and Tyumen markets are fully available from January, 2010 to September, 2016 including 161 by-weekly observations each. However, other price series are given for shorter time period. More specifically, Omsk price series start in December, 2010 generating 139 observations for this market. Price series for Novosibirsk market starts in July, 2011 (125 observations) and for Kemerovo in September, 2012 (97 observations).

Comparable set of the data is constructed for the USA based on the prices observed in Iowa and North Carolina (Figure 5) (source: GeoGrain and Nick Piggott, 2016). We use daily prices of the same time period for all price series from July, 2010 to June, 2012 (506 observations each) collected in eight markets in Iowa (Cedar Rapids, Clinton, Davenport, Eddyvile, Emmetsburg, Keokuk, Muscatine and West Burlington) and six markets in North Carolina (Candor, Cofield, Cresswell, Laurinburg, Roaring River and Statesville).

Before we begin with the price transmission analysis we test the properties of our price series. Results of the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) for a unit root (Appendix, Table A1) suggest that the all price series used in this study are integrated of order 1.

Further, we apply two different testing techniques to explore the potential of non-linearity in the market price pairs and to confirm the use of TVECM. Hansen and Seo (2002) provide a test to check the validity of linear co-integration under the null versus the presence of non-linear co-integration in a two-regime TVECM with 1 threshold as the alternative. Larsen (2012) provides an extension to the Hansen and Seo (2002) test by allowing for non-linear co-integration within a three-regime TVECM with 2 thresholds under the alternative hypothesis.

Results of the two tests are given in Table A2 in the Appendix. Both Hansen and Seo (2002) and Larsen (2012) test results suggest that the null hypothesis can be rejected at 10% level of significance agains threshold cointegration almost in all cases. Exceptions are three market pairs in Russia for the marketing year 2010/11 (out of 15), six matket pairs in Iowa (out of 27), and two market pairs in North Carolina (out of 15). Overall, threshold cointegration is supported for all 15 wheat price pairs of Russia in 2009/10 by at least by one of threshold cointegration test, and for all 6 price pairs in North Caucasus and 15 price pairs in West Siberia.

Therefore, since in the vast majority of cases test results of Hansen and Seo (2002) and Larsen (2012) suggest threshold cointegration, we consider these results as 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 the Russian regional wheat markets.

6 Results

6.1 The influence of the export ban 2010/11

The unusually low harvest in the key crop growing areas affected by the drought in 2010 induced Russian government to impose an export ban on wheat on August 15. Initially, the ban was introduced to last until December 2010, but it was subsequently prolonged to last until July 2011.

The measure had a profound impact on regional wheat trade in Russia. In particular, North Caucasus could no longer supply to the world market and was forced to supply wheat domestically instead. Table 3 shows that North Caucasus directed its flows to the markets which suffered the most from the harvest failure, specifically Black Earth, Central, Volga and Urals. This explains the observed wheat trade reversal, e.g. between North Caucasus and Volga region. West Siberia was less affected by the drought and also supplied wheat to the domestic grain producing regions which turned into deficit regions in 2010/11, in particular Volga and Urals.

Table 3. Interregional grain trade quantities by train, 2010/11

from / to	North Caucasus	West Siberia	Black Earth	Central	Volga	Urals
Regional trade (in t)						
North Caucasus	-2,494,506		534,336	1,205,324	453,936	300,910
West Siberia		-1,180,827		73,107	101,444	1,006,276
Total imports			534,336	1,278,431	555,380	1,307,186

Source: Götz et al. 2016

To foster interregional grain trade during the export ban, the Russian government introduced transport subsidy for grain producers located in North Caucasus starting from September 20, 2010. For example, Russian Railways cut delivery fees by half for dispatches heading from North Caucasus towards the regions of Volga, North West and Central. The given subsidy was valid for all grain supplies exceeding 300 kilometers and was removed together with the export ban in July 2011.

Even though railway tariff rates halfened during the export ban 2010/11, availability of trucks for grain transportation was limited as railways were heavily involved in the construction of sport facilities for the winter Olympic games in Sochi. Moreover, the volume of grain exported by North Caucasus to other domestic regions was extremely high and even exceeded the availability of trucks (Gonenko, 2011).

6.1.1 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 4 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.

Table 4: Parameters of the long-run price equilibrium regression, 2009/10 and 2010/11

Price pairs			Long-run price transmission elasticities			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.

In particular, long-run price transmission is strongest between the neighbouring regions Central and Black Earth (0.940), the first of which is the major consumption centre and the second is an important production region, and lowest between North Caucasus and West Siberia (0.132), the two grain producing regions which are the most distant to each other. One exception is the price pair North Caucasus-Central, which is integrated slightly stronger than the price pair North Caucasus-Black Earth, although Central is more distant to North Caucasus than Black Earth. The strong integration can be explained by the regions' trade position. Central and North Caucasus are both the largest importing regions of Russia and strongly competing for grain imports from other regions of Russia. Though, Central region is the main grain consuming region of Russia whereas North Caucasus is the primary grain exporting region.

Further, it becomes evident that neighboring regions are stronger integrated than regions which are not directly adjacent to each other. In particular, besides Central-Black Earth, Central-Volga, Black Earth-Volga, Volga-Urals and Urals-West Siberia are the regions which exhibit significantly stronger long-run price transmission elasticity compared to non-neighboring regions.

Our results suggest that North Caucasus is the grain producing region which 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. The two exceptions are the neighboring regions Central-Black Earth and Urals-West Siberia, for which the long-run price transmission parameter (almost) remains constant. Obviously, the domestic

Russian grain market is characterized by stronger market integration during the export ban. This can be explained by two factors. First, due to the export ban, the influence of the world market conditions on domestic price formation decreases 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. This is also reflected in the increase in the long-run price transmission parameter (in percentage), which is strongest for the price pairs involving North Caucasus, the increase varying between about 70% and 200%. Second, due to the severe harvest shortfalls of up to 60% in some regions in 2010/11, interregional trade flows increase strongly and are observed from the surplus regions North Caucasus and West Siberia to the deficit regions (compare Table 3), contributing to the strengthened domestic market integration. This rise in the domestic grain trade was fostered by the implementation of the wheat export ban.

6.1.2 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 5a and Table 5b.

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. For example, for the price pair Central–Black Earth, 40 observations are assigned to the middle regime, whereas 7 observations belong to the lower and one observation to the upper regime. 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.

Table 5a. Results of TVECM: Russia 2009/10

	Price pair	Lower regime			Middle regime			Upper regime		Total adjustment Number of obs.			
	Dependent – indep. variable	**Rho1**	**Pvalue**	**Lower Thresh.**	**Rho2**	**Pvalue**	**Upper Thresh.**	**Rho3**	**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**	0.000		**0.295**	0.000		**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 5b. Results of TVECM: Russia 2010/11

	Price pair	Lower regime			Middle regime			Upper regime		Total adjustment Number of obs.			
	Dependent – indep. variable	**Rho1**	**Pvalue**	**Lower Thresh.**	**Rho2**	**Pvalue**	**Upper Thresh.**	**Rho3**	**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**	0.000	***-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**	0.000	***-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.

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. For both marketing years the band of inaction is highest for all price pairs which include either Ural or West Siberia, two peripheral regions which are characterized by large distance to the grain consuming and exporting regions and thus high trade costs. Though, the band of inaction is rather low for the price pair Urals-West Siberia, which are neighbouring regions and are characterized by strong integration.

All price relations between the given regional markets are characterized by a positive and a negative threshold. For example, for the market pairs containing the Central region, the threshold with a positive value refers to the trade costs of wheat supplied to the Central region, whereas the negative threshold corresponds to trade costs of wheat originating in the Central region and exported to the respective partner region. As it was explained in section 2, it should be pointed out that Central is the pivotal region representing the largest wheat consuming region of Russia, while the other regional markets (Black Earth, West Siberia, Urals and Volga) are the primary suppliers of wheat to Central.

Estimates of the threshold parameters in 2009/10 generally confirm the influence of distance. For example, for all price pairs which include the Central market, the absolute value of the negative threshold increases with distance (compare Figure 1). In particular, the absolute value of the identified negative threshold is highest for the market pair Central-West Siberia (0.062), two markets which are the most far apart, while it is significantly lower for the price relationship between the markets Central and Black Earth (0.021) and Central and Volga (0.013) which are each neighbouring regions. Thus, parameter estimates indicate that it is almost three times costlier to supply wheat from West Siberia to Central, than from Black Earth to Central. The threshold is second highest for the market pair Central-Urals (0.047) which is in line with the actual distance between those markets.

A similar pattern is observed for all price pairs involving the region North Caucasus. The absolute value of the negative threshold is lowest for the neighbouring regions North Caucasus and Black Earth (0.021) and is highest for the most distant regions North Caucasus and West Siberia (0.049).

Generally, all price pairs including Urals or West Siberia as a region are characterized by relatively large thresholds, which can be explained by their peripheral location and the high transaction costs involved.

The increase in the band of inaction in 2010/11 compared to 2009/10 can be explained by the increase of the size of thresholds. Parameter estimates suggest that the size of thresholds had increased compared to 2009/10 for the vast majority of price pairs. The lower threshold increased for all price pairs except one. The identified upper threshold increased for 11 out of the 15 price pairs. 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 and the regime-specific total adjustment. 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. In the following we focus on the parameters which are statistically significant at least at the 10% level, and which are of the expected sign.

Among the 15 price pairs, the speed of adjustment parameter is highest for the neighbouring regions Central-Black Earth amounting to 34% to 73% per week in 2009/10 in the lower and upper regime, respectively. The size of the speed of adjustment decreases to 31% for the price pairs Central-Urals to 26% for Central-West Siberia, reflecting the influence of distance. The speed of adjustment parameters observed for price pairs involving North Caucasus are significantly lower. In particular, the highest speed of adjustment parameter is observed for the price pair North Caucasus-Central amounting to 30%. The regime-specific parameters are significantly lower for the price pairs North Caucasus-Black Earth, North Caucasus-Urals and North Caucasus-West Siberia, and are decreasing with increasing distance between the regions from 21% (North Caucasus-Black Earth) to 13% (North Caucasus West Siberia).

The influence of trade costs is also reflected when comparing the regime-specific speed of adjustment parameters and the total adjustment for each price pair. 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 trade costs.

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.

6.2 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. The corn market of the USA seems is particularly suitable for comparison since it is characterized by rather high variation in the level of production and strong domestic trade flows to balance supply and demand of corn. 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 assessing the efficiency of the Russian wheat market in this study.

Corn is the primary grain produced in the USA, accounting for more than 80% of total grain production (USDA NASS, 2016). For comparison, wheat has a 60% share in total grain production in Russia. The majority of corn is grown in the so-called “corn belt” region ranging over the states Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Kansas, Ohio and Missouri and accounting for about 80% of total corn production of the USA. Similar to Russia, the size of corn production in the USA is characterized by large regional fluctuations (Table 5). For example, corn production in Illinois varied between 65% in 2012 and 132% in 2014 of the average corn production of the previous 3 years. Nonetheless, the volume of harvested corn is quite stable on the national level.

Table 5: Corn production developments in the states of the “corn-belt” area of the USA (2004-2015), in % of the average of previous 3 years

State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Iowa	122	106	98	110	100	111	92	104	81	101	111	118
Illinois	126	95	97	122	110	99	90	95	65	122	132	105
Nebraska	124	113	95	117	107	117	99	104	85	113	108	113
Minnesota	119	114	101	101	103	109	108	97	110	100	91	111
Indiana	121	114	97	111	97	104	97	93	67	133	132	91
South Dakota	147	111	65	123	133	150	93	105	83	137	119	113
Kansas	133	137	86	123	111	134	109	81	70	107	127	120
Ohio	126	114	98	114	86	114	106	102	85	131	114	88
Wisconsin	97	116	104	112	93	109	117	116	82	93	107	111

Missouri	150	94	99	118	100	111	86	88	64	135	183	100
USA total	**124**	**108**	**96**	**117**	**105**	**111**	**98**	**98**	**85**	**117**	**115**	**105**

Note: USA total considers corn production in all states.
Source: Own illustration, data: USDA NASS, 2017.

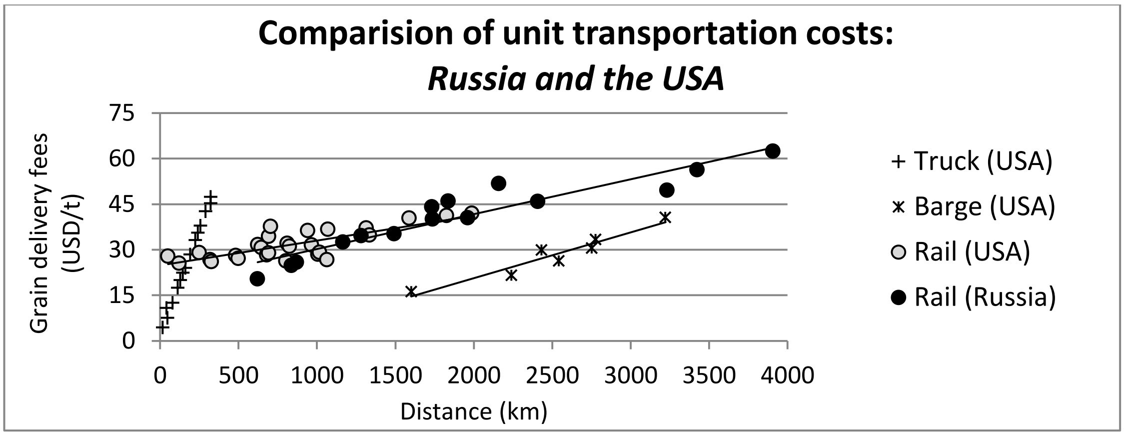
Moreover, USA is the world's largest exporter of corn occupying 35%-40% of total corn exports world-wide (USDA WASDE, 2017). Nonetheless, 80-90% of the corn production in the USA is supplied to the domestic market (USDA NASS, 2017). due to the rapid expansion of biofuel production, industrial use of the domestically produced corn has substantially increased. Even more, since 2010 amount of corn consumed by energy sector is exceeding the quantity of corn that is used as an animal feed. As of 2014, biofuel plants account for the 40% of total domestic corn usage (USDA ERS, 2017). Another characteristic of the USA grain market that structurally distinguishes it from Russia is that corn processing facilities are concentrated in the production areas. In order to ensure logistical efficiency ethanol plants are usually established close to the grain elevators, from where corn is primarily transported by trucks to the processing facilities.

Corn transportation in the USA is based on trucks, rails and barges (Sparger and Marathon, 2015). On average 80% of domestic corn transfers is performed by trucks since it is the most cost advantageous means of transportation on shorter distances (less than 500 kilometers). The rest of the domestic corn hauling on longer distances is conducted by rails. Corn for export is mainly transported by waterway transport. Barges are primarily busy for deliveries to the port export terminals. They transport around 70% of totally exported corn from the "corn belt" southwards to the Mississippi Gulf ports (FAPRI-UMC 2004), which by itself is one of the leading port for corn export accounting for 65% of total corn exports (USDA Federal Grain Inspection Service grains inspections, 2013, as cited in Denicoff et al., 2014). The remaining 30%-40% of the exported corn is hauled by rail predomionantly to the Pacific Northern harbors in the Washington state.

Figure 9 illustrates cost advantages of selected transportation modes in the USA depending on the distance covered and compares it with the railway tariff rates in Russia. Trucks are the cheapest transportation mode in the USA within distances less than 500 kilometers. While comparing long-distance transportation modes, barges are twice as cheap as trains if distance exceeds 1500 km, however access to this water transport emtirely depends on the geographic proximity of a corn trade facilities and its access to a river.

Figure 9 also shows railway tariff rates of wheat transportation in Russia to compare it with the rates in the USA. Railway tariff rates to transport 1 tonnes of wheat in Russia are almost undifferenciable from the rates given for corn transportation in the USA on comparable distances. However, critical dependence on the railway infrastructure largely differs between countries. While grain transportation over large distances solely depends on the only stated-operated railway company in Russia, low-cost barges and several railroad companies provide corn cargo transportation in the USA.

Figure 9. Estimated fees of grain deliveries in the USA and Russia by different modes of transportation



Notes: Barge rates represent spot shipping costs towards the southbound direction along the Mississippi River to the ports of New Orleans from 7 different origin locations (Twin Cities, minnessota; Mid-Mississippi; Lower Illinois River; St. Louis; Cincinnati; Lower Ohio; Cairo-Memphis) on October 05, 2010 when trade capacity and correspondingly, railway rates are at their peak. Distance for barge rates is calculated based on National Water Information System (2016). Rail tariff is estimated on October 01, 2010 corresponding to the peak transportation season. Distance for Rail rates is calculated based on BNSF (2016) railway distance calculator. Truck rates are estimated for the 3rd quarter in 2010 based on three different levels of truck rates that depend on the length of distance: 4.15 USD per mile if distance is at most 25 miles, 2.4 USD per mile if distance is at most 100 miles, and 2.28 USD per mile if covered distance is 200 miles. Rates are based on trucks with 80 000 lbs gross vehicle weight limit. Estiamted volume per truck is 25 metric tones.
Sources: Own illustration, data: Rosstat 2015 and USDA AMS, 2017.

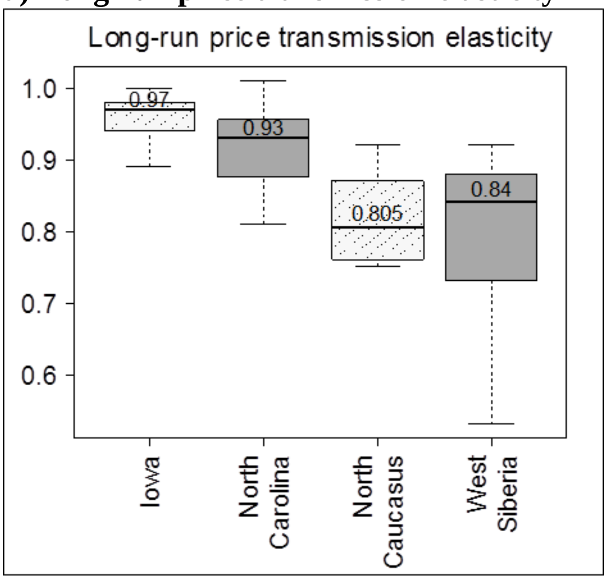
6.2.1 Parameters of long-run price equilibrium relationship and TVECM estimates

Compared to Russia, transportation logistics function more efficiently and delivery costs are much lower in USA. The influence of trade costs are usually reflected in the strength of market integration between spatially separated regions which decrease with increasing distance between the markets.

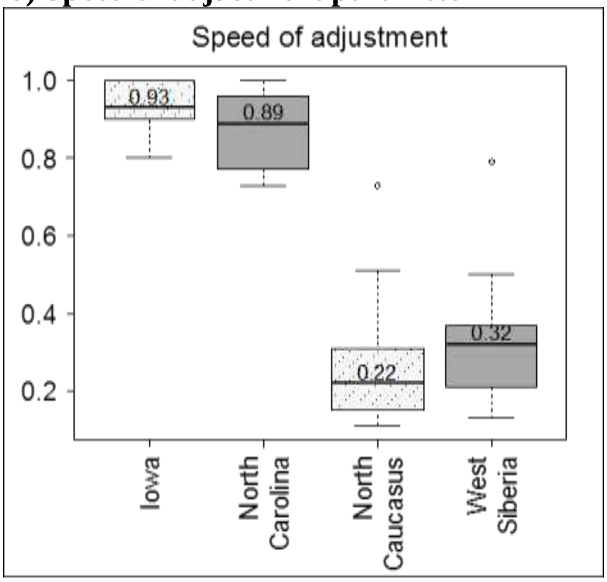
Table A3 and A4 (a, b, c and d) in the Appendix respectively shows estimates for the long-run price transmission elasticities and TVECM parameter estimates for markets in North Caucasus and West Siberia in Russia, and Iowa and North Carolina in the USA. However, in order to better visualize comparisions across countries, as well as cross-regional differences within the countries, we use estimation output from the Tables A3 and A4 and depict all comparisons in boxplots on Figure 10.

Figure 10: Boxplot comparisons of price transmission coefficients for Russia and the USA

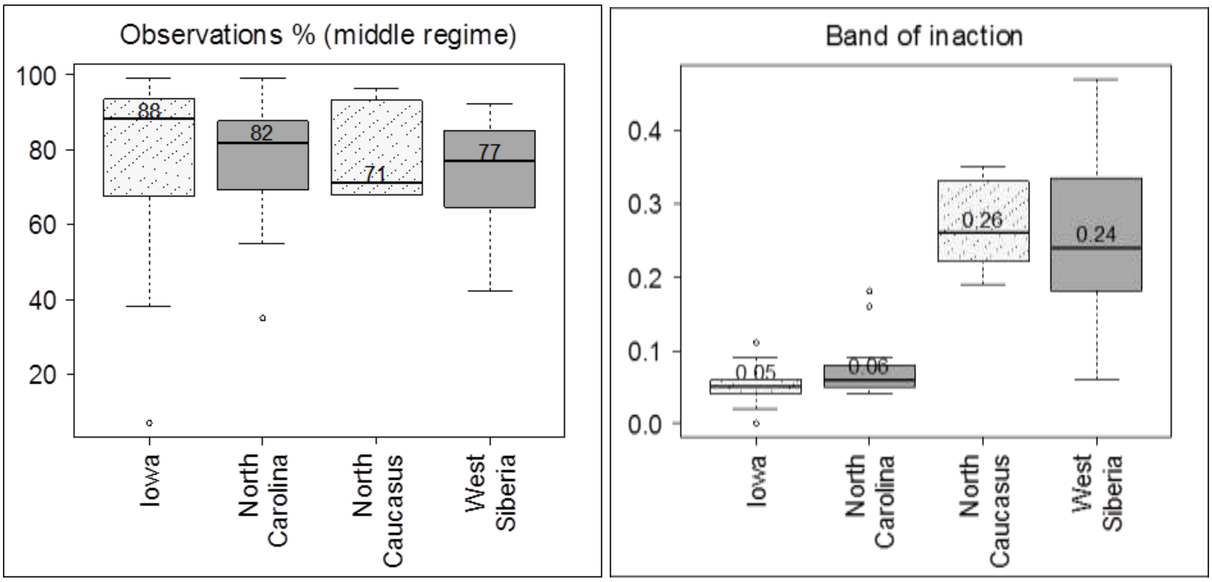
a) Long-run price transmission elasticity



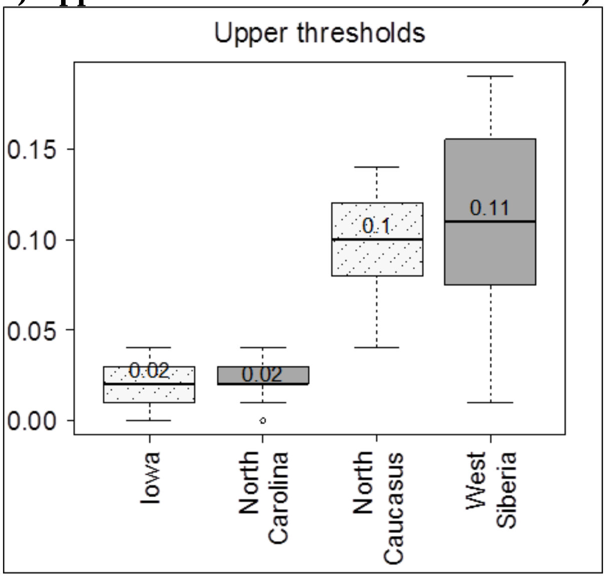
b) Speed of adjustment parameter



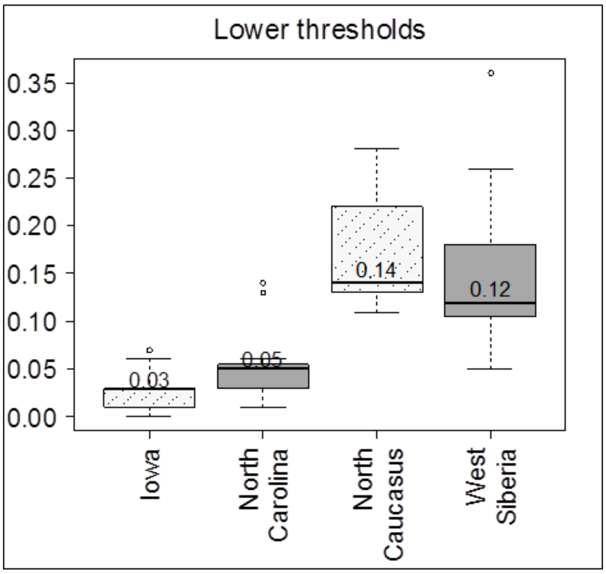
c) Observations in middle regime (%) **d) Band of inaction**



e) Upper thresholds



f) Lower thresholds



Source: Own illustration.

Analysis shows that overall, markets in Russia and the USA function differently. Long-run price transmission coefficients are much higher in the USA indicating almost complete transmission of price shocks compared to Russia (panel a, Figure 10). Median estimate of price transmission elasticities is 0.81 and 0.84 in North Caucasus and West Siberia, and 0.97 and 0.93 in Iowa and North Carolina, respectively. In addition, similar to the results of Russian market integration analysis on the regional level (compare table 4), price transmission coefficients are again more heterogeneous ranging between 0.53 and 0.92 in Russia, while it has modest variation in the USA varying between 0.81 and 1.01.

In addition, our results suggest that there are not significant differences in the functioning of grain markets between West Siberia and North Caucasus. This is surprising as we initially expected to observe notably lower degree of price transmission within West Siberia since the region is separated from the world market by large distances. On the contrary, grain in North Caucasus is only traded to export markets and local farmers have many alternatives to sell their harvest to the export-oriented traders.

Yet being segregated from the world market, West Siberia is active in domestic wheat trade. From the The region produces superior quality wheat and also has plentiful elevator facilities, explaining why markets in West Siberia are functioning equally as well as in North Caucasus. The only market in West Siberia which has low price transmission coefficient with the other markets is Kemerovo province (Table A3, b in Appendix), which is net-consumer market and is less active in the regional grain trade compared to other markets in West Siberia.

Further, efficiency of markets in transferring price shocks between regions is reflected in high speed to correct disequilibrium. As results indicate, eliminating short-run price disequilibrium is more time-consuming process in Russia compared to the USA (Panel b, Figure 10). In terms of median values, price disequilibrium between market pairs is almost completely eliminated in the USA in two weeks (93% Iowa and 89% in North Carolina), while just quarter to third of the amount adjusted in the USA is corrected in North Caucasus (22%) and West Siberia (32%) during the same time period.

For comparison, all market pairs in North Caucasus are within the distance interval up to 350 kilometers and show significant speed of adjustment towards equilibrium whereas distance diapason is larger in West Siberia (from 200 to 1550 km) and market pair Kemerovo-Tyumen with the largest distance in West Siberia does not show any adjustment at all towards long-run equilibrium.

Another measure of the market integration is the frequency of instances when error correction term between market pairs is smaller than the absolute value of the lower and upper threshold, providing evidence for strong market integration. This is measured by the percent (or, alternatively, by the number) of the ECT observations that fall in the middle regime (panel c, Figure 10). Agreeing with the findings of the long-run price transmission analysis, Russian markets again show lower degree of market integration compared to the USA as the median percent of observations attributed to the middle regime is respectively 71% and 77% in North Caucasus and West Siberia, whereas 88% and 82% of ECT values fall in the "band of inaction" interval in case of Iowa and North Carolina.

Comparison of the band of inaction (difference between the absolute value of the upper and lower threshold), upper and lower thresholds estimates univocally indicate that trade costs are much larger in Russia than in the USA (panel d, e and f, Figure 10). Median threshold values vary between 0.02 and 0.05 Iowa and North Carolina, whereas thresholds are 3-5 times larger in Russia ranging between 0.10 and 0.14. Furthermore, threshold estiamtions show that trade costs are more uniformly distributed in the USA and is characterized by higher variability in Russia. Difference between 75th and 25th quartile values which corresponds to the height of shaded area on the boxplots varies between 0.01 and 0.04 in the USA irrespective of the selected measure of thresholds (upper, lower or band of inaction values). In contrast, this difference is 0.11, 0.05 and 0.11 in North Caucasus and 0.08, 0.10 and 0.19 in West Siberia for lower thresholds, upper threshold and band of inaction, respectively. As industry practitioners indicate the key obstacles in Russia are large distances between markets and logistical challenges that hinder intensive trade linkages between markets of Russia.

6.2.2 Determinants of market integration and their impact in Russia and the USA

We utilize estimates of the long-run price transmission parameters from the price transmission analysis for the regonal markets in Russia (Table 4, 2009/10) and the USA (Table A5, Appendix) to associate it with various market characteristics and identify and compare determinants of market integration in those countries.

Results of a formal analysis of market characteristics and are summarized in Table 6. The analysis shows that in Russia distance has negative and statistically significant influence on price transmission in Russia. Closer markets are more strongly integrated in Russia than markets that are far away from each other. For instance, if we consider capital city Moscow in the Central region 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 18.4% than another market which is more distant from Moscow. The impact of distance is less pronounced in the USA. Increase of distance between markets by 1000 km translates into decreased price transmission coefficient only by 8.6%.

Table 6: Tobit regression results: analysis of the determinants of market integration[1]

Dependent variable:		**Parameter estimates**	
Long-run price transmission elasticity		**Russia** [a)]	**USA** [b)]
Distance	*1000 km*	-0.184***	-0.086***
		[0.017]	[0.008]
Exporter		-0.353***	0.081***
		[0.055]	[0.014]
Constant		0.987**	
		[0.019]	
Observations		78	
F-test (8, 70)		65.68***	
		(Prob > F = 0.000)	

Note: [a)] data sample refers to 2009/10 marketing year when trade was freely possible and includes data on 15 regional market pairs. [b)] data sample refers to 2008/11 marketing year and includes 63 observations.
*, **, *** indicate statistical significance at 10, 5 and 1%, respectively. Robust standard errors in square brackets.
Source: Own estimations.

Further, results indicate that the wheat export region of Russia is only loosely integrated with other production regions. This is in contrast to the USA where grain prices in the export-oriented regions strongly influences price discovery in other domestic markets in the USA. North Caucasus, which accounts for the lion's share of total Russian wheat export, demonstrates very low level of market integration (on average by 35.3%) compared to other regions in Russia. Contrary, if a region exports to the world markets in the USA, this strengthens integration of that region with the other domestic markets by 8.1%. We interpret this result as an indicator that in the USA market participants having easier access to the world markets consider price in exporting region as an opportunity cost and use this information as a reference price to negotiate their own trade transactions.

7 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 the strong influence of distance between the grain producing regions 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.

The results for Russia also indicate high level of variation in the strength of market integration across regions. Price pairs involving North Caucasus, the 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. This suggests that the Russian grain market can be divided in two clusters: the exporting region next to the Black Sea which is strongly influenced by

[1] Due to more convenient illustration, we present complete effect of each variable separately for Russia and the USA in this table instead of showing main effects of the variables for the USA and their incremental effect for Russia (coefficients on country dummy interaction terms).

world market conditions and the other grain production regions which are almost isolated from the exporting region and also the world market which are mainly influenced by domestic market conditions.

In a large country like Russia, distance between the grain producing regions has strong influence on their price relationships. The thresholds are highest for price pairs involving Urals and West Siberia, reflecting the relatively high trade costs due to the peripheral location of those regions within the Russian wheat market. This is reflected in a band of inaction and an upper and lower threshold increasing with distance between the regions, whereas the long-run price transmission elasticity, the speed of adjustment parameter and the total adjustment decrease with distance. Thus, we find the highest speed of adjustment parameters and total adjustment for neighbouring regions.

Our results suggest that the integration of the regional wheat markets strengthened during the wheat export ban in 2010/11, which can be explained by the increase in interregional trade flows. 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. Obviously, the transport subsidy was too low to prevent that total transaction costs of interregional trade increased during the export ban period. 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 Russian wheat market with the corn market of the USA makes evident that the efficiency of the Russian wheat market is significantly lower. In particular, the Russian market is characterized by a high heterogeneity in the degree of price transmission compared to the USA. Furthermore, TVECM estimations show that thresholds are larger and it takes more time for price shocks to be corrected in Russia compared to the USA.

Our analysis on the determinants of market integration confirms a lower influence of distance on market integration in the USA compared to Russia. Further, the exporting region is particularly strongly integrated with other regions in the USA whereas the integration of the exporting region in the other domestic markets is particularly low in Russia.

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.

Second, the grain export potential in Russia can be increased as long as this results from an increase in grain production in the exporting region which is well integrated in the world market. However, the mobilization of grain export potential in other grain production regions will require substantial investments in grain market infrastructure to improve their integration in the export market and thus in the world grain market, which might cause substantial additional costs. Ultimately world market price conditions will determine if this is efficient. As an alternative the wheat supply chain might be restructured in those regions. Livestock production might settle in the more remote grain production regions and instead of grains meat and meat products will be exported to the world market.

References

BALCOMBE, K., BAILEY, A. and BROOKS, J. (2007). Threshold Effects in Price Transmission: the Case of Brazilian Wheat, Maize and Soya Prices. American Journal of Agricultural Economics 89: 308-323.

BAYLIS, K., C. JOLEJOLE-FOREMAN and M. MALLORY (2014): Impact of wheat and rice export ban on Indian market integration. Contributed Paper, IAMO-Forum 2014 "The rise of the "emerging economies": Towards functioning agricultural markets and trade relations?", June 25-27, Halle (Saale), Germany.

BNSF (2016): Rail Miles Inquiry, http://www.bnsf.com/

CHAN, K. S. (1993). Consistency and Limiting Distribution of the Least Squares Estimator of a Threshold Autoregressive Model. The Annals of Statistics, 21: 520-533.

DENICOFF, M. R., PRATER, M. E., and P., BAHIZI (2014): Corn Transportation Profile, USDA Agricultural Marketing Service, August 2014, http://dx.doi.org/10.9752/TS090.08-2014

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

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

FAPRI-UMC (2004): Grain Transportation and Marketing Channels, FAPRI-UMC Briefing Paper #04-04.

GAŁECKI, A. T. and T. BURZYKOWSKI (2013). Linear mixed-effects models using R: A step-by-step approach. New York, NY: Springer.

GEOGRAIN (2016): unpublished data, http://geograin.com/

GONENKO, I. (2011). Grain wagons versus auto. Agroinvestor, 10 (45).

GOODWIN, B. K. and N. PIGGOTT (2001): Spatial market integration in the presence of threshold effects. In: American Journal of Agricultural Economics 83 (2): 302-317.

GÖTZ, L., T. GLAUBEN and B. BRÜMMER (2013): Wheat export restrictions and domestic market effects in Russia and Ukraine during the food crisis. In: Food Policy 38: 214-226.

GÖTZ, L., I. DJURIC and O. NIVIEVSKYI (2016): Regional price effects of extreme weather events and wheat export controls in Russia and Ukraine. In: Journal of Agricultural Economics 67 (3): 741-763.

GREB, F., KRIVOBOKOVA, T., MUNK, A. and S. VON CRAMON-TAUBADEL (2014). Regularized Bayesian Estimation of Generalized Threshold Regression Models. Bayesian Anal. 9, No. 1, 171-196.

GREB, F., S. VON CRAMON-TAUBADEL, T. KRIVOBOKOVA and A. MUNK (2013): The estimation of threshold models in price transmission analysis. In: American Journal of Agricultural Economics 95 (4): 900-916.

GTIS (2013). Global Trade Atlas, Global Trade Information Services. Unpublished data.

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

INTERFAX, 2016. Russia & CIS Food and Agriculture Weekly, various issues.

JOHANSEN, S. (1988): Statistical Analysis of Cointegration Vectors. In: 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 G. HENEBRY (2012): Grain production trends in Russia, Ukraine and Kazakhstan: New opportunities in an increasingly unstable world? In: G.M. Front. Earth Sci. 6 (2): 157-166.

LO, M.C. and E. ZIVOT (2001): Threshold cointegration and nonlinear adjustment to the Law of One Price. In: Macroeconomic Dynamics 5 (4): 533-576.

MACKINNON, J. G. (1996). Numerical Distribution Functions for Unit Root and Cointegration Tests. Journal of Applied Econometrics, 11, 601-618.

MINISTRY OF AGRICULTURE OF RUSSIA (2016): Специализированный Центр Учета В Агропромышленном Комплексе, http://www.specagro.ru/

NATIONAL WATER INFORMATION SYSTEM (2016): NWIS Mapper,https://maps.waterdata.usgs.gov/mapper

OECD/FAO (2012): OECD-FAO Agricultural Outlook 2012-2021. OECD Publishing and FAO.

ROSSTAT (2015): Federal State Statistics Service. www.gks.ru.

RUSSIAN GRAIN UNION (2014). Unpublished data.

SCHERBANIN, Y. (2012). Some problems of development of railway infrastructure in Russia (in Russian lnguage). Problems of Forecasting, 12: 49-62.

SPARGER, A. and N., MARATHON (2015). Transportation of U.S. Grains: A Modal Share Analysis 1978-2013 update, June 2015. USDA, Agricultural Marketing Service.

STEPHENS, E. C., MABAYA, E., VON CRAMON-TAUBADEL, S. and C. B. BARRETT (2012). Spatial price adjustment with and without trade. Oxford Bulletin of Economics and Statistics, 74-3: 453-469.

SURFACE TRANSPORTATION BOARD (2016): Carload Waybill Samples. www.stb.gov.

USDA AMS (2016): Market News online database, https://www.marketnews.usda.gov

USDA AMS (2017): Transportation Services Division, https://www.ams.usda.gov/services/transportation-analysis

USDA ERS (2017): Feed Grains Database, https://www.ers.usda.gov/data-products/feed-grains-database/

USDA NASS (2016): Crop Production 2015 Summary (January, 2016).

USDA NASS (2017): Quick stats database, https://quickstats.nass.usda.gov/

USDA WASDE (2017): World Agricultural Supply and Demand Estimates, WASDE-563 (March 9, 2017) https://www.usda.gov/oce/commodity/wasde/

Appendix

Table A1. Augmented Dickey-Fuller test for prices in levels and first differences

Variable	Determ. component	Lags	Test-stat	Δ Variable	Determ. component	Lags	Test-stat
				Russia (regional) 07/2005 – 12/2012			
Central	Constant & trend	2	-2.531	**Δ Central**	None	1	-7.396***
North Caucasus	Constant & trend	1	-2.287	**Δ North Caucasus**	None	0	-10.14***
Black Earth	Constant & trend	1	-2.362	**Δ Black Earth**	None	0	-8.520***
Volga	Constant & trend	2	-2.569	**Δ Volga**	None	1	-7.252***
Urals	Constant & trend	2	-2.380	**Δ Urals**	None	1	-7.351***
West Siberia	Constant & trend	2	-2.546	**Δ West Siberia**	None	1	-7.349***
				North Caucasus 07/2011 – 09/2016			
Adygeya	None	1	-0.085	**Δ Adygeya**	None	0	-9.628***
Krasnodar	Constant	1	-2.412	**Δ Krasnodar**	None	0	-8.827***
Rostov	Constant & trend	1	-2.674	**Δ Rostov**	None	0	-9.943***
Stavropol	Constant	0	-2.022	**Δ stavropol**	None	0	-10.41***
				West Siberia 07/2011 – 09/2016			
Altai	Constant	1	-2.356	**Δ Altai**	None	0	-6.979***
Kemerovo	Constant	1	-2.343	**Δ Kemerovo**	None	0	-9.098***
Novosibirsk	Constant & trend	0	-1.851	**Δ Novosibirsk**	None	0	-9.688***
Omsk	Constant & trend	1	-2.712	**Δ Omsk**	None	0	-8.317***
Tomsk	Constant	1	-2.052	**Δ Tomsk**	None	0	-6.737***
Tyumen	Constant & trend	0	-2.460	**Δ Tyumen**	None	0	-11.38***
				USA (regional) 07/2008 – 06/2011			
Arkansas	Constant & trend	1	-3.018	**Δ Arkansas**	None	0	-10.22***
California	Constant & trend	0	-3.080	**Δ California**	None	0	-11.94***
Colorado	Constant & trend	1	-2.548	**Δ Colorado**	None	0	-10.19***
Illinois	Constant & trend	1	-2.816	**Δ Illinois**	None	0	-10.14***
Iowa	Constant & trend	1	-2.753	**Δ Iowa**	None	0	-10.10***
Kansas	Constant & trend	1	-2.607	**Δ Kansas**	None	0	-9.961***
Minnesota	Constant & trend	0	-2.940	**Δ Minnesota**	None	0	-10.31***
Missouri	Constant & trend	0	-3.144*	**Δ Missouri**	None	0	-10.36***
Nebraska	Constant & trend	0	-2.849	**Δ Nebraska**	None	0	-10.54***
Oklahoma	Constant & trend	0	-2.878	**Δ Oklahoma**	None	0	-10.96***

Oregon	Constant & trend	0	-3.088	**Δ Oregon**	None	0	-10.32***
S. Dakota	Constant & trend	0	-2.822	**Δ S. Dakota**	None	0	-10.71***
Texas	Constant & trend	0	-2.948	**Δ Texas**	None	0	-10.25***
Virginia	Constant & trend	0	-3.038	**Δ Virginia**	None	0	-10.35***
Washington	Constant & trend	0	-3.152*	**Δ Washington**	None	0	-10.41***
Wyoming	Constant & trend	0	-2.688	**Δ Wyoming**	None	0	-10.50***
Iowa 07/2010 – 06/2012							
Cedar Rapids	Constant & trend	0	-2.915	**Δ Cedar Rapids**	None	0	-21.64***
Clinton	Constant & trend	0	-3.031	**Δ Clinton**	None	0	-21.91***
Davenport	Constant & trend	0	-3.212*	**Δ Davenport**	None	0	-21.02***
Eddyville	Constant & trend	0	-2.944	**Δ Eddyville**	None	0	-22.29***
Emmetsburg	Constant & trend	0	-3.026	**Δ Emmetsburg**	None	0	-21.91***
Keokuk	Constant & trend	0	-3.266*	**Δ Keokuk**	None	0	-21.14***
Muscatine	Constant & trend	0	-3.127*	**Δ Muscatine**	None	0	-21.48***
W. Burlington	Constant & trend	0	-3.268*	**Δ W. Burlington**	None	0	-21.32***
North Carolina 07/2010 – 06/2012							
Candor	Constant & trend	0	-2.844	**Δ Candor**	None	0	-23.36***
Cofield	Constant & trend	0	-2.984	**Δ Cofield**	None	0	-22.34***
Creswell	Constant & trend	0	-2.842	**Δ Creswell**	None	0	-23.48***
Laurinburg	Constant & trend	0	-2.906	**Δ Laurinburg**	None	0	-22.33***
Roaring River	Constant & trend	1	-2.916	**Δ Roaring River**	None	0	-27.18***
Rose Hill	Constant & trend	0	-2.906	**Δ Rose Hill**	None	0	-22.32***
Statesville	Constant & trend	0	-3.123*	**Δ Statesville**	None	0	-21.88***

Note: Prices are given in natural logarithm. The asterisks refer to the significance at 1% (***), 5% (**) and 10% (*) levels. Lag length selection is based on Schwarz Information Criterion. One-sided p-values are from MacKinnon (1996).
Source: Own calculations.

Table A2. Tests of threshold cointegration:
a) Russia (regional) 2009/10

Price series	Specification		Hansen & Seo test (2002) [a]		Larsen test (2012) [b]
	Intercept	Lags	Sup-Wald test statistic	5% critical value	P-value
Central – Black Earth	yes	1	11.111	18.398	**0.061**
Central – Volga	yes	2	**20.817***	21.537	0.512
Central – Urals	no	2	**20.363*****	18.295	0.140
Central – West Siberia	yes	2	**19.219***	20.598	**0.100**
North Caucasus – Central	no	2	**21.037*****	20.011	**0.033**
North Caucasus – Black Earth	no	1	**13.932***	14.233	**0.082**
North Caucasus – Volga	no	2	**21.666*****	18.378	**0.043**
North Caucasus – Urals	no	2	**24.227*****	18.548	**0.008**
North Caucasus – West Siberia	no	2	**20.543****	19.168	**0.040**
Black Earth – Volga	yes	3	**24.383***	05.088	**0.070**
Black Earth – Urals	yes	3	**25.332*****	24.907	**0.010**
Black Earth – West Siberia	yes	1	**15.223***	16.237	**0.080**
Volga – Urals	no	2	**17.746***	18.340	0.417
Volga – West Siberia	no	1	**12.149***	13.192	**0.076**
Urals – West Siberia	no	2	**18.002***	18.360	0.507

Note: Sample runs from 7/3/2009 to 6/25/2010 (52 obs.)

b) Russia (regional) 2010/11

Price series	Specification		Hansen & Seo test (2002) [a]		Larsen test (2012) [b]
	Intercept	Lags	Sup-Wald test statistic	5% critical value	P-value

Central – Black Earth	no	2	**18.477****	18.042	**0.032**
Central – Volga	no	2	**18.477*****	17.512	**0.027**
Central – Urals	no	2	**20.360****	19.903	**0.080**
Central – West Siberia	yes	1	**16.407***	17.643	0.358
North Caucasus – Central	yes	1	**15.189****	14.963	**0.081**
North Caucasus – Black Earth	yes	1	**15.038***	15.524	**0.047**
North Caucasus – Volga	no	3	**23.181****	23.167	**0.030**
North Caucasus – Urals	no	2	**23.871*****	17.998	0.130
North Caucasus – West Siberia	yes	1	14.983	17.988	0.264
Black Earth – Volga	no	3	**23.722****	13.249	0.446
Black Earth – Urals	no	1	11.489	13.571	0.169
Black Earth – West Siberia	no	3	**25.341*****	23.204	**0.040**
Volga – Urals	no	3	**24.684****	23.650	0.203
Volga – West Siberia	no	3	**24.313****	23.285	**0.108**
Urals – West Siberia	no	1	8.536	13.635	0.132

Note: Sample runs from 7/2/2010 to 6/24/2011 (52 obs.)

d) North Caucasus (Russia)

Price series	Specification		Hansen & Seo test (2002) [a]		Larsen test (2012) [b]
	Intercept	Lags	Sup-Wald test statistic	5% critical value	P-value
Adygea – Krasnodar	no	5	**33.365****	33.132	**0.017**
Adygea – Rostov	yes	5	16.635	22.353	**0.071**
Adygea – Stavropol	yes	5	**29.552***	31.008	**0.032**
Krasnodar – Rostov	no	5	**19.929*****	14.370	**0.005**
Krasnodar – Stavropol	no	5	**14.829****	14.603	**0.059**
Rostov – Stavropol	no	5	**19.970*****	14.208	**0.002**

Note: Sample runs from 7/01/2011 to 9/01/2016 (125 obs.). Sample containing Adygea runs from 7/01/2013 to 9/01/2016 (77 obs.).

e) West Siberia (Russia)

Price series	Specification		Hansen & Seo test (2002) [a]		Larsen test (2012) [b]
	Intercept	Lags	Sup-Wald test statistic	5% critical value	P-value
Kemerovo – Altai	yes	2	**23.137****	22.828	**0.039**
Kemerovo – Novosibirsk	yes	2	**27.360*****	21.975	**0.029**
Kemerovo – Omsk	no	1	**20.482*****	14.081	**0.009**
Kemerovo – Tomsk	no	2	**19.149***	20.155	**0.067**
Novosibirsk – Altai	no	2	**19.790***	20.568	0.307
Novosibirsk – Omsk	no	1	**19.122*****	14.382	**0.009**
Novosibirsk – Tyumen	no	1	11.444	14.608	**0.037**
Tomsk – Novosibirsk	no	1	**19.151*****	15.103	**0.013**
Tomsk – Altai	no	2	**21.258****	19.785	0.126
Tomsk – Omsk	no	1	**19.094*****	14.804	**0.004**
Tomsk – Tyumen	no	1	**16.832****	15.465	**0.044**
Altai – Omsk	yes	3	**27.514***	27.819	**0.021**
Altai – Tyumen	no	1	**15.165***	15.171	**0.003**
Tyumen – Kemerovo	yes	2	**22.884****	21.928	**0.002**
Tyumen – Omsk	no	1	**20.173*****	15.508	**0.001**

Note: Sample runs from 7/01/2011 to 9/01/2016 (125 obs.). Sample with Kemerovo runs from 9/01/2012 to 9/01/2016 (97 obs.).

f) Iowa (the USA)

Price series	Specification	Hansen & Seo test (2002) [a]	Larsen test (2012) [b]

	Intercept	Lags	Sup-Wald test statistic	5% critical value	P-value
Cedar Rapids – Emmetsburg	no	3	24.431	28.050	0.217
Clinton – Cedar Rapids	no	2	**27.187*** **	22.215	**0.074**
Clinton – Davenport	no	2	**24.477** **	23.376	**0.066**
Clinton – Emmetsburg	no	2	19.137	23.281	**0.061**
Clinton – Muscatine	yes	2	**25.395***	26.041	0.209
Davenport – Cedar Rapids	no	2	20.054	23.636	0.176
Davenport – S. Emmetsburg	no	2	**32.241*** **	23.040	**0.001**
Eddyville – Cedar Rapids	no	2	**25.386** **	23.167	**0.019**
Eddyville – Clinton	no	2	**21.868***	22.735	**0.074**
Eddyville – Davenport	no	2	**35.571*** **	23.287	**0.000**
Eddyville – Emmetsburg	no	2	**29.665*** **	23.347	**0.013**
Eddyville – Keokuk	no	2	**30.147*** **	23.205	**0.007**
Eddyville – Muscatine	no	4	28.437	33.871	0.190
Keokuk – Cedar Rapids	no	4	31.472	33.946	0.250
Keokuk – Clinton	no	1	**25.649*** **	16.836	**0.001**
Keokuk – Davenport	no	2	**30.148*** **	23.290	**0.006**
Keokuk – Emmetsburg	no	2	20.434	22.508	0.153
Keokuk – Muscatine	no	2	**26.417*** **	22.629	**0.026**
Muscatine – Cedar Rapids	no	2	**32.400*** **	17.332	**0.000**
Muscatine – Davenport	no	2	**21.769***	23.465	**0.020**
Muscatine – Emmetsburg	no	2	**30.974*** **	22.924	**0.016**
West Burlington – Cedar Rapids	no	4	**39.530*** **	33.104	**0.015**
West Burlington – Clinton	no	2	20.466	22.638	0.342
West Burlington – Davenport	no	4	**36.641** **	34.202	**0.033**
West Burlington – Eddyville	no	4	**39.114*** **	33.906	**0.026**
West Burlington – Emmetsburg	no	2	**21.803***	22.424	0.290
West Burlington – Keokuk	no	4	**31.696***	33.709	**0.059**

Note: Sample runs from 6/25/2010 to 6/01/2012 (506 obs.). The asterisks refer to the significance at 1% (***), 5% (**) and 10% (*) levels.

g) North Carolina (the USA)

Price series	Specification		Hansen & Seo test (2002) [a]		Larsen test (2012) [b]
	Intercept	Lags	Sup-Wald test statistic	5% critical value	P-value
Candor – Creswell	no	2	**23.120** **	21.675	**0.007**
Cofield – Candor	no	1	**23.179*** **	17.185	**0.005**
Cofield – Creswell	no	1	**34.182*** **	17.031	**0.000**
Laurinburg – Candor	no	3	**30.420** **	27.055	0.150
Laurinburg – Cofield	no	3	**31.259** **	28.029	0.134
Laurinburg – Creswell	no	2	**24.169** **	22.374	**0.064**
Laurinburg – Roaring River	no	3	20.899	28.304	0.604
Laurinburg – Statesville	no	3	**30.895** **	27.819	**0.016**
Roaring River – Candor	no	3	**33.271*** **	27.880	0.283
Roaring River – Cofield	no	4	**31.830***	33.638	**0.007**
Roaring River – Creswell	no	4	30.025	33.727	0.533
Roaring River – Statesville	no	3	28.335	28.316	**0.033**
Statesville – Candor	no	3	**35.062*** **	27.807	**0.060**
Statesville – Cofield	no	2	**26.437*** **	22.143	**0.009**
Statesville – Creswell	no	2	**44.873*** **	21.756	**0.000**

Note: Sample runs from 6/25/2010 to 6/01/2012 (506 obs.). The asterisks refer to the significance at 1% (***), 5% (**) and 10% (*) levels.[a]: H_0: linear cointegration | H_1: threshold cointegration. 1 threshold, trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is 'fixed Regression'.
[b]: H_0: linear cointegration | H_1: threshold cointegration. 2 thresholds, trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is 'fixed Regression'.

Source: Own estimations.

Table A3: Parameters of the long-run price equilibrium regression

a) North Caucasus (Russia)

Dependent variable	Independent variable	Distance (km)	Long-run price transmission elasticities	Intercept parameter
Adygea	**Krasnodar**	132	0.915***	0.777
Adygea	**Rostov**	344	0.863***	1.182
Adygea	**Stavropol**	229	0.763***	2.159***
Krasnodar	**Rostov**	277	0.867***	1.165***
Krasnodar	**Stavropol**	297	0.745***	2.309***
Rostov	**Stavropol**	343	0.799***	1.863***

b) West Siberia (Russia)

Dependent variable	Independent variable	Distance (km)	Long-run price transmission elasticities	Intercept parameter
Kemerovo	**Altai**	411	0.526***	4.925***
Kemerovo	**Novosibirsk**	267	0.649***	3.219***
Kemerovo	**Omsk**	906	0.549***	4.134***
Kemerovo	**Tomsk**	218	0.595***	3.632***
Novosibirsk	**Altai**	226	0.916***	0.690**
Novosibirsk	**Omsk**	654	0.843***	1.440***
Novosibirsk	**Tyumen**	1280	0.888***	1.055***
Tomsk	**Novosibirsk**	268	0.876***	1.230***
Tomsk	**Altai**	490	0.920***	0.782***
Tomsk	**Omsk**	911	0.807***	1.879***
Tomsk	**Tyumen**	1538	0.841***	1.589***
Altai	**Omsk**	880	0.861***	1.338***
Altai	**Tyumen**	1504	0.882***	1.173***
Tyumen	**Kemerovo**	1548	0.879***	1.016
Tyumen	**Omsk**	624	0.832***	1.480***
Tyumen	**Omsk**	624	0.832***	1.480***

c) Iowa (the USA)

Dependent variable	Independent variable	Distance (km)	Long-run price transmission elasticities	Intercept parameter
Cedar Rapirs	**Emmetsburg**	354	0.918***	0.483***
Clinton	**Cedar Rapids**	138	0.984***	0.097***
Clinton	**Davenport**	66	0.979***	0.139***
Clinton	**Emmetsburg**	489	0.905***	0.564***
Clinton	**Muscatine**	114	0.984***	0.100***
Davenport	**Cedar Rapids**	129	0.992***	0.027
Davenport	**Emmetsburg**	483	0.919***	0.459***
Eddyville	**Cedar Rapids**	174	0.964***	0.190***
Eddyville	**Clinton**	290	0.978***	0.104***
Eddyville	**Davenport**	240	0.963***	0.210***
Eddyville	**Emmetsburg**	367	0.889***	0.633***
Eddyville	**Keokuk**	182	0.991***	0.036
Eddyville	**Muscatine**	166	0.966***	0.181***
Keokuk	**Cedar Rapids**	188	0.968***	0.180***
Keokuk	**Clinton**	253	0.982***	0.096***
Keokuk	**Davenport**	190	0.969***	0.191***
Keokuk	**Emmetsburg**	542	0.893***	0.626***
Keokuk	**Muscatine**	140	0.971***	0.170***
Muscatine	**Cedar Rapids**	105	0.994***	0.031
Muscatine	**Davenport**	48	0.991***	0.063**

Muscatine	**Emmetsburg**	462	0.916***	0.490***
West Burlington	**Cedar Rapids**	159	0.963***	0.203***
West Burlington	**Clinton**	193	0.978***	0.115***
West Burlington	**Davenport**	126	0.965***	0.211***
West Burlington	**Eddyville**	151	0.997***	0.008
West Burlington	**Emmetsburg**	512	0.888***	0.647***
West Burlington	**Keokuk**	66	0.993***	0.035**

d) North Carolina (the USA)

Dependent variable	Independent variable	Distance (km)	Long-run price transmission elasticities	Intercept parameter
Candor	**Creswell**	360	0.864***	0.846***
Cofield	**Candor**	333	0.994***	-0.009
Cofield	**Creswell**	97	0.872***	0.760***
Laurinburg	**Candor**	71	0.925***	0.396***
Laurinburg	**Cofield**	343	0.927***	0.426***
Laurinburg	**Creswell**	370	0.812***	1.110***
Laurinburg	**Roaring River**	261	0.968***	0.159***
Laurinburg	**Statesville**	211	0.906***	0.536***
Roaring River	**Candor**	192	0.943***	0.321***
Roaring River	**Cofield**	286	0.935***	0.400***
Roaring River	**Creswell**	475	0.819***	1.093***
Roaring River	**Statesville**	65	0.918***	0.488***
Statesville	**Candor**	157	1.009***	-0.082*
Statesville	**Cofield**	439	1.005***	-0.018
Statesville	**Creswell**	470	0.878***	0.736***

Note: The asterisks refer to the significance at 1% (***), 5% (**) and 10% (*) levels.
Source: Own estimations.

Table A4. Results of TVECM:
a) North Caucasus, Russia

	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	**Adygeya - Krasnodar**	**-0.306**	0.000	***-0.109***	0.027	0.475	***0.084***	-0.078	0.196	**0.306**	**-**	**-**	***0.192***
	Krasnodar - Adygeya	0.115	0.330		-0.066	0.441		0.133	0.215	8	47	14	
2	**Adygeya - Stavropol**	**-0.222**	0.002	***-0.131***	-0.103	0.122	***0.107***	-0.095	0.137	**0.222**	**-**	**-**	***0.238***
	Stavropol - Adygeya	***-0.130***	0.057		0.036	0.570		0.050	0.414	11	53	10	
3	**Adygeya -Urals**	**-0.237**	0.001	***-0.136***	**-0.111**	0.043	***0.089***	**-0.111**	0.043	**0.237**	**0.111**	**0.111**	***0.224***
	Urals - Adygeya	-0.036	0.679		0.131	0.142		0.131	0.142	7	52	15	
4	**Krasnodar - Rostov**	**-0.513**	0.064	***-0.140***	**-0.148**	0.018	***0.143***	0.316	0.748	**0.513**	**0.148**	**-**	***0.283***
	Rostov - Krasnodar	***-0.689***	0.032		-0.086	0.302		0.989	0.321	3	117	2	
5	**Krasnodar - Stavropol**	-0.117	0.458	***-0.223***	**-0.151**	0.016	***0.122***	**-0.129**	0.102	**0.486**	**0.384**	**0.129**	***0.345***
	Stavropol - Krasnodar	**0.486**	0.007		**0.232**	0.012		0.059	0.580	1	114	8	
6	**Rostov - Stavropol**	-0.164	0.359	***-0.283***	-0.085	0.289	***0.041***	-0.130	0.158	**0.730**	**0.219**	**0.148**	***0.325***
	Stavropol - Rostov	**0.730**	0.000		**0.219**	0.006		**0.148**	0.011	1	84	38	

b) West Siberia, Russia

	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	**Kemerovo – Altai**	**-0.204**	0.037	***-0.176***	**-0.198**	0.038	***0.049***	**-0.172**	0.066	**0.204**	**0.198**	**0.172**	***0.226***
	Altai – Kemerovo	-0.127	0.225		-0.096	0.353		***-0.188***	0.062	4	60	30	
2	**Kemerovo – Novosibirsk**	**-0.483**	0.006	***-0.085***	-0.063	0.576	***0.060***	-0.063	0.576	**0.483**	**0.331**	**0.331**	***0.146***
	Novosibirsk – Kemerovo	0.151	0.429		**0.331**	0.014		**0.331**	0.014	8	73	13	
3	**Kemerovo – Omsk**	**-0.318**	0.026	***-0.120***	**-0.191**	0.038	***0.147***	**-0.366**	0.015	**0.318**	**0.191**	**0.366**	***0.267***
	Omsk – Kemerovo	-0.012	0.940		0.124	0.319		-0.175	0.317	5	86	2	
4	**Kemerovo – Tomsk**	**-0.786**	0.000	***-0.099***	-0.042	0.578	***0.088***	**-0.491**	0.018	**0.786**	-	**0.491**	***0.187***
	Tomsk – Kemerovo	-0.285	0.218		0.013	0.917		***-0.577***	0.020	11	78	5	
5	**Novosibirsk – Altai**	**-0.456**	0.000	***-0.257***	**-0.364**	0.000	***0.157***	**-0.333**	0.000	**0.456**	**0.364**	**0.333**	***0.413***
	Altai – Novosibirsk	-0.076	0.297		-0.047	0.459		-0.037	0.518	4	108	10	
6	**Novosibirsk – Omsk**	**-0.304**	0.001	***-0.166***	**-0.149**	0.009	***0.192***	**-0.310**	0.002	**0.304**	**0.383**	**0.310**	***0.358***
	Omsk – Novosibirsk	0.099	0.410		**0.235**	0.003		0.117	0.335	7	112	4	
7	**Novosibirsk – Tyumen**	0.126	0.321	***-0.364***	**-0.133**	0.010	***0.105***	-0.042	0.450	**0.310**	**0.133**	**0.157**	***0.469***

	Tyumen – Novosibirsk	**0.310**	0.030		0.085	0.201		**0.157**	0.027	1	93	29	
8	**Tomsk – Novosibirsk**	-0.024	0.719	***-0.128***	0.026	0.738	***0.157***	0.024	0.769	**0.329**	**0.243**	**0.416**	***0.285***
	Novosibirsk – Tomsk	**0.329**	0.000		**0.243**	0.001		**0.416**	0.000	11	107	5	
9	**Tomsk – Altai**	**-0.386**	0.001	***-0.047***	**-0.497**	0.002	***0.014***	**-0.362**	0.000	**0.386**	**0.497**	**0.362**	***0.061***
	Altai – Tomsk	0.015	0.896		-0.084	0.606		0.092	0.374	16	61	45	
10	**Tomsk – Omsk**	**-0.194**	0.025	***-0.068***	-0.079	0.447	***0.105***	-0.049	0.547	**0.194**	**0.261**	**0.407**	***0.172***
	Omsk – Tomsk	0.155	0.120		**0.261**	0.026		**0.407**	0.000	20	95	8	
11	**Tomsk – Tyumen**	0.017	0.805	***-0.176***	-0.024	0.558	***0.132***	-0.002	0.971	**0.361**	**0.214**	**0.224**	***0.308***
	Tyumen – Tomsk	**0.361**	0.000		**0.214**	0.001		**0.224**	0.003	7	94	22	
12	**Altai – Omsk**	**-0.177**	0.044	***-0.113***	***0.216***	0.048	***0.019***	0.104	0.221	**0.177**	**0.441**	**0.461**	***0.132***
	Omsk – Altai	0.165	0.118		**0.441**	0.001		**0.461**	0.000	11	51	59	
13	**Altai – Tyumen**	-0.072	0.138	***-0.225***	0.008	0.816	***0.171***	0.008	0.816	**0.241**	**0.208**	**0.208**	***0.396***
	Tyumen – Altai	**0.241**	0.001		**0.208**	0.001		**0.208**	0.001	6	100	16	
14	**Tyumen – Kemerovo**	-0.089	0.368	***-0.109***	-0.175	0.157	***0.101***	-0.089	0.368	-	-	-	***0.210***
	Kemerovo – Tyumen	0.110	0.128		-0.086	0.358		0.110	0.128	19	48	17	
15	**Tyumen – Omsk**	**-0.322**	0.000	***-0.114***	**-0.318**	0.000	***0.125***	**-0.322**	0.000	**0.322**	**0.318**	**0.322**	***0.239***
	Omsk – Tyumen	-0.002	0.972		-0.004	0.951		-0.002	0.972	27	74	12	

c) Iowa, the USA

	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	**Cedar Rapids – Emmetsburg**	**-0.812**	0.063	***-0.012***	**-0.807**	0.067	***0.008***	**-0.812**	0.063	**0.812**	**0.807**	**0.812**	***0.020***
	Emmetsburg – Cedar Rapids	-0.554	0.372		-0.549	0.381		-0.554	0.372	121	226	153	
2	**Clinton – Cedar Rapids**	-0.959	0.387	***-0.024***	**-0.996**	0.053	***0.012***	-0.887	0.552	**-**	**0.996**	-	***0.037***
	Cedar Rapids – Clinton	0.983	0.279		-0.695	0.621		0.982	0.303	3	481	16	
3	**Clinton – Davenport**	**-0.891**	0.083	***-0.009***	0.818	0.130	***0.039***	**-0.891**	0.083	**0.891**	**-**	**0.891**	***0.048***
	Davenport – Clinton	-0.204	0.851		0.239	0.803		-0.204	0.851	158	334	8	
4	**Clinton – Emmetsburg**	**-0.879**	0.046	***-0.001***	0.795	0.191	***0.021***	**-0.921**	0.028	**0.879**	**-**	**0.921**	***0.021***
	Emmetsburg – Clinton	-0.648	0.317		0.452	0.613		-0.702	0.280	254	190	56	
5	**Clinton – Muscatine**	0.783	0.477	***-0.025***	0.825	0.293	***0.017***	0.629	0.618	**0.999**	**-**	**0.998**	***0.042***
	Muscatine – Clinton	**0.999**	0.010		0.808	0.313		**0.998**	0.009	9	460	31	
6	**Davenport – Cedar Rapids**	0.418	0.662	***-0.032***	0.491	0.523	***0.028***	-0.491	0.523	**0.899**	**-**	**-**	***0.059***
	Cedar Rapids – Davenport	**0.899**	0.075		0.468	0.537		0.468	0.537	26	460	14	
7	**Davenport – Emmetsburg**	**-0.917**	0.059	***-0.023***	**-0.960**	0.022	***0.010***	**-0.921**	0.054	**0.917**	**0.960**	**0.921**	***0.033***
	Emmetsburg – Davenport	-0.319	0.754		0.711	0.346		-0.372	0.706	18	377	105	
8	**Eddyville – Cedar Rapids**	0.460	0.733	***-0.045***	0.626	0.373	***0.028***	0.460	0.733	**0.986**	**-**	**0.986**	***0.073***

	Cedar Rapids – Eddyville	**0.986**	0.035		0.541	0.463		**0.986**	0.035	6	473	21	
9	**Eddyville – Clinton**	-0.516	0.666	***-0.028***	0.506	0.538	***0.032***	-0.114	0.945	**-**	**-**	**0.988**	***0.060***
	Clinton – Eddyville	0.927	0.138		0.642	0.363		**0.988**	0.027	20	462	18	
10	**Eddyville – Davenport**	-0.688	0.238	***-0.002***	0.750	0.463	***0.001***	-0.637	0.282	**-**	**-**	**-**	***0.003***
	Davenport – Eddyville	0.429	0.561		0.387	0.788		0.486	0.473	252	37	211	
11	**Eddyville – Emmetsburg**	**-0.958**	0.016	***-0.034***	**-0.900**	0.034	***0.022***	-0.668	0.165	**0.958**	**0.900**	**-**	***0.056***
	Emmetsburg – Eddyville	-0.828	0.163		-0.689	0.267		0.100	0.891	20	400	83	
12	**Eddyville – Keokuk**	**-0.981**	0.026	***-0.026***	**-0.954**	0.031	***0.014***	-0.880	0.143	**0.981**	**0.954**	**-**	***0.041***
	Keokuk – Eddyville	-0.299	0.819		0.425	0.668		0.735	0.340	17	414	72	
13	**Eddyville – Muscatine**	0.058	0.965	***-0.031***	0.329	0.725	***0.023***	0.116	0.920	**-**	**-**	**0.900**	***0.054***
	Muscatine – Eddyville	0.876	0.139		0.729	0.251		**0.900**	0.075	11	449	40	
14	**Keokuk – Cedar Rapids**	-0.603	0.574	***-0.033***	0.082	0.938	***0.040***	-0.651	0.542	-	-	-	***0.073***
	Cedar Rapids – Keokuk	0.810	0.326		0.828	0.128		0.814	0.340	14	485	1	
15	**Keokuk – Clinton**	***0.999***	0.090	***-0.060***	0.189	0.845	***0.033***	***0.999***	0.090	**0.001**	**-**	**0.060**	***0.093***
	Clinton – Keokuk	**0.999**	0.010		0.830	0.116		**0.999**	0.010	1	492	7	
16	**Keokuk – Davenport**	**-0.928**	0.073	***-0.026***	0.087	0.940	***0.016***	**-0.917**	0.090	**0.928**	**-**	**0.917**	***0.042***
	Davenport – Keokuk	0.279	0.815		0.877	0.121		0.333	0.773	13	425	62	
17	**Keokuk – Emmetsburg**	-0.553	0.289	***-0.011***	-0.553	0.289	***0.035***	-0.553	0.289	**-**	**-**	**-**	***0.046***
	Emmetsburg – Keokuk	0.259	0.695		0.259	0.695		0.259	0.695	139	343	21	
18	**Keokuk – Muscatine**	0.595	0.415	***-0.021***	0.589	0.411	***0.027***	0.592	0.416	**0.924**	**0.917**	**0.922**	***0.048***
	Muscatine – Keokuk	0.924	0.027		0.917	0.028		0.922	0.028	22	455	23	
19	**Muscatine – Cedar Rapids**	-0.889	0.260	***-0.041***	**-0.989**	0.008	***0.012***	-0.915	0.207	**-**	**0.989**	**-**	***0.053***
	Cedar Rapids – Muscatine	0.735	0.483		-0.678	0.459		0.557	0.659	2	424	74	
20	**Muscatine – Davenport**	**-0.907**	0.024	***-0.008***	**-0.905**	0.025	***0.011***	**-0.905**	0.025	**0.907**	**0.905**	**0.905**	***0.019***
	Davenport – Muscatine	-0.457	0.548		-0.449	0.559		-0.449	0.559	170	202	128	
21	**Muscatine – Emmetsburg**	**-0.910**	0.021	***-0.013***	**-0.910**	0.021	***0.012***	**-0.918**	0.009	**0.910**	**0.910**	**0.918**	***0.024***
	Emmetsburg – Muscatine	-0.729	0.204		-0.729	0.204		-0.722	0.180	109	277	114	
22	**W. Burlington – Cedar Rapids**	***0.999***	0.034	***-0.066***	-0.537	0.470	***0.039***	***0.999***	0.034	**0.999**	-	**0.999**	***0.105***
	Cedar Rapids – W. Burlington	**0.999**	0.003		0.360	0.675		**0.999**	0.003	1	494	5	
23	**W. Burlington – Clinton**	***0.999***	0.001	***-0.063***	-0.757	0.225	***0.025***	***0.999***	0.001	**0.999**	**-**	**0.999**	***0.088***
	Clinton – W. Burlington	**0.999**	0.000		-0.046	0.967		**0.999**	0.000	1	487	12	
24	**W. Burlington – Davenport**	-0.731	0.642	***-0.033***	-0.605	0.422	***0.031***	0.871	0.400	**-**	**-**	**0.996**	***0.063***
	Davenport – W. Burlington	0.678	0.692		0.105	0.926		**0.996**	0.053	3	486	11	
25	**W. Burlington – Eddyville**	-0.079	0.961	***-0.034***	-0.194	0.876	***0.016***	0.503	0.671	**-0.960**	**-0.945**	**-0.918**	***0.050***
	Eddyville – W. Burlington	***-0.960***	0.100		***-0.945***	0.067		-0.918	0.167	2	440	58	
26	**W. Burlington – Emmetsburg**	-0.580	0.245	***-0.012***	-0.201	0.796	***0.025***	-0.201	0.796	**-**	**-**	**-**	***0.036***
	Emmetsburg – W. Burlington	-0.081	0.912		0.438	0.529		0.438	0.529	139	322	42	
27	**W. Burlington – Keokuk**	-0.983	0.132	***-0.021***	**-0.996**	0.036	***0.014***	-0.947	0.256	**-**	**0.996**	**-**	***0.035***
	Keokuk – W. Burlington	-0.066	0.977		-0.733	0.571		0.590	0.717	10	459	31	

d) North Carolina, the USA

	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	**Candor – Creswell**	**-0.804**	0.018	***-0.012***	-0.468	0.338	***0.029***	-0.475	0.300	**0.804**	**-**	**-**	***0.040***
	Creswell – Candor	-0.588	0.241		0.151	0.822		0.187	0.765	236	173	91	
2	**Cofield – Candor**	**-0.761**	0.097	***-0.025***	-0.773	0.116	***0.019***	-0.773	0.116	**0.761**	**-**	**-**	***0.044***
	Candor – Cofield	-0.449	0.457		-0.494	0.439		-0.494	0.439	52	352	96	
3	**Cofield – Creswell**	**-0.942**	0.001	***-0.043***	**-0.926**	0.002	***0.024***	**-0.761**	0.067	**0. 942**	**0. 926**	**0.761**	***0.067***
	Creswell – Cofield	***-0.798***	0.070		***-0.761***	0.098		-0.257	0.719	4	409	87	
4	**Laurinburg – Candor**	-0.657	0.123	***-0.032***	-0.653	0.126	***0.015***	**-0.713**	0.061	**-**	**-**	**0.713**	***0.047***
	Candor – Laurinburg	-0.454	0.361		-0.441	0.379		-0.547	0.216	47	360	93	
5	**Laurinburg – Cofield**	**-0.831**	0.078	***-0.049***	-0.774	0.119	***0.003***	**-0.820**	0.070	**0.831**	**-**	**0.820**	***0.051***
	Cofield – Laurinburg	-0.409	0.590		-0.443	0.531		-0.289	0.710	10	276	214	
6	**Laurinburg – Creswell**	**-0.729**	0.035	***-0.034***	**-0.945**	0.002	***0.010***	**-0.729**	0.035	**0. 729**	**0.945**	**0.729**	***0.044***
	Creswell – Laurinburg	-0.458	0.367		***-0.886***	0.026		-0.458	0.367	34	341	125	
7	**Laurinburg – Roaring River**	-0.622	0.227	***-0.050***	-0.622	0.227	***0.037***	-0.764	0.586	**-**	**-**	**0.999**	***0.088***
	Roaring River – Laurinburg	-0.125	0.876		-0.125	0.876		**0.999**	0.034	2	495	3	
8	**Laurinburg – Statesville**	0.178	0.843	***-0.058***	-0.730	0.166	***0.016***	0.178	0.843	**0.910**	**-**	**0.910**	***0.074***
	Statesville – Laurinburg	**0.910**	0.025		0.049	0.956		**0.910**	0.025	10	428	62	
9	**Roaring River – Candor**	**-1.000**	0.000	***-0.029***	-0.871	0.106	***0.024***	-0.720	0.273	**1.000**	**-**	**-**	***0.053***
	Candor – Roaring River	***-0.965***	0.099		-0.780	0.184		-0.277	0.753	11	443	46	
10	**Roaring River – Cofield**	**-0.991**	0.008	***-0.144***	-0.686	0.210	***0.034***	-0.686	0.210	**0.991**	**-**	**-**	***0.178***
	Cofield – Roaring River	-0.103	0.942		-0.070	0.930		-0.070	0.930	3	474	23	
11	**Roaring River – Creswell**	**-0.997**	0.000	***-0.125***	**-0.756**	0.027	***0.035***	**-0.756**	0.027	**0.997**	**0.756**	**0.756**	***0.160***
	Creswell – Roaring River	-0.050	0.965		-0.618	0.132		-0.618	0.132	3	421	76	
12	**Roaring River – Statesville**	**-0.991**	0.026	***-0.129***	-0.477	0.531	***0.028***	-0.494	0.543	**1.972**	**0.865**	**0.900**	***0.157***
	Statesville – Roaring River	**0.981**	0.045		**0.865**	0.043		**0.900**	0.036	3	478	19	
13	**Statesville – Candor**	***0.832***	0.052	***-0.051***	-0.252	0.690	***0.016***	***0.832***	0.052	**0.961**	**-**	**0.961**	***0.068***
	Candor – Statesville	**0.961**	0.001		0.449	0.429		**0.961**	0.001	8	398	94	
14	**Statesville – Cofield**	0.204	0.747	***-0.034***	-0.151	0.828	***0.027***	-0.214	0.737	**0.741**	**-**	**-**	***0.061***
	Cofield – Statesville	**0.741**	0.062		0.591	0.241		0.539	0.281	28	420	52	
15	**Statesville – Creswell**	**-0.879**	0.005	***-0.046***	**-0.914**	0.001	***0.004***	**-0.795**	0.003	**0.879**	**0.914**	**0.795**	***0.050***
	Creswell – Statesville	0.617	0.211		-0.710	0.102		-0.544	0.168	28	274	198	

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.Speed of adjustment coefficients which have opposite sign than threoretically exected and are significant at least at 0.10 level are given in italic. Speed of adjustment parameters for Iowa and North Carolina in tabels c) and d) are adjusted from daily to by-weekly frequencies in order to make coefficients comparable with the estimates for North Caucasus and West Siberia in tables a) and b). Source: Own estimations.

Table A5: Parameters of the long-run price equilibrium regression, the USA 2008/11

Dependent variable	Independent variable	distance	Slope	Intercept	P-value
Arkansas	**Illinois**	595	0.967	0.177	<0.001
Arkansas	**Iowa**	475	0.974	0.161	<0.001
Arkansas	**Kansas**	993	0.941	0.325	<0.001
Arkansas	**Minnesota**	531	0.953	0.279	<0.001
Arkansas	**Missouri**	393	0.929	0.406	<0.001
Arkansas	**Nebraska**	581	0.979	0.109	0.094
Arkansas	**South Dakota**	1144	0.894	0.593	<0.001
California	**Illinois**	3288	0.764	1.968	<0.001
California	**Iowa**	3084	0.776	1.93	<0.001
California	**Kansas**	2356	0.758	2.019	<0.001
California	**Minnesota**	3224	0.761	2.01	<0.001
California	**Missouri**	2945	0.725	2.189	<0.001
California	**Nebraska**	2675	0.784	1.863	<0.001
California	**South Dakota**	2548	0.715	2.258	<0.001
Colorado	**Illinois**	1720	0.982	*0.045*	0.369
Colorado	**Iowa**	1273	0.997	*-0.003*	0.929
Colorado	**Kansas**	494	0.979	0.088	<0.001
Colorado	**Minnesota**	1482	0.978	0.103	<0.001
Colorado	**Missouri**	974	0.929	0.346	<0.001
Colorado	**Nebraska**	866	1.007	-0.082	0.032
Colorado	**South Dakota**	901	0.919	0.418	<0.001
Oklahoma	**Illinois**	1315	1.08	-0.437	<0.001
Oklahoma	**Iowa**	1289	1.093	-0.473	<0.001
Oklahoma	**Kansas**	220	1.078	-0.393	<0.001
Oklahoma	**Minnesota**	1498	1.073	-0.361	<0.001
Oklahoma	**Missouri**	789	1.02	*-0.101*	0.244
Oklahoma	**Nebraska**	874	1.104	-0.558	<0.001
Oklahoma	**South Dakota**	1073	1.009	*-0.016*	0.787
Oregon	**Illinois**	3642	0.777	1.656	<0.001
Oregon	**Iowa**	2836	0.788	1.619	<0.001
Oregon	**Kansas**	2472	0.77	1.708	<0.001
Oregon	**Minnesota**	2926	0.774	1.698	<0.001
Oregon	**Missouri**	2895	0.735	1.889	<0.001
Oregon	**Nebraska**	2660	0.796	1.554	<0.001
Oregon	**South Dakota**	2245	0.728	1.945	<0.001
Texas	**Illinois**	1226	0.951	0.26	<0.001
Texas	**Iowa**	1487	0.963	0.223	<0.001
Texas	**Kansas**	380	0.948	0.3	<0.001
Texas	**Minnesota**	1695	0.945	0.322	<0.001
Texas	**Missouri**	985	0.899	0.553	<0.001
Texas	**Nebraska**	1032	0.972	0.148	<0.001
Texas	**South Dakota**	1262	0.89	0.621	<0.001
Virginia	**Illinois**	1349	0.922	0.49	<0.001
Virginia	**Iowa**	1897	0.929	0.478	<0.001
Virginia	**Kansas**	2356	0.909	0.577	<0.001
Virginia	**Minnesota**	1833	0.908	0.588	<0.001
Virginia	**Missouri**	1754	0.879	0.739	<0.001
Virginia	**Nebraska**	2037	0.934	0.421	<0.001
Virginia	**South Dakota**	2565	0.852	0.887	<0.001
Washington	**Illinois**	3375	0.788	1.574	<0.001
Washington	**Iowa**	2393	0.800	1.538	<0.001
Washington	**Kansas**	2351	0.787	1.602	<0.001
Washington	**Minnesota**	2482	0.785	1.618	<0.001

Washington	**Missouri**	2628	0.746	1.811	<0.001
Washington	**Nebraska**	2342	0.808	1.473	<0.001
Washington	**South Dakota**	1801	0.739	1.870	<0.001
Wyoming	**Illinois**	1782	0.974	0.088	0.079
Wyoming	**Iowa**	1221	0.989	*0.041*	0.285
Wyoming	**Kansas**	721	0.97	0.136	<0.001
Wyoming	**Minnesota**	1310	0.97	0.147	<0.001
Wyoming	**Missouri**	1033	0.921	0.387	<0.001
Wyoming	**Nebraska**	800	0.999	*-0.037*	0.352
Wyoming	**South Dakota**	653	0.912	0.458	<0.001

Note: All slope parameters are significant at a level lower than 1%. Weekly price series include 156 observations recorded between 2008 and 2011 marketing years. Estimation of long-run price transmission coefficients was preceeded by identification of linear or threshold cointegration (Johansen, 1988; Hansen and Seo 2006, Larsen, 2012). Tests confirmed existence of cointegration between regional market pairs in the USA. Results are available from authors upon request.

Source: Own estimations.