Spatial integration of Russian domestic wheat markets

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Paper prepared for presentation at the EAAE 2014 Congress
'Agri-Food and Rural Innovations for Healthier Societies'

August 26 to 29, 2014
Ljubljana, Slovenia

Abstract

This study employs the econometric framework of price transmission to analyze spatial integration of major wheat growing markets in Russia. Russian government frequently intervenes to regulate trade relations by restricting export of wheat abroad in the periods of deficit of supply. Different non-linear models are used to capture the impact of intervention measures. The results show that in isolation from global markets, Russian export-oriented wheat producers increase their presence inside the country and domestic trade becomes more active. As a result, government interventions lead to reduction of wheat deficits.

1. Introduction

Recently Russia became one of the top exporters of grain in the world. In 2002-2010 Russia's grain exports fluctuated in the range of 10-22 million tons annually. It means that about every tenth ton of grains sold in the world market comes from Russian farmers (Rosstat, 2013). The share of wheat in grain cultures exported from Russia amounts to 70%.

Among the factors that determine activity of Russia in world grain trade uncertain weather conditions, big distances and poor transport infrastructure inside the country are mentioned most often. Grain cultures in Russia are grown on the overall territory of more than 50 million hectares that might be subject to extreme fluctuations in the rates of temperature, sun light and precipitation. Dynamics of wheat yield shows that under certain circumstances a relative difference in the amount of harvest reaped might reach 40% on a year-to-year basis (Rosstat, 2013). In the years of deficit harvest, Russian government actively intervened to stem the outflow of grains abroad and preclude excessive oscillations of prices for both grain commodities and related by-products (meal and bread). In the period 2004-2011 measures to restrict grain exports ranged from export duty and export tax that affected particular commodities to complete ban of export of major grain cultures (USDA Foreign Agricultural Service, 2011).

The current study is primarily concerned about the implications of the export ban for integration between spatially distant wheat-growing markets inside Russia. That ban became a reaction of Russian government to the noticeably low harvest in the leading crop growing areas hit by severe drought in the summer of 2010. The authorities went so far as to prohibit the complete export of such products as wheat and flour, maize, barley and rye and flour starting in the middle of August 2010 and until the end of June 2011. Such measure resulted into the drastic reconfiguration of the patterns of wheat trade between Russian regions. After the border was closed, grain-producing regions in the South of the country as well as in West Siberia that remained unaffected by bad weather supplied their stocks to the regions in the Center that suffered most. In fact, that was a visible reversal of trade flows inside the country especially with respect to the regions of North Caucasus, which are predominantly targeted to supply their grain abroad and which usually do not supply grain to domestic markets. Following the abolishment of the export ban in July 2011 North Caucasus grain producers resumed their supplies to outside world and almost halted any shippings inside Russia.

Another aspect that the given study pursues refers to the influence of transaction costs on relations between wheat markets in Russia under the conditions of both export ban and free trade. In the context of agricultural trade, transaction costs are traditionally associated with expenditures to make the realization of contractual arrangements possible and those usually include transportation costs, search costs, costs of insurance, risk premium and others. Transaction costs are high when trade involves transferring of goods between distantly separated regions (Coase, 1937; de Silva *et al.*, 2008). Curtailment of transaction costs played a crucial role in redistribution of wheat from the regions with abundant stocks to the regions with a harsh deficit of grain in the wake of drought in 2010. Specifically, grain producers with stocks situated in the Southern regions as well as in Siberia and Urals were given a privilege of transporting commodity to the drought-hit regions by the means of state rail-way company at special tariffs that were lowered until the end of the export ban period (Russian Railways, 2010).

Using theoretical framework of spatial market integration, this study aims to investigate price relationships when wheat exports to the world market are freely possible compared to the situation of an export ban in 2010-2011. Specifically, price relations between economic regions of North Caucasus, West Siberia, Urals, Black Earth, Central and Volga are in the focus of attention. As a major transport hub, North Caucasus is a strategically important partner for export-oriented producers from other areas. Therefore, one of the primary objectives is to understand whether the selected markets became more integrated or disconnected under the circumstances of their temporary isolation from global trade. Taking into account the significance of transaction costs for spatial integration, this research also makes an explicit endeavor to estimate the value of transportation costs needed to deliver wheat by the means of state railways. Estimated value of transportation costs will be also compared with the official rates of tariffs. This will be done to clarify whether special measures to reduce tariffs for transportation of grains by railways, undertaken by Russian government to stimulate domestic trade, really led to activation of wheat arbitrage.

Another innovation comes from utilization of a novel estimation technique that embraces a shift in the long-run equilibrium relation between spatially separate markets by introducing exogenous variable. Previous methodologies intended to capture non-linear effects within integrated processes were quite efficient in analyzing the changes of short-run dynamics that reflect the impact of transaction costs. At the same time, they were proved largely inadequate in dealing with non-linear behavior emanating from, e.g., fundamental shifts in demand and supply that affect the long-run equilibrium estimator. An approach proposed by Gonzalo and Pitarakis (2006) allows explicitly for the structural break that leads to the split of the initial equilibrium relation in two different equilibria. The timing of the shift directly depends on the realization of the exogenous regressor termed threshold variable. This approach will be used to complement the results of threshold autoregressive model (TAR) widely applied to test for the presence of a threshold in short-run parameters and that might help to shed some light on the magnitude of transportation costs.

2. Market environment and the export ban 2010/2011

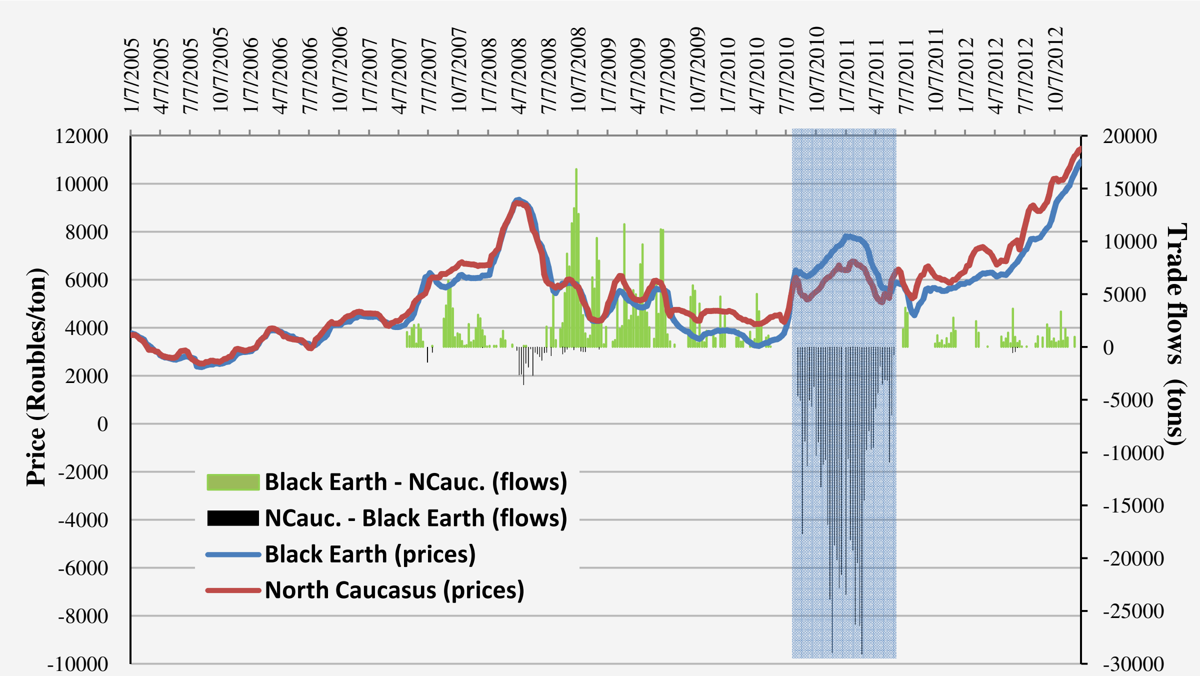

Figure 1. Prices and trade flows for wheat markets in North Caucasus and Black Earth economic regions (2005-2012). The shadowed area covers time of export ban. Black columns show amounts of wheat supplied from North Caucasus to Black Earth**.**

This study is solely dedicated to Russian domestic market of wheat. Wheat remains the most important crop culture for the country's agrarian industry. Averagely, every year around 25 million hectares of arable land (30% of the total area under crops) are allocated to sow wheat either in spring or summer. Wheat sown in summer time (named winter wheat as plants stay lying under the snow cover) is usually cultivated in the Southern and Central areas that include oblasts of Black Earth, North Caucasus and Volga economic regions with relatively mild and snowy winters, but often hot and dry summer months. Spring wheat is grown in the southern areas of West Siberia and Urals economic regions, where sun light and humidity suffice. Due to climatic risks and poor fertilization practices, amount of yield still fluctuates in a wide corridor between 30 and 60 million tons annually if the period 2005-2012 is considered (Rosstat, 2013).

Production of wheat is not evenly distributed across Russia. Biggest crops are traditionally gathered in North Caucasus, West Siberia and Volga, which together account for more than two thirds of the total amount of wheat officially declared by Rosstat. By and large, there are 22 oblasts with significant rates of wheat harvest that form so-called "wheat production belt". In the summer of 2010, most of them were exposed to severe drought that resulted into the steep decline in the amount of crop harvested (Figure 2). For instance, Volga farmers managed to reap just 70% of the amount of wheat produced in 2009. Even worse was the situation in Urals and Black Earth economic regions where the harvest was twice as low as in 2009. Interestingly, the drought went completely unnoticed in North Caucasus that produced even more wheat in 2010 comparably to the year before (Rosstat, 2013).

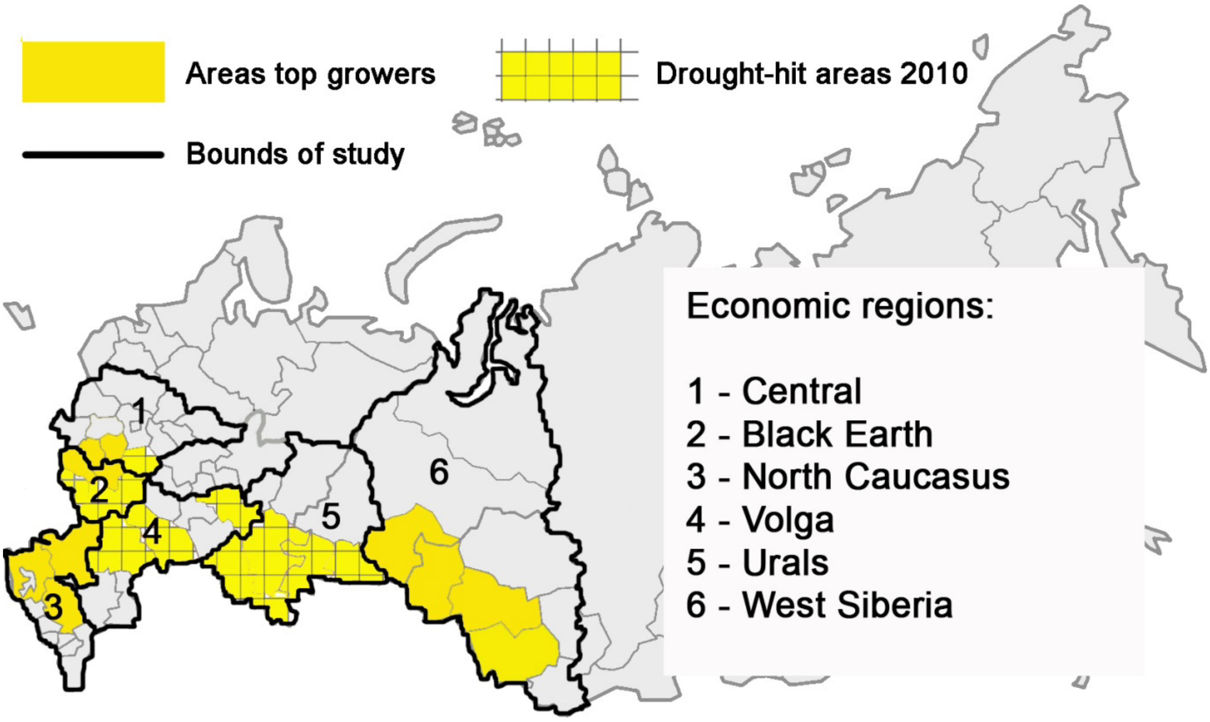

Figure 2. The scope of drought that affected 12 oblasts of wheat production belt

In the attempt to cope with withering supply and raising prices, Russian government stepped in to introduce several measures. First of all, a complete ban to export such products, as wheat and flour, maize, barley and rye and flour was implemented until July 2011. Secondly, it reduced the cost of transportation of grains inside Russia by implementing special railway tariffs for several directions. In particular, Russian railway monopoly cut delivery fees (charge per vagon) by 50% to transport grains from stations in North Caucasus and by 70% from stations in West Siberia. That was done to facilitate redistribution of wheat from the regions of excessive supply (North Caucasus and West Siberia) to the regions suffering from deficit (Volga, North Western and Central federal districts). Discounted tariffs were valid until July 2011 and expired together with export ban (Russian Railways, 2013).

The implemented measures led to a noted reconfiguration of wheat trade links between domestic markets in Russia. Since the border was closed, export-oriented North Caucasus redirected its flows inside the country, mostly supplying to neighboring economic regions of Volga, Black Earth and Central (Figure 1). The second big supplier that survived through the drought and retained relatively large reserves of grain was West Siberia. According to railway statistics, during the ban period it primarily supplied to Urals and Volga. Other crop-growing regions like Volga, Urals and Black Earth are also normally net-suppliers, but in the marketing year 2010-2011 they mostly consumed grain transported from North Caucasus and West Siberia (Rosstat, 2013).

It should be noted that the amount of wheat traded domestically is only a small share of wheat produced in Russian regions. While other ways of transportation can be applied in wheat trade, railways remain the basic one accounting for 80% of all crop deliveries. Based on the estimates of Russian railway monopoly, the share of wheat exported from one domestic region to another fluctuates in the diapason of 0 and 40% in the period 2008-2012. In 2008 and 2009, the biggest trader on the domestic market was Black Earth that supplied to other regions 20% and 38% of produced commodity respectively. Afterwards, its share dropped and West Siberia became a leading internal supplier. In 2011 and 2012 it exported domestically 11% and 5.7% of its harvest respectively.

3. Theoretical foundations and literature review

Researchers frequently allude to ***the law of one price*** (LOP) as a principal concept behind the idea of integration between spatially distant markets (Fackler and Goodwin, 2001). Schematically, it is illustrated as a pairwise combination of prices for a homogenous product (product whose cost structure is independent of the area of production) in two distantly separated locations. Under the circumstances of perfect market efficiency, prices in two locations are equal – a rather theoretical scenario commonly referred in literature as a strong version of LOP. In a more realistic environment, prices in two locations should differ by the amount of transaction costs needed to market a certain product – a situation known as a weak version of LOP (Bakucs, 2012; Blavy and Juvenal, 2008).

A price equilibrium conditioned by LOP is increasingly fragile and temporary since the manifold of factors exert their influence and lead to sometimes protracted disparity. When the difference between two prices exceeds the amount of transaction costs, the given market becomes an attractive place for arbitrageurs that strive to extract extra profit by selling in the location with higher prices. Again, such arbitrage opportunities by assumption can not last long in the efficient environment since such trading leads to accumulation of resources in the location with higher prices, which ultimately fall under the pressure of satisfied demand. On the contrary, in the location with lower prices consumers start suffering from the deficit of supply that propels prices up and therefore drives economy to equilibrium. Unfortunately, in the markets with deficient institutional environment, poor legal framework and monopolized industries this self-correcting mechanism of invisible hand does not always work properly. Thereby, that may lead to the situation when entire territories may find themselves in disequilibrium (Blavy and Juvenal, 2008).

Studies investigating the problems of market integration in Russia are scarce and generally suffer from the absence of high-quality empirical data, which is a precondition for producing reliable and policy-relevant results (Von Cramon-Taubadel, 1997). Moreover, many research attempts resorted to the decade that started immediately after the deconstruction of USSR and that was exposed to macroeconomic turbulence and uncertainty, including hyper inflation 1993-1994 and steep Rouble devaluation following the crises 1998 (Gluschenko, 2010). In some studies the entire time periods spoiled with structural perturbations were simply discarded to preserve computational accuracy and analytical consistency (Gardner and Brooks, 1994). Additionally, researchers mostly focused their attention upon analyzing markets of retail goods constituting a basket of most sought-after products: bread, milk, butter, eggs, potato etc. Despite some similarities in conclusions, those studies have different perspectives on the configuration of spatial links and give conflicting estimates of integration (Goodwin *et al.*, 1999; Gluschenko, 2010; Wehrheim and Loy, 1999).

One point on which those studies agree is that in the 1990s regional retail markets in Russia were primarily disintegrated and transaction costs were high enough to prohibit any arbitrage (Gluschenko, 2010). Some of them also notice economic segmentation and establishment of local centres that determine their relationships with regions-satellites. By observation, the status of region-leaders can be either dependent on the presence of key administrative and commercial offices (Moscow) or can be explained by proximity to important production areas or infrastructural objects (Krasnodar) (Goodwin *et al.*, 1999). At the same time, long distances, bad infrastructure and domination of local administrative policies are mentioned as the pivotal determinants that inhibit integration and sometimes lead to increasing economic isolation of regions. Later studies using empirical data that covers the period of the 2000s emphasize some improvement in regional integration, but only between the regions of Central and Western Russia, while spatially distant areas of Siberia and Far East became even more self-sufficient (Gluschenko, 2010).

4. Data

The current analysis is based upon two major data sets: prices and trade flows. The source of data is the Federal State Statistics Service (Rosstat). A price reflects a quote for wheat of 3d class at which a single metric ton of commodity was sold by a farmer to an interested trader. Prices are reported every week by trade agents situated in the most important wheat growing areas of Russia. The complete data set covers the calendar period from January 2005 until December 2012 and contains 417 observations per each economic region (Figure 3). Geographical boundaries of the given study include the following economic regions: Central Black Earth (further called Black Earth), Central, North Caucasus, Volga, Urals and West Siberia.

Besides price series, trade flows of wheat between different economic regions considered in the study are used. In the given context, trade flows reflect volumes of wheat in metric tons transported through the Russian railways within the geographical limits of analysis. Covered time period is from the middle of 2007 until the end of 2012. Data was extracted on a weekly basis to achieve a temporal coherence with price series.

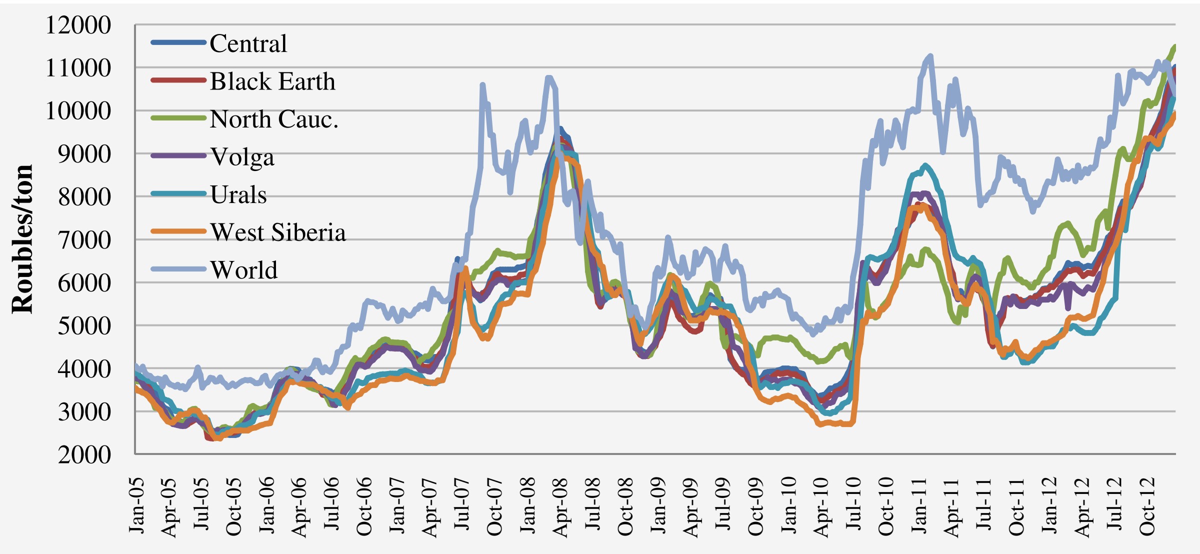

Figure 3. Wheat price series for different economic regions

4. Methodology

Transaction costs associated with marketing of goods entail challenges for both estimation and interpretation of results. It is proved that disregarding non-linear effects caused by transaction costs might lead to distorted outcomes and misleading conclusions about the nature of spatial links (Enders and Siklos, 2001). At the same time, attempts to explicitly incorporate a nuisance parameter do not come at any cost. The major difficulty lies in the organization of a testing procedure that assumes the absence of the nuisance parameter under the null hypothesis, but its presence under the alternative one. In this case, as pointed out in Andrews and Ploberger (1994), standard inferences are difficult and Monte Carlo experiments should be run to produce accurate critical values for test statistics. Additionally, incorporating the threshold variable into the analytical framework reduces the testing power dramatically (Enders and Siklos, 2001).

Apart from transaction costs, there are other factors determining behavior of integrated markets. In contrast to transaction costs, whose effects are short-run, other processes may have a more profound impact that results into the emergence of a new equilibrium. The absolute majority of frameworks intended to study non-linear dynamics are well equipped to deal with short-run effects. A novel approach devised by Gonzalo and Pitarakis (2006) takes the above considerations into account and allows testing for a shift in the long-run equilibrium relation.

In this study two techniques illustrating non-linear behavior are used. First, threshold autoregressive model (TAR) is applied to understand whether the magnitude of transaction costs is high enough to cause a break in the short-run parameter. Second, model of Gonzalo and Pitarakis is employed to find out if the equilibrium relation conditional upon exogenous variable is also exposed to a change.

4.1 Non-linearity in the short run parameter

The notion of integration is assumed to be an equivalent of *cointegration* used in statistics to describe the long-run relation between variables. In the given context, cointegration is tested for a pair of wheat prices collected from two different economic regions in Russia. The long-run equilibrium relationship between the prices can be described as follows (Engle and Granger, 1987):

$$\ln P_{1t} = \alpha + \beta \ln P_{2t} + \mu_t \qquad (1)$$

Where P_1 and P_2 are prices in locations 1 and 2 at time t taken in logarithms to ensure that the further analysis is done in relative terms. α is intercept, which is commonly interpreted as the constant spatial margin (Abdulai, 2000) and β is elasticity of price transmission. Additionally, μ_t is a residual term, which can be serially correlated.

As a first step in estimation, Engle and Granger (1987) suggest using ordinary least squares (OLS) to obtain estimators of intercept and elasticity of price transmission and extract residuals. Subsequently, as a second step, Dickey-Fuller (DF) test should be run to determine whether residuals of the long run regression are a stationary series (Dickey and Fuller, 1979). The DF regression function is as follows:

$$\Delta\mu_t = \rho\mu_{t-1} + \varepsilon_t \qquad (2)$$

Where $\Delta\mu_t$ is a residual in first difference and μ_{t-1} is a past-period residual, while ε_t represents white noise process. To reject the null hypothesis of no stationarity, it is enough that the coefficient ρ will be significant and will fall in the interval $-2 < \rho < 0$. In the event of negative outcome (the null is not rejected), prices are not statistically cointegrated that also means the lack of economic association between the analyzed spatial markets. In fact, it does not necessarily imply that the two markets exist in isolation. What it means is that in the confines of a selected econometric model, a statistically significant connection is not established.

The abovementioned two-step procedure is also frequently referred to in literature as the *linear cointegration model*. Linearity here relates to the invariance of the coefficient of decay ρ (as well termed *speed of adjustment)*. In other words, irrespective of the magnitude of the spread between regional prices in the past, equilibrium reestablishes itself at a constant speed ρ. Usually, this situation is rare in economy. Empirical applications suggest that such factors, as transaction costs, market power, and imposition of price ceilings lead to the emergence of so-called *band of inaction*, within which normal economic activity is either sluggish or even completely dampened (Simioni *et al.*, 2013; Nakajima, 2012; Goodwin and Piggot, 2001). Band of inaction represents an area where spatial arbitrage is not profitable due to prohibitive costs. However, beyond it markets revive as the prices in regions differ sufficiently to set off incurred costs.

This discrepancy in the state of economy inside and outside of inaction band is captured by the threshold autoregressive model (TAR). Comparably to linear cointegration model, in TAR the speed of decay parameter is allowed to vary. The extent of that variation depends on whether it is below or above a certain threshold. A simple two-regime and one threshold TAR is formulated in the following way (Enders and Siklos, 2001):

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \varepsilon_t \tag{3}$$

It is seen that in (3) the speed of adjustment parameter is split in two such that for each regime there is own value ofρ. I_t is the Heaviside indicator function that can be written as:

$$I_t = \begin{cases} 1 \; if \; \mu_{t-1} \geq \tau \\ 0 \; if \; \mu_{t-1} < \tau \end{cases} \tag{4}$$

Where τ is the value of the threshold. $\{\varepsilon_t\}$ yield the sequence of independent and identically distributed random variables with zero mean and homoskedastic variance. Moreover, ε_t is independent of μ_t.

According to Petrucelli and Woolford (1984), stationarity is achieved if $\rho_1 < 0$, $\rho_2 < 0$ and $(1 + \rho_1)(1 + \rho_2) < 1$ are satisfied for any value of the threshold. Overall, in this type of TAR analysis three null hypotheses are tested. The first two assumptions relate to the problem of cointegration. These are the separate hypothesis that $\rho_1 = 0$ and $\rho_2 = 0$ (t-test) and the joint hypothesis that $\rho_1 = \rho_2 = 0$ $(\Phi - \text{test})$. The joint hypothesis has higher power and more chances of being rejected than the t-test. Due to the presence of the nuisance parameter, asymptotic distribution of both test statistics is non-standard, but Enders and Siklos (2001) provide critical values for the test statistics obtained from the Monte Carlo simulation. The third hypothesis $(\rho_1 = \rho_2)$ concerns a symmetry of the adjustment parameters (F-test). Provided that the null of symmetric adjustment is rejected, it can be said that the economy switches between two regimes: below and above a certain threshold (Enders and Siklos, 2001).

Estimation of the threshold value is critical for the analysis as thresholds are quite significant when trade relations involve big distances. On the other hand, the actual measurements of transaction costs, if available at all, have to be taken with a grain of salt since they rarely cover the entire set of expenditures (Goodwin *et al.*, 1990). According to method of Chan (1993), the optimal threshold should be selected from the sequence of residuals μ generated from the long-run equilibrium equation (1). The entire sample is truncated such that the 15% of the lowest and 15% of the highest values are discarded, while the rest of the sample is subject to a grid search. The criterion of the selection is the sum of squared residuals (SSR). Chan (1993) proved that the threshold with the lowest SSR is a superconsistent estimate.

4.2 Non-linearity in the long-run parameter.

In (1) it is taken for granted that β remains intact under the influence of economic factors, and the entire dynamics is centered around residual μ. Still, theoretically, the given assumption is not well substantiated. For instance, policy-induced measures, such as governmental interventions, to regulate the balancing of demand and supply are expected to affect “beta” leading to the emergence of a setting with multiple equilibria.

The model where stability of the long-run parameter depends on some exogenous variable was devised by Gonzalo and Pitarakis (2006). (1) should be slightly modified to match the original representation given in Gonzalo and Pitarakis (2006):

$$\ln P_{1t} = \beta \ln P_{2t} + \lambda \ln P_2 I(q_{t-d} > \gamma) + \mu_t \qquad (5)$$

Where P_1 and P_2 are logarithmic prices in locations 1 and 2 at time *t*. q_{t-d} is the stationary exogenous variable responsible for the shift in the long-run equilibrium. I is the indicator function that amounts to one when the exogenous variable exceeds the threshold γ and zero otherwise. μ_t is a stationary disturbance term. Deterministic component is omitted to preserve brevity, but it can be included without compromising statistical properties of the model.

Gonzalo and Pitarakis (2006) propose Lagrange Multiplier (LM) test with the null hypothesis that $\lambda = 0$ versus the alternative hypothesis that $\lambda \neq 0$. Rejecting the null hypothesis will imply that the effect of the exogenous variable is strong enough to result in a shift in the long-run equilibrium. The timing of the shift depends on the realizations of the exogenous variable.

The choice of the exogenous variable is a matter of theoretical considerations. In the bounds of the given study, it is conjectured that the spatial equilibrium between two prices can be disturbed due to changes in the configuration of trade flows. The details related to the construction of the variable containing information about trade flows will be given in the next section. The Gonzalo and Pitarakis test was previously applied in price transmission analysis by Götz and von Cramon-Taubadel (2008).

5. Estimation and results

5.1 Data preparation

In this section preliminary results of the analysis of selected domestic wheat markets are presented. The configuration of forces in the market suggests the critical importance of North Caucasus for the rest of the selected regions. In the time of free trade, North Caucasus plays the part of transport gates for grain producers searching to export the commodity abroad due to the availability of high-capacity sea terminals. In exceptional cases, as the export ban of 2010-2011 demonstrated, North Caucasus is also able to turn into an active trader in the domestic market. Apart from North Caucasus, this study gives a closer look at Volga and Western Siberia that effectively control domestic wheat supply when harvest is good.

North Caucasus is confronted against other regions to form four different paired combinations: Black Earth–North Caucasus, Central–North Caucasus, Volga–North Caucasus and Urals-North Caucasus. In turn, West Siberia is combined with Central and Volga. Owing to its proximity to the world grain market, North Caucasus is by default a region that dictates pricing situation inside the country. Another argument in favor of its status as a price maker is the determination of local wheat growers to deliver extensive portions of harvest to the areas that might be subject to grain deficits. On the other hand, complete closure of borders for grains was a last resort measure that never had precedents in the past and did not lead to the reorientation of North Caucasus towards Russian domestic markets. Normally, in favorable time West Siberia and Volga remain key domestic suppliers that determine price situation in the country. The presence of several big producing regions makes trade relations extremely complex. Therefore, each paired combination is estimated twice such that each variable can be treated both as dependent and independent.

Prior to running estimation procedures, each price series was shortened to 126 observations that cover the period of export ban and the ensuing period of free trade, that is, from August 2010 until the end of December 2012. Moreover, this small sample was supplementarily decomposed in two sub-samples to reflect the fact of a structural break in the series in the middle of 2011 when the export ban was cancelled. As a result, two regimes were analysed separately from each other to help avoiding potential complications associated with structural changes in the series. At the same time, the initial length of the sample (126 observations) was preserved to apply the model of Gonzalo and Pitarakis (2006), which is itself a test for a structural break in the long-run parameter. The first sub-sample coinciding with the time interval of export ban contains 42 observations. The second sub-sample contains 84 values and accounts for the time of free trade.

Table 1. Results of the long-run regression

Pair of makets	Regime	Value of beta[1]	# of lags	DF t-value[2]
Black Earth-North Caucasus	Export ban	1.07 (16.811***)	2	-2.238**
	Free trade	0.99 (42.484***)	1	-3.169***
North Caucasus-Black Earth	Export ban	0.82 (16.811***)	1	-4.086***
	Free trade	0.97 (42.48***)	2	-3.608***
Central-North Caucasus	Export ban	1.05 (16.583***)	1	-4.112***
	Free trade	0.98 (41.595***)	1	-3.077***
North Caucasus-Central	Export ban	0.83 (16.583***)	1	-4.112***
	Free trade	0.98 (41.595***)	2	-3.556***
Volga-North Caucasus	Export ban	1.31 (21.466***)	1	-4.835***
	Free trade	0.97 (31.379***)	1	-2.482**
North Caucasus-Volga	Export ban	0.69 (21.466***)	1	-5.093***
	Free trade	0.95 (31.379 ***)	1	-2.215**
Urals-North Caucasus	Export ban	1.09 (10.737***)	1	-4.029***
	Free trade	1.11 (14.151***)	1	-2.334**
North Caucasus-Urals	Export ban	0.68 (10.737***)	1	-3.774
	Free trade	0.64 (14.151***)	1	-2.432**
Central-West Siberia	Export ban	0.59 (11.519***)	Various	NA
	Free trade	0.70 (23.16***)	1	-2.297**
West Siberia-Central	Export ban	1.29 (11.519***)	Various	NA
	Free trade	1.23 (23.16***)	1	-2.353**
Volga-West Siberia	Export ban	0.75 (13.624***)	Various	NA
	Free trade	0.71 (29.73***)	Various	NA
West Siberia-Volga	Export ban	1.09 (13.624***)	0	-2.032**
	Free trade	1.28 (29.73***)	1	-1.718*

[1]Levels of significance (*** for 1%, ** for 5% and * for 10%).
[2]Levels of significance (*** for 1%, ** for 5% and * for 10%). Critical values for 1%, 5% and 10% significance levels for the test with no constant and trend are -2.62, -1.95 and -1.61 respectively.
NA – t-value of the Dickey-Fuller test is not significant

5.2 Estimation of the long-run regression and TAR model

Statistical properties of price series were checked by using Dickey-Fuller test that confirmed the presence of a unit root for prices in levels. However, repeating the procedure for the same prices in first differences resulted into rejection of the null hypothesis (the detailed results of the Dickey-Fuller test can be obtained upon request).

The results of the long-run regression show that the prices in majority of combinations are cointegrated (Table 1). Exceptions concern solely relations between West Siberia and more centrally located economic regions divided by large spaces. Yet, integration gets noticeably weaker the larger distance separating two regions. It can be seen that in the pairs uniting regions-neighbors with common borders the parameter of price transmission tends to be close to one signifying solid economic linkages. By contrast, trade between locations that do not share any borders can be less active. For instance, North Caucasus and Urals only trade sporadically, but in the export ban regime North Caucasus supplied a lot to Urals. Table 1 shows that the relations between the two regions are stronger when North Caucasus is treated as an independent variable. At the same time, in the reverse function the extent to which price signals are transmitted from Urals to North Caucasus is lower. This may be an indication of the fact that transportation of wheat from Urals to North Caucasus is a costly enterprise.

Table 2. Results of TAR analysis

Pair of markets	Regime	$\rho_1 = \rho_2 = 0$	$\rho_1 = \rho_2$	$\rho_1(\geq \tau)$	$\rho_2(< \tau)$	$\tau(thresh$
Black Earth-North Caucasus	Export ban	4.18***	3.06**[0.08]	-0.55 (-2.89**)	-0.16 (-0.893)	0.024
	Free trade	6.77***	3.22**[0.077]	-0.29(-3.3***)	-0.11(-1.73**)	0.042
North Caucasus-Black Earth	Export ban	10.897***	3.85**[0.05]	-0.74(-4.28***)	-0.31 (-2.133*)	0.022
	Free trade	8.06***	2.801**[0.09]	-0.14 (-2.11***)	-0.3 (-3.57***)	-0.041
Central-North Caucasus	Export ban	9.58***	1.86 [0.18]	NA	NA	NA
	Free trade	6.26***	2.83**[0.09]	-0.28 (-3.23**)	-0.10 (-1.543)	0.043
North Caucasus-Central	Export ban	17.14***	10.45***[0.0026]	-0.80 (-5.67***)	-0.20 (-1.62)	0.023
	Free trade	7.41***	2.01[0.16]	NA	NA	NA
Volga-North Caucasus	Export ban	15.55***	5.16***[0.029]	-0.31 (-1.796**)	-0.82 (-5.39***)	-0.016
	Free trade	3.53***	2.09[0.15]	NA	NA	NA
North Caucasus-Volga	Export ban	18.45***	6.92***[0.012]	-0.87 (-5.97***)	-0.28 (-1.551)	-0.018
	Free trade	3.899***	1.59[0.21]	NA	NA	NA
Urals-North Caucasus	Export ban	11.314***	4.7839*[0.035]	-0.18 (-1.78**)	-0.53 (-4.36***)	-0.050
	Free trade	5.6363***	5.5155***[0.02]	0.028 (-1.024)	-0.167(-3.19***)	-0.128
North Caucasus-Urals	Export ban	9.4873***	3.7174**[0.061]	-0.53(-3.97***)	-0.19 (-1.66)	0.017
	Free trade	4.4702***	2.8847**[0.093]	-0.16 (-2.51***)	-0.04 (-1.570)	0.078
Central-West Siberia	Export ban	NA	NA	NA	NA	NA
	Free trade	4.514***	3.5817**[0.062]	0.0009 (0.019)	-0.11 (-3.004**)	-0.085
West Siberia-Central	Export ban	NA	NA	NA	NA	NA
	Free trade	3.8909***	NA	NA	NA	NA
Volga-West Siberia	Export ban	NA	NA	NA	NA	NA
	Free trade	NA	NA	NA	NA	NA
West Siberia-Volga	Export ban	9.96***	14.415***[0.001]	0.045 (0.904)	-0.23 (-4.372***)	-0.065
	Free trade	NA	NA	NA	NA	NA

Asterisks denote levels of significance (*** for 1%,** for 5% and * for 10%). Squared brackets contain p-values for F-test. NA means that the hypothesis of symmetric adjustment is not rejected and the values of parameters and the threshold are not available

The results of TAR analysis generally conform to the findings of the linear model (Table 2). It follows that the farther the regional markets are located from each other, the higher the chance that the null hypothesis of no cointegration will not be rejected. It is worth noting that the assumption of asymmetric adjustment holds for the majority of combinations. However, there are only four pairs, for which non-linear model is more preferable for both regimes:

Black Earth-North Caucasus, North Caucasus-Black Earth, Urals-North Caucasus and North Caucasus-Urals. Irrespective of the place of the variables in the equilibrium equation, adjustment is noticeably faster during the export ban period. For example, when North Caucasus drives both Black Earth and Urals, more than 50% of the previous period error is corrected just in a single week. It means that arbitrageurs need just two weeks to completely eliminate the spatial spread that exceeds the value of a threshold. By contrast, within the band of inaction, the parameter of decay is either insignificant or slow as trade may be too costly. The situation is a little bit different when free trade is an actual regime. The value of a threshold is higher than in the export band time, but adjustment is registered even inside the band of inaction meaning trade is continuous despite costs may be higher than returns. This finding holds for pair Black Earth-North Caucasus and is certainly counterintuitive as North Caucasus almost does not supply to Black Earth that time, but some studies suggest that correction towards equilibrium is still possible even with no trade since prices might reflect the reaction of traders to specific information (Stephens *et al.*, 2012). The values of thresholds are also higher the longer the distance connecting two locations. For instance, North Caucasus shares quite similar thresholds with adjacent regions, but further eastward the threshold value tends to be higher.

5.3 Estimation of the value of threshold

Threshold is commonly interpreted in literature as a proxy variable for transaction costs (Brosig *et al.*, 2010). Within the context of price transmission analysis, it also has a specific meaning of the random relative margin (marketing margin) that supplements the constant absolute margin represented by the intercept term (Meyer and Von Cramon-Taubadel, 2004; Abdulai, 2000; Nakajima, 2012). Black Earth–North Caucasus and North Caucasus–Black Earth are two pairs for which the assumption of asymmetry holds in both regimes and therefore the consistent values of a threshold can be estimated. It is clear that the threshold values in the free trade regime are higher than in the export ban. That may be in line with economic reality since during the export ban Russian government implemented transport subsidies to make the delivery of grains by the means of the state railway company from North Caucasus to Black Earth cheaper. Therefore, when North Caucasus is an independent variable, the critical random margin is 2,4% in the export ban regime and 4,2% in the free trade regime. These are the random margins between logarithmic prices that should be exceeded to either activate trade or simply make it possible.

Table 3. Estimation of the threshold value

Entry	Export ban	Free trade
Threshold = random margin, Roub/ton	155	409
Transport costs (*delivery fee*), Roub/ton	615-780	840-890

In an attempt to provide a basis for comparison with the monetary value of transaction costs expressed in roubles, those two margins were modified by converting their logarithmic values back into levels. The results given in Table 3 show that the monetary equivalents of the random margin in the export ban and the free trade regimes are 155 roubles and 409 roubles respectively. When compared with the average delivery fee[1] charged by the state railway company per ton of wheat, it is visible that the transportation costs are higher than the random margin. This may be due to the fact that transportation costs and costs of processing are often associated in the market integration literature with the constant relative margin or intercept (Nakajima, 2012). The problem is that for this particular pair of markets (Black

[1] The average delivery fee depends on several factors as number of vagons, vagons's capacity and distance. It is estimated using on-line form on the website of the Russian railway company. Details are available upon request.

Earth–North Caucasus), the intercept term was not found statistically significant. Moreover, its extraction from the logarithmic equilibrium equation is computationally involved. Using pure heuristic reasoning, it is possible to assume that the total value of transaction costs needed to sell wheat from North Caucasus in Black Earth equals the sum of the average delivery fee and the random margin estimated in roubles. By doing that, it yields 770-935 roubles in the export ban regime and 1249-1299 roubles in the free trade regime. These estimates explain very well what is seen in Figure 1. Simple differences between prices in levels are most of the time enough to cover the estimated transaction costs in export ban, and thereby trade flourishes. On the contrary, price differentials in free trade are almost never sufficient to compensate the amount of transaction costs and that affects trade negatively.

5.4 Estimation of Gonzalo-Pitarakis model

Gonzalo-Pitarakis test (2006) was run to understand whether the long-run equilibrium can be also subject to a structural change. Currently, only the pair Black Earth–North Caucasus is given attention. As mentioned in the review of methodology, the outcome of the test is directly contingent on the realization of an exogenous variable that is believed to affect the fundamentals of an economic system. On the basis of empirical observations, trade flows are selected as a best proxy to represent changes in demand and supply, which are assumed to account for a shift in equilibrium. Since North Caucasus drives relationships in the pair, volumes of wheat supplied from North Caucasus to Black Earth starting from August 2010 until the end of December 2012 are considered. Instead of original values of trade flows in levels, a new variable was created that exhibits the proportion of the amount of each weekly flow with respect to the maximum amount of weekly flow that was registered during the period of observation. According to available statistics, the biggest portion of wheat was supplied in the last week of February 2011 and amounted to 29 000 tons. Therefore, each value of the newly produced variable $\boldsymbol{q}$ falls in the closed interval such that $q \in [0,1]$. This operation is needed to ensure the exogenous variable is stationary.

The results of the test lead to rejection of the null hypothesis of no breakdown and the establishment of two separated equilibria with different values of the beta coefficient (Table 4). Both betas are proved to be statistically significant. The number of observations in each regime reproduces the number of observations in the export ban and the free trade periods that were manually created for TAR analysis (42 and 84 correspondingly). Furthermore, the division time coincides with the first week of June 2011, when the last portion of the cargo left North Caucasus. Four weeks later the export restrictions were lifted and shippings from North Caucasus to Black Earth happened on occasion. Unfortunately, the results of Dickey-Fuller test performed to check the stationarity of residuals in both regimes are negative. Repetition of the test for different number of lags did not help leading to conclusion that the markets are not cointegrated. Also, the mechanics of Gonzalo-Pitarakis test does not allow direct application of TAR model to test for cointegration with asymmetry in adjustment process. Consequently, finding the breakdown in the long-run parameter might not be a sufficient condition for cointegration.

Table 4. Results of Gonzalo-Pitarakis test for pair Black Earth-North Caucasus

Parameter	Regime 1 (42 values)	Regime 2 (84 values)
beta	1.03104	0.97499
(t-value)	(10.446***)	(33.339***)

6. Conclusions

In this study integration of domestic wheat markets in Russia was considered. More specifically, trade relations between economic regions of North Caucasus, West Siberia, Black Earth, Central, Volga and Urals were analyzed by applying price transmission approaches that are capable of detecting non-linear dynamics caused by the influence of both transaction costs and government intervention.

Generally, wheat trade leads to extremely strong relationships between North Caucasus and economic regions of Black Earth, Central, Volga and Urals. Those links do not weaken in the wake of the intervention to restrict trade with outside world. By contrast, West Siberia is found largely disintegrated with the regions clustered in the central part of Russia that can be attributed to big distances separating those locations.

The results of TAR analysis show the activation of domestic arbitrage when the world markets are closed. Moreover, in some cases there are indications of trade even when transaction costs are higher than potential returns that points to the conjecture that invisible forces (for instance, information flows) may also determine traders behavior. However, due to the temporary character of the intervention measure, the trade relations established during the export ban regime were also transitory since North Caucasus is historically more oriented towards the world market and only supplies to internal regions on occasion. The neighboring domestic markets, though try to sell wheat to North Caucasus on a more regular basis, have better presence in the primary consuming regions situated in the Center and North.

Analysis of thresholds for pair North Caucasus-Black Earth demonstrated that they were almost twice as low in the export ban regime as in the free trade. Comparing the monetary values of the threshold with the actual rates of tariffs set by the railway carrier shows that the differential of prices for wheat between North Caucasus and Black Earth is sufficiently wide to cover potential costs when the export ban is an actual regime. On the contrary, following the reestablishment of the free trade regime tariff reductions were abolished and that made arbitrage too expensive. And though North Caucasus resumed their shippings to the world market, Black Earth struggled to regain its pre-crisis trade positions in North Caucasus.

New methodology to account for non-linearity in the long-run equilibrium was applied to the pair Black Earth–North Caucasus. The presence of a shift in the long-run coefficient is confirmed. However, the residuals from the two new equilibrium equations are found non-stationary. That means that the markets are not integrated. One case is not a representative example to form inferences about the workability of the given technique, and the other pairs should be also tested to have a basis for comparison in future.

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