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The influence of Russia's 2010/2011 wheat export ban on spatial market integration and transaction costs of grain markets

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Abstract

Strong harvest shortfall and high world market prices prompted the Russian government to implement a wheat export ban in 2010 aiming to dampen domestic wheat prices. Building on regional price and trade data of Russia's wheat producing regions, we find strengthened domestic wheat market integration during the export ban period. Market integration decreased to its pre-ban level in the post-ban period; however, higher transaction costs resulting from increased risk of domestic grain trade during the export ban continued to prevail. Although market integration was temporarily strengthened, the export ban generally hampers market development in the long run.

KEYWORDS

export ban, regional market integration, Russia, TVECM, wheat

JEL CLASSIFICATION

Q02; Q11; Q18

Export controls on food and agricultural markets are widely implemented as crisis policy measures in many countries, aiming to stabilize domestic prices in the case of, for example, skyrocketing world market prices, domestic harvest shortfalls and, most recently, COVID-19-induced disturbances of the international trade system. During the 2007/2008 and 2010/2011 food price spikes, 33 countries applied 87 food-export-restricting measures (FAO, 2011).

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Russia has repeatedly implemented wheat export restrictions since it advanced from a wheat importing to one of the largest wheat exporting countries worldwide. The Russian government restricted grain exports by imposing an export tax of up to 40% during the 2007/2008 world market price spike, which was followed by a complete ban of grain exports in 2010/2011 and again by a grain export tax of 15% with an additional payment of 7.5 euro per ton in 2015. In the context of the COVID-19 pandemic, in 2020, Russia implemented a grain export quota of 7 million tons (April to June 2020), limiting the export of grain to nonmember states of the Eurasian Economic Union¹ (Ministry of Agriculture of the Russian Federation, 2020a, 2020b).

This study focuses on Russia's wheat export ban that was implemented on August 15, 2010. This governmental policy intervention in Russia's wheat export market was prompted by the strong harvest shortfall in Russia's key crop producing area, which decreased supply on domestic wheat markets while domestic wheat prices strongly increased, especially in the drought-affected regional markets. Concurrently, high world market prices created strong incentives for grain traders to export to the world market, thus reinforcing the supply-reducing and price-increasing effects of Russia's 2010 harvest shortfall. By prohibiting wheat exports to the world market, the Russian export ban spurred wheat exports to the drought-affected regions within Russia, thereby dampening regional wheat prices and increasing the availability of wheat in the deficit regions. The effects of the export ban were intensified by supplementing rail transport subsidies for domestic grain transport by reducing transport costs for domestic grain exports from grain-surplus to grain-deficit regions. Initially, the ban was supposed to last until December 2010, but it was subsequently prolonged until July 2011.

Given the observed domestic trade and price effects, our research question is: What are the effects of Russia's 2010 wheat export ban on the integration of regional markets within Russia? We hypothesize that to induce respective domestic trade flows, even the reversal of trade flows in some cases, and to stabilize prices within the country, by transmitting price information between regional markets fast and completely, the integration of domestic regional wheat markets in Russia has strengthened during the wheat export ban. However, the existing literature suggests that the long-term implications of export restrictions for domestic market development may rather be negative. For example, Stucchi et al. (2018) and Aragie et al. (2018) find that export restrictions have discouraged production of beef cattle in Bolivia and maize in Malawi, respectively, with respective implications for food security.

We address this research question within a price transmission framework and compare the spatial integration of wheat markets in Russia during the export ban period (2010/2011) vis-à-vis the open trade regime during the pre-ban and post-ban periods (2009/2010 and 2011/2012). We explicitly account for possible consequences of export restrictions for transaction costs of grain trade within Russia. Considering transaction costs is essential especially for the Russian wheat market, which is characterized by regional trade over long distances of up to 4000 kilometers and thus rather high transaction costs. As spatial trade arbitrage theory (Goodwin & Piggott, 2001) postulates, trade arbitrage between two spatially separated markets will take place if the price difference exceeds transaction costs. The presence of high transaction costs contradicts the conditions of an efficiently functioning market, which is characterized by low search costs and easy access to information (Aker, 2010). We use a threshold vector error correction model (TVECM) to explicitly account for the influence of transaction costs on spatial price relationships and employ an advanced regularized Bayesian estimator, as suggested by Greb et al. (2014).

We are not aware of any existing study that has investigated the effects of export restrictions on domestic market integration and thus relationship of domestic prices in Russia. The effects

of Russia's wheat export restrictions on the domestic price level, on the other hand, have been investigated in the literature before. Götz et al. (2013) find a rather low price dampening effect of the 2007/2008 export tax in Russia during the global food price crisis, whereas results of Götz, Djuric, and Nivievskiy (2016a) suggest a strong regional variation in the price dampening effects of the 2010/2011 wheat export ban, varying between 35% and 67%. While those studies focus on the relationship between the world market price and Russian wheat market prices, this study differs, as it solely investigates the influence of the 2010/2011 export ban on domestic price relationships between the grain producing regions of Russia. Moreover, to the best of our knowledge, this is the first study that addresses the effects of export restrictions on transaction costs in the domestic market of the country that implemented such a trade policy measure. Porteous (2017), for example, has investigated the effect of the export ban on inter-country transaction costs for the maize market in Africa.

A further novelty of our approach is that, by using a TVECM, the potential effects of the export ban on transaction costs may be assessed. In this regard, we complement Svanidze and Götz (2019a), who, based on a TVECM, investigated regional integration of the wheat market in Russia in comparison to that of the United States. However, their study focuses on a period when exports to the world market were not restricted by political market interventions. Furthermore, we complement the econometric analysis of prices across spatial markets by trade flows data to align the results of market integration analysis with the observed trade patterns.

RUSSIAN WHEAT MARKET CHARACTERISTICS, TRANSACTION COSTS AND THE 2010/2011 EXPORT BAN

Wheat production in Russia is mainly concentrated in six economic regions (Figure A1). Black Earth, North Caucasus, Volga, Ural, and West Siberia usually supply their excess grain to other regional markets or to the international markets, whereas the Central region containing Moscow is the primary wheat deficit region, depending heavily on external supply.

North Caucasus is the primary production and export region, accounting for almost 40% of Russia's total wheat production and 80% of total wheat exports (Table 1). Since North Caucasus supplies wheat primarily to the world markets, its role in domestic trade is limited. During 2009–2015, wheat production in North Caucasus increased from 18 to 24 million tons, of which 70%–80%, on average, was exported to the world market (with the exception of the 2010 marketing year). In contrast, West Siberia, which is among the largest grain producing regions, exports only 1%–5% of its total wheat production to the world market. Located 4000 kilometers away from the Black Sea ports, West Siberia has limited access to the country's main export gateways, and thus its role in the global wheat supply is rather limited. West Siberia is far away from not only the world market but also the main grain consumption regions within Russia. In particular, Moscow is about 2000–3000 kilometers away. Wheat produced in West Siberia is mainly consumed within the region or delivered to the neighboring region of Ural.

Weather conditions strongly influence grain production in Russia, resulting in large temporary variations across regions and years. For instance, Russia's total wheat production decreased by 33% in 2010 and 2012 compared to the previous year, respectively, owing to a severe drought. Unusually, low harvest in the key crop-growing areas in 2010 led the Russian government to impose a wheat export ban on August 15. The measure had a profound effect on regional wheat trade in Russia. Although the 2010 drought did not impact wheat crops in North Caucasus

TABLE 1 Wheat production (million tons) and exports (as percentage of production), 2009–2015

Year	Total Russia	North Caucasus	West Siberia	Volga	Black earth	Ural	Central
2009	61.8 (30%)	17.9 (–)	11.3 (–)	10.1 (–)	7.9 (–)	5.7 (–)	4.0 (–)
2010	41.5 (10%)	18.6 (15%)	8.1 (0%)	3.4 (10%)	3.3 (2%)	2.5 (0%)	2.6 (0%)
2011	56.2 (38%)	20.7 (86%)	8.8 (3%)	6.8 (14%)	5.7 (21%)	7.2 (13%)	2.6 (6%)
2012	37.7 (30%)	12.9 (68%)	4.4 (5%)	5.7 (7%)	5.4 (21%)	3.1 (6%)	3.0 (5%)
2013	52.1 (36%)	17.8 (79%)	8.0 (4%)	7.2 (21%)	7.8 (23%)	4.0 (4%)	3.8 (5%)
2014	59.1 (39%)	22.4 (77%)	6.8 (1%)	8.9 (27%)	8.3 (24%)	4.5 (5%)	4.0 (4%)
2015	61.0 (42%)	23.9 (79%)	8.0 (3%)	7.4 (30%)	7.6 (40%)	5.5 (6%)	4.4 (8%)

Note: The en dash (–) indicates that data is not available.

Source: Rosstat (2018) for production and IKAR (2018) for export data.

specifically, the region could no longer export wheat to the world market and was forced to supply wheat domestically instead.

Data on the interregional grain trade by rail for Russia makes evident that the domestic grain trade almost doubled during the export ban period, increasing from 4.6 million tons in 2009/2010 to 8.3 million tons in 2010/2011 and again reducing to 3.8 million tons in 2011/2012 (Rosstat, 2018).² Moreover, the trade status has reversed for North Caucasus, which became a net exporter of wheat to other domestic regions, whereas Black Earth and Volga, which, due to the severe harvest shortfall in 2010/2011, turned from net grain exporters into net grain importer regions during the period of the export ban (Figure A2). The trade status of the other regions did not change, although Central and Ural doubled their grain inflows and West Siberia further increased its grain exports to other regions of Russia in 2010/2011.

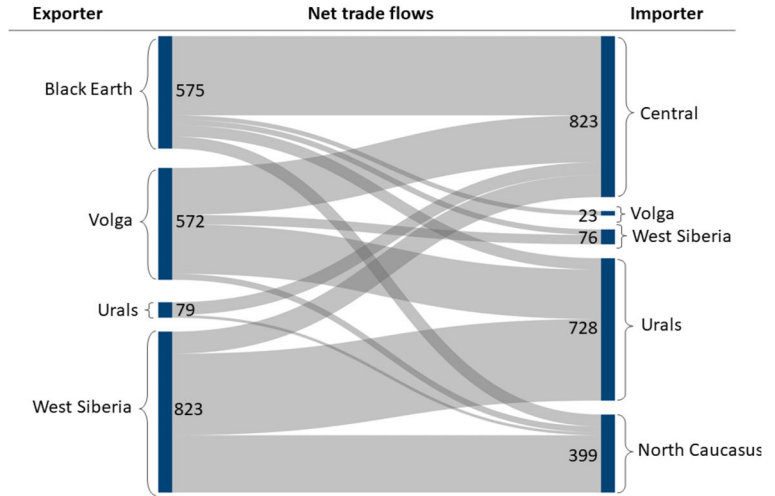
Usually, during the open trade regime, there is a positive net trade of wheat by railway from Black Earth, Volga and West Siberia to Central and Ural³ for domestic consumption and North Caucasus for further export (Figure 1a,c). However, during the 2010/2011 export ban, North Caucasus was actively involved in domestic trade of wheat, and wheat supply mainly from North Caucasus and West Siberia was directed to markets that suffered the most from harvest failure, specifically Black Earth and Volga, but also Central and Ural (Figure 1b).

To foster interregional grain trade during the export ban, the Russian government introduced railway tariff subsidies for grain producers located in North Caucasus starting on September 20, 2010. The subsidy was valid for all grain supplies exceeding 300 kilometers and was removed when the export ban was lifted in July 2011. Russian Railways cut delivery fees by half for dispatches heading from North Caucasus towards Black Earth, Central, Ural and Volga (Russian Railways, 2015). However, delivery fees capture just parts of the full transport costs. Other expenses may include storage fees, costs of transportation to and from the railway stations and grain processing facilities, loading and unloading costs, insurance premiums, etc. The share of the delivery fee in total transport costs may vary significantly, amounting to 30%–70% of transport costs.⁴

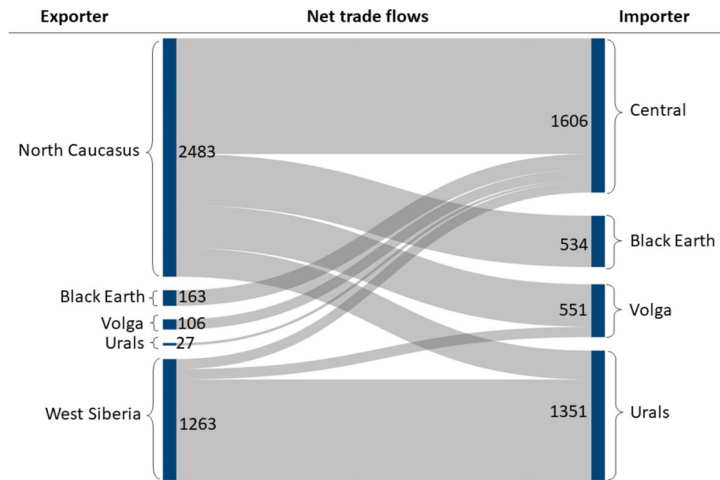
As production areas cover large territories, the influence of transport infrastructure is crucial on the distribution of wheat within Russia. Grain traders regularly complain that the number of grain wagons in the peak seasons does not suffice (Gonenko, 2011). During the 2010/2011 export ban, the availability of wagons for grain transportation was limited, as railways were heavily involved in the construction of sports facilities for the winter Olympic games

FIGURE 1 Net domestic grain trade between regions of Russia by railway. The exporting region is located on the left edge; the importing region is located on the right edge. Trade flows smaller than 5 (1000 t) are not included in the figure.
Source: Rosstat (2018), own elaboration

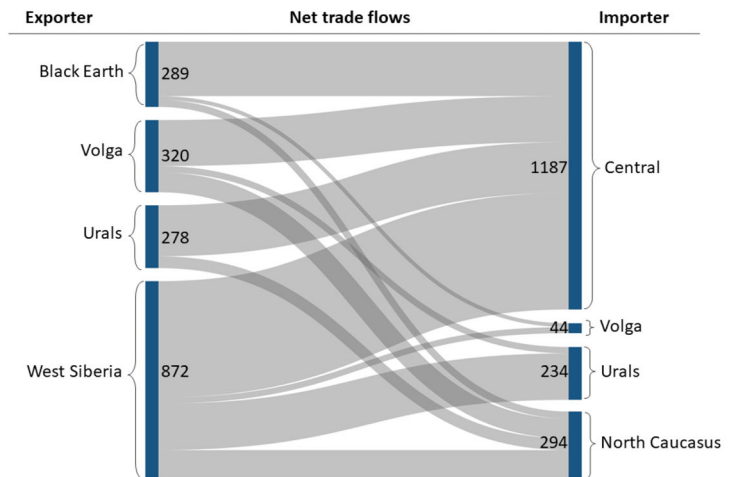
a Pre-ban period (2009/10)



b Export ban period (2010/11)



c Post-ban period (2011/12)



in Sochi. Moreover, trade flows reversed, and the volume of grain exported by North Caucasus to other domestic regions was extremely high, even exceeding the availability of trucks (Gonenko, 2011). Grain markets in Russia are also characterized by inadequate transport infrastructure and logistics and high business risk (PWC, 2015). Transaction costs are especially high due to the difficulty of enforcing contracts and unforeseen policy interventions on grain markets (Götz et al., 2013; Götz, Djuric, & Nivievskiy, 2016a).

METHODOLOGICAL FRAMEWORK AND ESTIMATION STRATEGY

In markets analysis, the notions of market integration and market efficiency are loosely defined (Barrett, 2001; Fackler & Goodwin, 2001; McNew, 1996). Following Fackler and Goodwin (2001), we interpret spatially separated markets as highly integrated and efficient markets if they are characterized by (a) strong long-run price relationships, where price changes are fully transmitted between the markets, while (b) price shocks may lead to temporary deviations from the long-run equilibrium which are fast corrected. An efficient market is also characterized by (c) low transaction costs, which may be determined by, for example, distance to other markets, quality and quantity of transport infrastructure, search costs and market risk (Tomek & Robinson, 2003).

The underlying theory of spatial market equilibrium rests on the idea that trade flows are a key mechanism of transmitting price information across markets. For a homogeneous good, any price difference between spatially distinct markets exceeding transaction cost will be quickly eliminated via profitable trade arbitrage, resulting in a physical movement of the good between the markets until the price differential is smaller than transaction costs. However, Jensen (2007) demonstrates that access to price information can also improve price convergence across markets, even in the absence of physical trade activities. Moreover, Stephens et al. (2012) empirically show that spatial price adjustment is higher during the non-trade period compared to the trading season, indicating that information flows in addition to physical trade are important for bringing about markets in spatial equilibrium. In this case, new market information is changing price expectations of spatial arbitrageurs across markets and causing the price adjustment (Goodwin, 1990; Götz, Qiu, et al., 2016b; Lence et al., 2018). Two markets for which price shocks are not transmitted are defined as non-integrated or separated (Fackler & Goodwin, 2001, p. 979). One proposition for the existence of a long-run equilibrium and thus market integration is that the price series, which are usually nonstationary, are cointegrated, implying that the prices follow a common long-run trend and do not drift apart too far. However, cointegration does not necessarily imply market integration. For example, if transport costs are nonstationary, then absence of cointegration could misleadingly be interpreted as lack of market integration even in spatially efficient market (Fackler & Goodwin, 2001, p. 1006).

We characterize the long-run price equilibrium between spatially separated markets via the equation

$$p_{1t} = \alpha + \beta p_{2t} + \varepsilon_t \quad (1)$$

where p_{1t} and p_{2t} are domestic prices of the regional markets 1 and 2 expressed in the natural logarithm, and ε_t represents the stationary disturbance term. α denotes the intercept, and β is a coefficient of the long-run price transmission elasticity, characterizing the magnitude of the

transmission of price shocks from one market to another. To correctly identify a long-run price equilibrium, we implicitly assume that transaction costs are stationary over time (Fackler & Goodwin, 2001).

Long-run equilibrium is a static notion. It is natural that prices in different markets periodically diverge from this parity owing to unexpected market shocks. According to spatial trade arbitrage theory (Goodwin & Piggott, 2001), trade arbitrage between two spatially separated markets will take place only if the price difference exceeds transaction costs. Thus, a “regime dependent,” nonlinear price adjustment process may be observed, which can be analyzed within a TVECM.

In this study, we utilize a three-regime TVECM framework which we estimate with the regularized Bayesian estimator (Greb et al., 2013) and is particularly capable of appropriately modeling the specifics of the Russian wheat market, that is, trade reversals, oscillating spatial price co-movements and changing price behavior across years. One advantage of Greb's (2013) Bayesian estimator is that it performs particularly well in small samples (see Appendix A for further discussion).

The three-regime TVECM (Figure 2) is based on the assumption that two thresholds (τ_1 and τ_2 with $\tau_1 < 0 < \tau_2$) exist corresponding to the costs of trade in both directions, that is, from market 1 to market 2, and vice versa, respectively, which may be different depending on the trade direction ($\tau_1 \neq \tau_2$). Transaction costs consider directly observed costs, such as transportation and marketing costs, as well as indirect costs, such as contract default risk, policy uncertainty, bargaining, search and information costs, which cannot be directly observed. When only unidirectional trade between markets is observed, this may be interpreted as evidence for transaction costs, which are prohibitively high in the reverse direction, preventing trade arbitrage between those two markets in the opposite direction given actual regional price differences. Owing to large variation in the size of regional grain harvests in Russia, it is quite common that the direction of interregional trade routes differs by the marketing year (compare Figure A3) depending on the size of regional grain harvest and thus the regions delivering and receiving wheat from neighboring regions. This may result even in reversing directions of interregional trade arbitrage in different marketing years. Thus, although trade is observed as unidirectional in one marketing year, it is bidirectional by its nature in the long term. This implies that trade arbitrageurs account for observable and unobservable transaction costs of all possible trade routes in

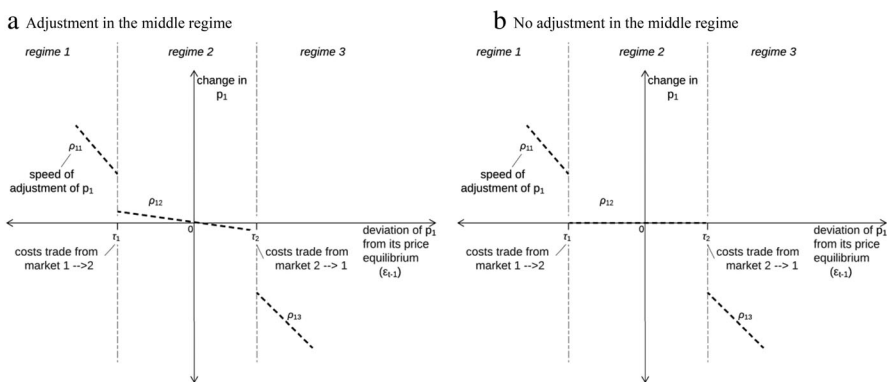


FIGURE 2 Structure of the “regime-dependent” price adjustment process.

Source: own elaboration

their decisions even when trade takes place only along some trade routes. We therefore account for transaction costs of realized and unrealized trade flows and use this information as a prior when modeling price relationships for a given marketing year in the context of bidirectional trade within a three-regime TVECM with two thresholds (for model specification details and estimation see Appendix A).

Prices in market 1 correct deviation from the long-run equilibrium with prices in market 2 in regime 1 and regime 3 (ρ_{11} and ρ_{13}) at a relatively high speed owing to profitable trade arbitrage opportunities with deviations from the price equilibrium exceeding transaction costs, while the speed of adjustment in regime 2 (ρ_{12}) is relatively low, as price deviations are smaller than transaction costs. Thus, in regime 2, the price adjustment may be induced by information flows or third markets (Figure 2a) or may not be observed (Figure 2b).

TVECM models as, for example, provided by Greb et al. (2013) are criticized for their unrealistic assumption of fixed transaction costs, which is reflected in the constancy of the threshold parameter (Cáceres-Hernández & Martín-Rodríguez, 2017; Lence et al., 2018; Santeramo, 2015). However, in order to ensure that our model meets the assumption of fixed transaction costs, our estimations are based on weekly price series for one marketing year only. In this short period, transportation costs are stable in Russia, as railway tariffs for grain deliveries are updated twice a year only (usually in January and July). Dividing the sample of 1-year length with weekly data further into smaller segments is not feasible owing to the number of parameters to be estimated.

We proceed as follows: First, we test the order of integration of each price series with the augmented Dickey-Fuller (ADF) unit root test with breaks (Perron & Vogelsang, 1992). If the Gregory and Hansen (1996) test identifies a regime shift in the cointegration relationships when the export ban was introduced in Russia, the open trade regime (pre-ban 2009/2010 and post-ban 2011/2012 periods) and the export ban regime (2010/2011) are distinguished. Second, we test the existence of a long-run price equilibrium separately in each period by a test for threshold cointegration (Larsen, 2012). If pairwise cointegration of individually nonstationary price series is confirmed, we estimate the long-run price equilibrium in Equation (1) via ordinary least squares. This is followed by TVECM estimations to identify thresholds and other model parameters within the restricted maximum likelihood framework (Greb et al., 2014).

PRICE SERIES, UNIT ROOT AND COINTEGRATION

We use a unique dataset of weekly wheat prices (ruble/t) provided by the Russian Grain Union (2015) for the six primary grain producing regions of Central, Black Earth, North Caucasus, Ural, Volga, and West Siberia. Traders pay the quoted prices to farmers based on ex-works contracts. However, owing to weather conditions, regional wheat harvest in Russia is highly volatile, resulting in changing direction and size of trade flows between regions and oscillating price developments. For example, prices in North Caucasus are higher in some years and lower in others than prices, for example, in Volga and West Siberia (Figure A3).

The interregional price relationships depicted in the price transmission model are not stable, and thus parameter estimates may not be constant. We assume that the data generating process differs from one marketing year to another. Therefore, we follow Svanidze and Götz (2019a, 2019b) and estimate the price transmission model for Russia based on price data for one marketing year exclusively, which is characterized by relatively stable price relationships. In particular, to evaluate the effect of the export ban on domestic price relationships, we confine our

analysis to the pre-ban and post-ban periods, that is, 2009/2010 and 2011/2012 marketing years (when wheat exports were freely possible) as a benchmark, against which price relationships prevailing during the 2010/2011 export ban are evaluated. We create three separate datasets for 2009/2010, 2010/2011 and 2011/2012, with each price series consisting of 52 weekly observations between July and June of a marketing year (Figure A4) and comprising 15 regional price pairs.

Results of the ADF test with breaks, the ADF Gregory–Hansen test and the threshold cointegration test (see Appendix B and Tables A1, A2 and A3 in Appendix) suggest that the price series are nonstationary and price relationships within the Russian wheat market are characterized by a long-run spatial price equilibrium and thus the regional wheat markets are integrated and may be analyzed by a TVECM.

EMPIRICAL RESULTS

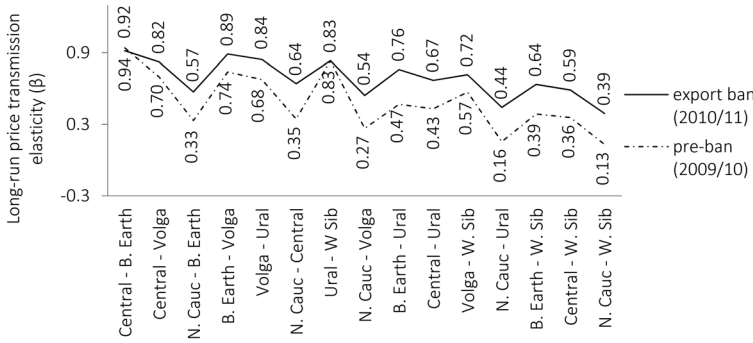
We discuss findings of the price transmission analysis of the Russian wheat market in the 2010/2011 export ban period, which is compared to the pre-ban 2009/2010 and post-ban 2011/2012 marketing years, when trade was freely possible. Selected parameters of the three-regime TVECM, which is estimated for 15 price pairs separately for the 2009/2010, 2010/2011 and 2011/2012 marketing years, are provided in [Tables A5, A6 and A7 in Appendix](#), respectively.

The long-run price equilibrium

Individual estimates of the long-run price transmission elasticities for 2009/2010 are widely dispersed across price pairs (Figure 3), indicating that wheat market integration before the implementation of the export ban is heterogeneous, ranging from almost fully integrated to only weakly integrated markets. Results suggest that distance is a major determining factor (Figure 3a). In particular, the long-run price transmission elasticity is the highest between the neighboring regions Central (a major consumption center) and Black Earth (a large production region), amounting to 0.94. The long-run price transmission elasticity is lowest between the two grain production regions North Caucasus and West Siberia (0.13), which, with roughly 4000 km between them, are the most distant regions from each other.

The median wheat price transmission elasticity is equal to 0.43 and 0.51 during the open trade regimes of 2009/2010 and 2011/2012 (Figure 4a). However, in the 2010/2011 marketing year, when several production regions experienced a severe drought and exports to the world market were banned, the median price transmission elasticity increased to 0.67, which is 56% and 31% higher compared to the pre-ban period and the post-ban period, respectively. Furthermore, during the export ban period, the slope coefficient increased for 13 out of 15 price pairs compared to 2009/2010 (Figure 3a). All price pairs involving North Caucasus, which, differing from free trade periods, became heavily involved in domestic grain trade during the export ban period, show the largest increase in the long-run price transmission elasticities, varying between about 70% and 200%, compared to increase by -2% to 65% for the other price pairs. Similarly, price transmission elasticity decreased for 12 out of 15 price pairs during the post-ban period compared to 2010/2011 (Figure 3b), especially for price pairs including Ural, which became self-sufficient in grain production and therefore reduced wheat imports from other regions of Russia (compare Table 1 and Figure A2).

a Pre-ban (2009/10) and export ban (2010/11) periods



b Post-ban (2011/12) and export ban (2010/11) periods

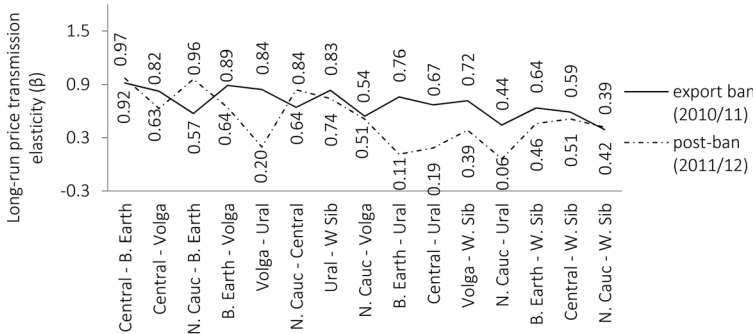


FIGURE 3 Parameters of the long-run price transmission elasticities. Price pairs on the x-axis are presented by distance between markets varying between 526 km and 3984 km (see Table A4 in Appendix for further details); the median parameter is indicated in bold.

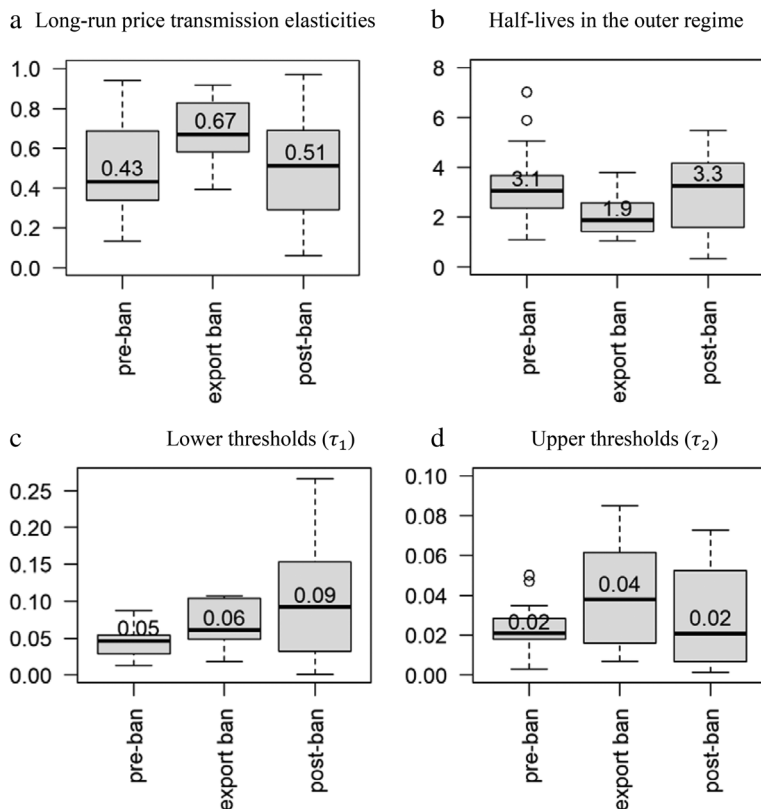
Source: own calculations and elaboration

Furthermore, we use the Wald test to assess whether the estimated long-run price transmission elasticities are statistically different between the open trade and export ban regime. We follow Götz, Djuric, and Nivievskyi (2016a) in our testing procedure and estimate model (1) by 2-year periods for 2009–2011 and 2010–2012, in which model variables are interacted with a dummy variable to account for the period with export restrictions. Wald test statistics reported in Table A4 in Appendix makes evident that for 11 and 10 out of 15 investigated price pairs, the price transmission elasticities observed during the export ban period differ statistically significantly from the values observed during the 2009/2010 and 2011/2012 open trade regimes, respectively. This result is not confirmed for the price pairs Central–Black Earth, Central–Volga, Black Earth–Volga and Ural–West Siberia in 2009–2011 and for the price pairs Black Earth–West Siberia, Central–West Siberia, North Caucasus–Ural, North Caucasus–West Siberia and Ural–West Siberia in 2010–2012, which are characterized by the stable direction of trade flows, even during the export ban.

Half-life coefficients

Given that the price adjustment process is nonlinear, the half-life coefficients, defined as the time required for phasing out half of a price shock, are nonlinear as well, and thus half-life coefficients for the outer (i.e., lower and upper) and the middle regimes are distinguished.⁵ In the following, we discuss half-lives for the outer regimes, while results for the middle regime are presented in Appendix C.

FIGURE 4 Boxplots of the estimated parameters, 2009/2010, 2010/2011 and 2011/2012. “pre-ban” = 2009/2010, “export ban” = 2010/2011, “post-ban” = 2011/2012. Plots are based on estimated parameters given in Figure 3 and Tables A5, A6 and A7 in Appendix. The half-lives for the outer regime are estimated as the average of the half-lives in the upper and lower regimes $H_{outer} = \frac{H_{lower} + H_{upper}}{2}$. Absolute values of the point estimates of threshold are plotted on the graphs. *Source:* own calculations and elaboration



Results for the outer regimes confirm that the half-life coefficients decreased and, thus, the speed of price adjustment increased during the export ban period (Figure 4b). The median half-life decreased from about 3 weeks in 2009/2010 to about 2 weeks in 2010/2011 and increased to 3.3 weeks after the removal of the export ban, corresponding with an acceleration of price adjustment by almost 50% during the export ban period.

Considering the half-life estimates of the outer regimes in the pre-, post- and export ban periods, results show that half-lives vary between 1 and 4 weeks for the majority of price pairs during the 2009/2010 open trade period (Figure 5). Among the 15 investigated price pairs, the half-life estimates for the outer regimes suggest that the price adjustment is fastest between the neighboring regions Central and Black Earth during the 2009/2010 open trade period, as half of the price disequilibrium is corrected in 1 week. The half-life estimates increase to 2 weeks for the price pairs Central–Ural and 3 weeks for the price pairs Central–West Siberia, reflecting the negative influence of distance. Similar to the long-run price equilibrium analysis, price pairs involving North Caucasus typically report lower levels of price adjustment compared to the price pairs without North Caucasus during the pre-ban period. For price pairs that include North Caucasus, the half-life parameter is smallest for the North Caucasus–Central price pair (2.9 weeks) and largest for the North Caucasus–Ural price pair (5.9 weeks). Half-lives for North Caucasus–Black Earth, North Caucasus–Volga, and North Caucasus–West Siberia vary between 3 and 4 weeks.

During the export ban period, the time required for the price adjustment in the outer regimes decreases significantly for 12 out of 15 price pairs, which we explain by the increase in domestic trade volumes compared to the pre-ban period (Figure 5). The largest decrease in the adjustment time is observed for the price pair Black Earth–Volga, with the half-life coefficient

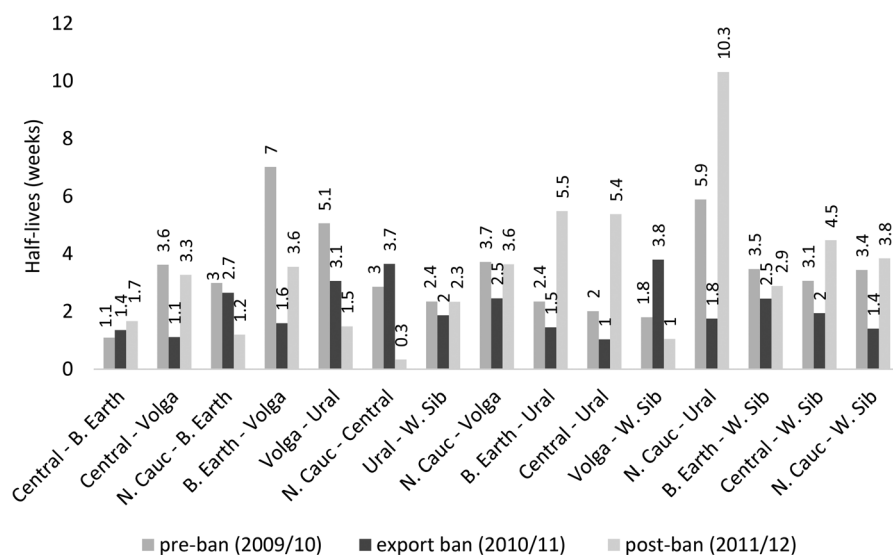


FIGURE 5 Half-lives in the outer regime: Pre-ban, export ban and post-ban periods. Price pairs are presented on the *x*-axis by distance between markets, varying between 526 km and 3984 km (see Table A4 in Appendix for further details on distances).

Source: own calculations and elaboration

decreasing by 5.4 weeks in the export ban regime compared to the 2009/2010 open trade period. This may be explained by the strong increase in trade from other regions (compare Figure A2). A severe harvest shortfall of 60% compared to the previous year has turned Black Earth and Volga into grain-deficit markets (compare Table 1 and Figure A2), strongly increasing grain imports from grain-surplus regions. Similarly, half-lives decreased for the price pairs North Caucasus–Black Earth, North Caucasus–Volga and North Caucasus–Ural in 2010/2011 compared to the pre-ban period. Trade has increased strongly, with the trade direction changing and wheat supply substantially increasing from North Caucasus to Black Earth, Volga and Ural (see Figure 1), regions that were affected by severe harvest shortfalls. In contrast, the half-life increased by 0.3 weeks for the price pair Central–Black Earth, corresponding to a decrease in trade flows between those markets during 2010/2011 compared to the pre-ban period.

After the removal of the export ban, half-life parameters for the outer regimes increase again in 2011/2012, mainly reflecting the decrease in domestic trade flows (Figure 5). In particular, instead of supplying grain to the domestic market, North Caucasus exported its grain surplus to the international wheat market. The largest increase in the time required for price adjustment is observed for the price pairs that included Ural, raising by 4, 4.3 and 8.6 weeks for Black Earth–Ural, Central–Ural and North Caucasus–Ural, respectively. This may be explained by Ural having a bumper crop of wheat in the 2011/2012 marketing year, turning Ural into a self-sufficient wheat region and thus strongly reducing the wheat trade.

Transaction costs

Figure 4c,d presents point estimates (posterior medians) of lower (τ_1) and upper (τ_2) thresholds corresponding to transaction costs in reversed and regular trade directions, respectively.⁶

Regardless of the state of trade openness, transaction costs are usually lower for regular compared to reversed trade routes. Specifically, the median upper threshold is 1.5, 2.5 and 4.5 times lower compared to the lower threshold in 2009/2010, 2010/2011 and 2011/2012, respectively.

Turning to the individual estimates provided in Tables A5, A6 and A7 in Appendix, the upper threshold values (τ_2) are smaller than the lower thresholds (τ_1) in each of the three marketing years for all price pairs but Black Earth–Ural (2009/2010), North Caucasus–West Siberia (2010/2011), Ural–West Siberia (2011/2012) and North Caucasus–Volga (2011/2012). For the price pair Black Earth–Ural, however, wheat is usually exported from Black Earth to Ural ($\tau_1 = -0.039$) rather than from Ural to Black Earth ($\tau_2 = 0.05$) (compare Figure 1a). Concerning the price pair North Caucasus–West Siberia, wheat was regularly delivered from West Siberia to North Caucasus for further exports during the open trade regime (compare Figure 1a), which corresponds to the size of the upper threshold (τ_2) amounting to 0.027 in 2009/2010. However, during the export ban, the upper threshold increases by almost 3 times to a value of 0.075, which we explain as due to increasing rail transport rates, while railway tariff subsidies did not apply to grain deliveries from West Siberia in 2010/2011. This distribution scheme of railway subsidies created less advantageous conditions for wheat deliveries from West Siberia in general.

Our results further show that thresholds increased for 14 (out of 15) price pairs during the 2010/2011 export ban period compared to the pre-ban period in Russia. For the post-ban period, we find the upper threshold corresponding to transaction costs in regular trade directions decreases for 10 out of 15 price pairs, while lower threshold decreases for only 6 out of 15 price pairs in 2011/2012 compared to 2010/2011. Furthermore, the test on the statistical differences of the estimated parameters (Appendix, Table A8) indicates that the estimates differ between the export ban period and the open trade regime in 2009/2010 for six price pairs at the 10% significance level or for seven price pairs at the 15% significance level out of 15 price pairs altogether. Results for the post-ban period also indicate that the estimated thresholds are statistically different for the majority of price pairs.

Therefore, the increase in the size of thresholds observed during the export ban period implies rising interregional transaction costs in 2010/2011 (Figure 4c,d). The median upper threshold (τ_2) is about 2 times higher in 2010/2011 (0.04) than in 2009/2010 (0.02), and the median lower threshold also increases by 20% during the export ban (0.06) compared to the open trade regime (0.05). The median upper threshold (τ_2) returns to its pre-ban level after the removal of the export ban (0.02); however, the median lower threshold further increases by 50% during the post-ban period (0.09) compared to the export ban regime (0.06). We attribute this increase in thresholds to the higher risk and uncertainty that persisted in the Russian grain market even after the removal of the ban.

We also find thresholds significantly increasing for the price pairs North Caucasus–Black Earth and North Caucasus–Ural during the 2010/2011 export ban period (Appendix, Table A8), coinciding with the reversal of trade flows from North Caucasus to Black Earth and Ural, where unfavorable weather conditions heavily reduced the wheat harvest (compare Figure 1b). Transaction costs also increase for regions affected by significant harvest shortfalls (Central–Ural and Volga–Ural). Furthermore, we identify increasing thresholds for price pairs including West Siberia during the export ban period (Central–West Siberia, Volga–West Siberia and North Caucasus–West Siberia). This could be explained by railway subsidies for in-country grain deliveries originating from North Caucasus only, which disadvantaged wheat deliveries from West Siberia to other regions. However, after the removal of the export ban, thresholds decreased for West Siberia in the direction of Central, Black Earth and Volga during the post-ban period (Appendix, Table A8).

DISCUSSION OF RESULTS AND CONCLUSIONS

We have investigated domestic price effects of the 2010 wheat export ban, induced by a severe harvest shortfall, skyrocketing world wheat prices and supplemented by grain rail transport subsidies in Russia. By prohibiting wheat exports, spurred by high world market prices, the export ban increased domestic supply, dampening the price increases caused by the harvest shortfall. This process was accelerated and strengthened by grain transport subsidies, which reduced the transaction costs of grain exports from domestic production-surplus to the drought-affected, grain-deficit regions.

Results of the price transmission analysis have made evident that during the period of export restriction, the transmission of price changes strengthened, and the correction of deviations from price equilibrium accelerated, indicating that the market integration strengthened compared to the open trade regime. Differing transaction costs increased for half of the investigated price relationships within the domestic grain market compared to the open trade regime, which indicates that market integration decreased.

Using a TVECM approach to analyze spatial price relationships, we found more price pairs correcting price disequilibria (and more rapidly) in the outer regimes compared to the middle regime. In general, the time required to eliminate a half of price disequilibrium varies between 1 and 4 weeks for the majority of price pairs during the open trade regime. However, this is a rather slow adjustment when compared to the adjustment time for corn prices in the United States (Svanidze & Götz, 2019a), where it usually takes just less than a week to correct half of the deviation from the long-run price equilibrium. Furthermore, the estimated thresholds for price pairs are larger in reversed trade direction compared to regular trade routes. Our results also indicate that the degree of wheat market integration in Russia is a function of distance: We identify the weakest price relationships (lowest price transmission elasticities), the slowest correction of short-run deviations from the long-run price equilibrium (smallest speed of adjustment parameters) and the highest transaction costs (largest thresholds) for the most distant markets. The transaction costs are remarkably high for price pairs including Ural and West Siberia, two peripheral regions located thousands of kilometers away from the major export regions and consumption centers.

Particularly strong increases in price transmission elasticity during the export ban period is observed for price pairs that include North Caucasus. We explain this finding by the decreasing influence of world market conditions on domestic wheat price formation. Thus, the role of common domestic factors increased, strengthening the integration of the domestic wheat market, particularly in regions usually involved in grain exports to the world market. Domestic wheat market integration was also strengthened by the strong rise in interregional trade flows from the surplus regions of North Caucasus and West Siberia to the deficit regions. Our results of the analysis of spatial market integration are in line with previous findings by other studies. Porteous (2017) identifies increased market integration during the export ban period for the regional maize markets in East and Southern Africa. Similar to increased interregional wheat trade in Russia, maize trade also continued in Africa during the export ban period, but via informal marketing channels. In contrast, Baylis et al. (2014) find that the integration of the domestic rice market decreased in India, as interregional trade was not facilitated and rice was stored at the port in anticipation of the removal of the grain export ban. Interestingly, market integration increased for India's wheat consumption regions, which became more integrated with the port markets during the restricted export regime, tracing back to the increased flows of imported wheat from ports to the consumption centers (Baylis et al., 2014).

The rise of the size of thresholds in both trade directions during 2010/2011 confirms the increase in transaction costs during the export ban period. In particular, the government increased railway transport costs by 10% from 2009/2010 to 2010/2011. Further, search and trade risk of interregional grain transactions increased since grain trade destinations changed and flows of trade reversed within Russia, supposing new business relationships while difficulties in contract enforcement prevailed. Although transport subsidies were provided for certain trade routes, they were too low to cushion increasing total transaction costs during the export ban.

Furthermore, exploring the domestic wheat market developments after the removal of the export ban in Russia, results indicate that the degree of wheat market integration decreased during the post-ban period and returned to its pre-ban level, corresponding with the size of domestic wheat trade flows. After the removal of the export ban, domestic trade flows were redirected from the domestic to international markets. However, transaction costs remained high for some grain producing regions in Russia, attributable to the persistence of increased risk and uncertainty in the Russian grain market even after the removal of the export ban.

Our study offers several important implications in terms of trade policy and food security. First, long distance and poor infrastructure challenge the distribution of grains between spatially protracted areas, leaving grain-deficit areas vulnerable to harvest failures. To improve regional connectivity and to cushion potential production shocks, investments in transport infrastructure and storage facilities should be increased. Second, although export restrictions have shown to be capable of enhancing regional market integration and thus to be effective in counteracting the influence of regional supply shocks in a large market in the short run, their long-term implications for market development may rather be negative. In particular, as our results indicate, the wheat export ban in Russia resulted in higher transaction costs, arising from heightened uncertainty and market risk persisting even after the export ban was removed. By increasing market instability, recurring governmental interventions discourage investments in grain production, negatively affect the further development of the grain sector and have a detrimental effect on the realization of Russia's wheat production potential, with respective implications for future global food security (Fellmann et al., 2014; Lioubimtseva & Henebry, 2012).

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ENDNOTES

- ¹ The member states of the union are Russia, Kazakhstan, Kyrgyzstan, Belarus and Armenia.
- ² The size of grain trade by rail approximates the total domestic grain trade on long-distance routes quite well. However, grain traded over short distances (<1000 km) is transported by trucks and thus the size of grain transported by rail is significantly smaller than the total grain trade of short-distance routes.
- ³ In 2011/12, however, grain production was exceptionally high in Ural (compare Table 1), making the region grain self-sufficient.

- ⁴ This information was provided in a personal interview with Rudolf Bulavin of the Russian Grain Union.
- ⁵ Following Durborow et al. (2020), regime-specific half-life coefficients for each regime r , $r = 1, 2, 3$ corresponding to the lower, middle and upper regimes, respectively, are calculated via the equation $H_r = \frac{\ln(0.5)}{\ln(1-\rho_r)}$, where ρ_r is the total speed of adjustment parameter for each regime r , $r = 1, 2, 3$ provided in Tables A5, A6 and A7 in the Appendix. For the discussion of results, half-lives in the outer regimes alone are used: $H_{outer} = \frac{H_1 + H_3}{2}$.
- ⁶ For illustrative purposes, we additionally provide posterior density plots for regional price pairs containing North Caucasus in Appendix D.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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