Trade Policy Interventions on Agricultural Markets in Countries of the Former Soviet Union and the Balkans

Habilitationsschrift
zur Erlangung der Lehrbefähigung im Fachgebiet Agrarökonomie

vorgelegt an der
Naturwissenschaftlichen Fakultät III
der Martin-Luther-Universität Halle-Wittenberg, Halle (Saale)

von

Dr. Linde Johanna Götz

geboren am 10. Januar 1973 in Neustadt an der Weinstraße

Gutachter
Prof. Dr. Thomas Glauben, Martin-Luther-Universität Halle-Wittenberg
Prof. Dr. Bernhard Brümmer, Georg-August-Universität Göttingen
Prof. Dr. Thomas Heckelei, Rheinische Friedrich-Wilhelms-Universität Bonn

Dekan
Prof. Dr. Matthias Müller-Hannemann, Martin-Luther-Universität Halle-Wittenberg

Verteidigung der Habilitationsschrift
16. Oktober 2017

Feststellung der Lehrbefähigung und Zuerkennung der Lehrbefugnis
6. November 2017

ACKNOWLEDGEMENT

This habilitation thesis emerged from my research conducted at the Leibniz Institute of Agricultural Development in Transition Economies (IAMO) where I have been employed since 2008. I am very grateful to Thomas Glauben, the head of the Department for Agricultural Markets, Marketing and World Agricultural Trade for the inspiring working environment. I am particularly indebted for his steady support of my research and encouragement to write this thesis.

The studies included in this habilitation thesis are the result of joint research endeavours. Therefore, I would like as well to express my acknowledgment to my coauthors Thomas Glauben, Ivan Djuric, Ulrich Koester, Bernhard Brümmer, Rudolf Bulavin, Jean-Philippe Gervais, Oleg Nivievskyi, Kateryna Goychuk-Schroeder, Jarilkasin Ilyasov, William Meyers, Dmytro Serebrennikov, Miranda Svanidze and Feng Qiu. I am also grateful to my colleagues Ihtiyor Bobojonov, Inna Levkovych and Sören Prehn for having good laughs and serious discussions. Special thanks to Susanna Hönle, Antje Elsner and Silke Scharf for formatting this thesis book.

Above all, I would like to thank my husband Edgar for his personal support and fruitful discussions, and my sons Louis and Casimir for always welcoming me with a smile, even when I came home too late. I am also grateful to my parents Anne and Klaus for their continuous support.

ABSTRACT

Trade policy interventions have recently been widely used world-wide in the context of skyrocketing prices on world commodity markets. By intervening in export and import markets, many countries have tried to prevent the high world market prices from spreading to domestic markets. These interventions in international agricultural trade were aimed at combating food price rises in order to safeguard low food prices for domestic consumers.

This habilitation thesis focuses on export controls for wheat which were implemented in Russia, Ukraine, Kazakhstan and Serbia. In these countries the export of wheat was restricted by means of export duties, export quotas and export bans in 2006-2008 and 2010-2011, periods of high and rapidly rising prices on global markets.

The overarching topic of the studies included in this habilitation thesis lies in the question of the effectiveness of export controls to stabilize domestic food prices. This question is addressed by investigating the export controls' intended and unintended effects on domestic prices aiming to identify and measure the observable effects of wheat export controls on the wheat, flour and bread price level and also price volatility. This also involves investigating how well grain markets are functioning in transition countries more in general, particularly in a country as Russia in which the market stretches across a large geographical area. Besides, we focus on the wheat price developments in the neighbouring countries of the South Caucasus and Central Asia which are strongly depending on grain imports from the Black Sea region.

We are following a time-series econometric approach in the quantitative analyses. To identify the effects of the export controls on the domestic price level we make use of several price transmission frameworks which capture the influences of the export controls by a switch in the price transmission regime.

The results of our analyses regarding Russia, Ukraine, Kazakhstan and Serbia, have shown that the strongest wheat price dampening effects of wheat export controls were observed in Russia during the wheat export ban in 2010/11, when the domestic wheat price dampening effect differed strongly between the regions, varying between 67% and 35%. This is followed by Ukraine for which the identified price dampening effects of the export quotas and the export tax implemented in the time period 2006 to 2011 vary between 10% and 26% on the national level. However, the effects of the export controls in 2008 and 2010/11 on regional wheat prices fluctuate rather slightly between 1% and 12%.

Further, our results make evident that wheat export controls are not always successful in dampening the domestic wheat price. In particular, the export tax of up to 40% implemented in Russia 2007/08 could not prevent that the domestic wheat price increased beyond the wheat world market price. Similarly, the domestic wheat price in Kazakhstan and in Serbia increased to a level exceeding the world wheat market price when an export ban for wheat was implemented in 2008 (Kazakhstan) and 2007/2010 (Serbia). The size of the wheat price dampening effect differs depending on the restrictiveness of the export controls. However, additional case-specific factors play a large role as e.g. the sequencing of governmental market interventions, which may counteract the price dampening effects of export controls.

The studies investigating the relationship between wheat export controls and domestic wheat price volatility in Russia, Ukraine and Serbia have made evident that domestic wheat price volatility did not decrease but rather increased when wheat exports became restricted.

Also, analyses of price transmission along the wheat-to-bread supply chain in Serbia have shown that mills, bakeries and retailers have not fully transmitted the price dampening effects along the supply chain. Rather, particularly the large mills managed to widen the gross margin by 30% and bakeries and retailers by 270%. Contrasting, the end consumers were confronted with increasing bread prices, which increased the poor households' expenditures for bread and cereals by over 14% in 2008. Similarly, the mills in Russia increased their margin as well, but increases in the bread price can be explained by raising production costs. From this we can conclude that the effectiveness of wheat export controls to reduce domestic bread price inflation is rather limited and economic access to food is merely enhanced.

Finally, we have provided preliminary evidence that the wheat export controls in Russia and Kazakhstan have significantly increased wheat prices in the land-locked countries Kyrgyzstan, Armenia and Azerbaijan. Differing, price increasing effects were not identified for Georgia, which we explain with its favourable geographical location with direct world market access.

At the same time, export controls create considerable market distorting effects by increasing market and price risk, which raises production costs, and decreases the export price, whilst also preventing traders from benefiting from high world market prices. In the long-run wheat export controls reduce profitability and the volume of wheat production and also negatively affect food availability and in this sense even reduce food security. In the case of a large wheat exporting country, even global food security is negatively affected.

Therefore, the government should desist from market interventions by means of trade-oriented measures to influence domestic food prices. Rather, it should focus on consumer-oriented measures. In particular, instead of trying to dampen domestic food prices, it would be a more effective and in the long-run cost-efficient response of the government to allow domestic food prices to increase and instead only focus on the most vulnerable population sections to adapt to high consumer prices within social safety nets. To ensure that such safety-net measures can be implemented in a crisis situation in the short term, the existence of well-targeted social assistance programs, which may be scaled up or the number of eligible households expanded in times of acute crisis, needs to be ensured. However, export controls remain an attractive measure for policy makers since different to social safety net measures, they do not cause any budgetary costs, and instead even generate budgetary income in the case of an export tax.

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1 Scope and Structure

SCOPE AND STRUCTURE

This thesis is prepared to partially fulfil the requirements for obtaining the Habilitation Degree (the Venia Legendi in Agricultural Economics) according to the regulations of the Martin-Luther-University Halle-Wittenberg. The title of the thesis is “Trade Policy Interventions on Agricultural Markets in Countries of the Former Soviet Union and the Balkans”.

Trade policy interventions have recently been widely used world-wide in the context of skyrocketing prices on world commodity markets. By intervening in export and import markets, many countries have tried to prevent the high world market prices from spreading to domestic markets. In particular, countries with surpluses restricted their exports to global markets to increase the supply on domestic markets thereby decreasing domestic prices. Importing countries likewise tried to increase the supply on their domestic markets by liberalising the markets and eliminating existing trade restrictions such as import tariffs. These interventions in international agricultural trade were aimed at combating food price rises in order to safeguard low food prices for domestic consumers. During the phase of high prices in 2007-08, 37 exporting countries and 59 importing countries across the globe undertook market interventions (FAO 2008).

The 10 studies contained in this habilitation thesis are focusing on export controls for wheat which were implemented in Russia, Ukraine, Kazakhstan and Serbia. In these countries the export of wheat was restricted by means of export duties, export quotas and export bans in periods of high and rapidly rising prices on global markets.

The overarching topic of these studies lies in the question of the effectiveness of export controls to stabilize domestic food prices. This question is addressed by investigating the export controls’ intended and unintended effects on domestic prices. What are the observable effects of wheat export controls on the wheat, flour and bread price level and price volatility? What differences are there between regions and countries and how can these be explained? This also involves investigating how well grain markets are functioning in transition countries more in general, particularly in a country as Russia in which the market stretches across a large geographical area.

We also focus on the neighbouring countries of the South Caucasus and Central Asia which are strongly depending on grain imports form the Black Sea region. Were those countries affected by the export controls as well and can domestic price effects be observed in those countries?

In the quantitative analyses we are following a time-series econometric approach. To identify the effects of the export controls on the domestic price level we make use of a price transmission framework which captures the influences of the export controls by a switch in the price transmission regime. Applying several econometric regime-switching approaches, the question which naturally arises is which model performs best to identify the domestic wheat price effects? A further challenge lies in the applicability of complex model frameworks as e.g. a 3 regime threshold vector error correction model, which we apply to the grain market of Russia which is characterized by pronounced instability not only in regional price relationships but also interregional trade flows and trade directions vary substantially.

The domestic price effects of wheat export controls is a topic particularly relevant to the Russia, Ukraine and Kazakhstan (RUK) and Serbia. These four countries are characterised by excellent natural conditions for the cultivation of grains. Russia, Ukraine and Serbia have large areas of extremely fertile black earth. In the last few years these states have become important grain-exporting countries. Today, RUK's share of global grains exports amounts to 20% (USDA 2014). Actually, it is expected that Russia will become the primary wheat exporter in the world in 2016/17 (Interfax 2016). Whereas Russia and Ukraine have their own ports on the Black Sea and thus export predominantly to the large cereal-importing countries of North Africa and the Middle East, Kazakhstan is a landlocked country without direct access to the global market. Consequently, the neighbouring South Caucasian and Central Asian countries are the main importers of wheat and wheat flour from Kazakhstan. Serbia, by contrast, is a small cereals exporter, but nonetheless a country of great regional importance as a supplier of cereals. Serbia exports predominantly to the neighbouring countries of the western Balkans, such as Bosnia-Herzegovina, Montenegro, Macedonia and Albania.

The OECD/FAO (2012) estimates that the annual global demand for cereals will rise to three billion tonnes by 2050, which means that the global grain production will have to rise by 30%. The Eastern cereal-producing nations may play an important role here, as they have large untapped potential to increase further their production of grains. Production efficiency might be increased by, for example, intensifying the application of fertilisers or using high-performance seeds (Bokusheva and Hockmann 2006). In addition, former agricultural land, large areas of which were taken out of production during the transition process, could be recultivated. To exploit this potential, however, extensive investment is needed, including from private financiers. For example, it is reckoned that in Ukraine the investment needed to exploit the existing cereal potential is 1,000-2,000 US$ per hectare of farmland (Harmgart 2011).

Export restrictions, however, create very negative incentive effects on investment in the grain sector and thus hamper its further development. In the short term, export controls produce large losses for producers and cereal traders, who cannot benefit from the high global market prices. At the same time, grain production is exposed to an increased price risk on the domestic market and raising production costs and thus reduce profitability of grain production. In the long-term, therefore, these market interventions do not increase but rather negatively affect food security and also harm future food security world-wide in the case of large exporting countries.

This habilitation thesis comprises altogether ten research papers (see table of contents). Seven studies address the influences of wheat export controls on the stability of domestic wheat prices. The impact of export controls on flour and bread prices is addressed within two articles. One paper focuses on the effects of export controls on the wheat prices in countries which are heavily depending on imports from the export restricting countries.

In particular, the export controls' effects on the level of domestic wheat prices is investigated within three papers focusing on Russia, Ukraine and Serbia. Two papers address the impact on the regional price level in Russia and Ukraine. One paper investigates the influence of the Russian export ban 2010/11 on the relationship between domestic wheat prices in different regions of Russia. One paper focuses on the effects of the export controls implemented in Ukraine on the domestic wheat price volatility.

The effects of wheat export controls on flour and bread prices are analysed for Russia, Ukraine, Kazakhstan and Serbia within two articles. Finally, one paper captures the impact of the export controls implemented in Kazakhstan and Russia on wheat prices in the neighboring countries in Central Asia and the South Caucasus.

In section II we give an overview on the theoretical background, methodological framework and research results of the studies included in this habilitation thesis. Section III presents the ten scientific articles themselves in full length.

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2 Overview on Theoretical Framework, Methodological Approach and Research Results

Overview on Theoretical framework, Methodological Approach and Research Results

1 Wheat export controls in Russia, Ukraine, Kazakhstan and Serbia

At the core of the journal articles and research papers included in this habilitation thesis lie the exports controls for wheat which were implemented by various trade policy instruments in Russia, Ukraine, Kazakhstan (RUK) and Serbia during the agricultural crisis of 2007-08 and the phase of high prices on global agricultural markets in 2010-11. In the following we provide an overview on the realized trade policy measures which were implemented by means of export taxes, export quotas and export bans.

2 Economics of domestic price effects of wheat export controls

In general, export controls for agricultural products are implemented with the aim to dampen domestic agricultural and food prices. Besides the domestic price dampening effects, export controls may have unintended effects on the world price and on countries which usually import from the export restricting countries.

This section provides an overview on the characteristics of the domestic price effects of wheat export controls and the unintended domestic price effects on importing countries, which are addressed by the different studies included in this thesis.

Dampening effect on the wheat, flour and bread price

Export restrictions for wheat are implemented in Russia, Ukraine, Kazakhstan and Serbia with the aim to prevent bread price inflation. Initially, wheat export controls target to temporarily decrease the price level of wheat prevailing on the domestic market.

This wheat price dampening effect is the result of two partial effects, the domestic supply effect and the price insulating effect. By decreasing the size of wheat exports and increasing the supply on the domestic wheat market, export controls reduce the domestic market price for wheat compared to the price that would prevail if trade was possible.

As the second effect, export controls separate domestic wheat prices from world market price developments and prevent high prices prevailing on the world market from being transmitted to the domestic market. If arbitrage activities become restricted or even prohibited, domestic prices become to some degree insulated from price developments on the world market, and the importance of domestic factors for domestic price determination increases, whereas the influence of the international prices decreases. This also contributes to dampening the domestic price relative to the world market price.

For wheat price decreases to substantiate in bread price decreases, the price changes need to be transmitted by the supply chain actors along the wheat-to-bread supply chain via the flour price to the bread end consumer price.

The domestic price effects of export controls are identified and quantified within price transmission models which allow their parameters to change in phases when exports are restricted by export controls.

The assessment of the domestic price dampening effects is in the center of several of our studies (Djuric et al. 2015; Djuric and Götz 2016; Götz et al. 2013a, 2015a, 2015c, 2016a, 2016b). However, they differ in the countries and phases of export restrictions addressed, some analyses are conducted based on national average price data and other on regional price data thus pointing to regional differences of those impacts. Also, some focus on the effects on wheat prices, other on flour and bread prices. Finally the studies differ regarding the applied econometric framework.

Impact on regional prices and price relationships

From the perspective of regional markets, the price dampening effect is relevant to the region which has direct access to the world market and is actually exporting to the world market. In general, an export control, be it an export quota, an export tax or an export ban, can be depicted as an export tax (Alston and James 2002). Accordingly, an export ban can be understood as an export tax which is prohibitively high. Therefore, the introduction of an export control is equivalent to a change in the fob price relevant to the exporting company.

The change in the fob price is transmitted to the producer price in the exporting region and further to the other regions according to the degree of integration of the regional markets. Markets become integrated by spatial arbitrage, either directly by trade between the regions themselves or indirectly through the network via the trading linkages that connect the regions (Fackler and Goodwin 2001: 979). According to the Law of One Price, regional prices differ at most by the size of transaction costs if markets are efficient, resulting in an optimal resource allocation. The regional variation of domestic wheat price effects in Russia and Ukraine are investigated by Götz et al. 2016b.

Export controls may also impact interregional price relationships. For example, price relations might strengthen due to the increase in trade between two regions. The influence of the wheat export ban in Russia on interregional price relationships is analyzed in Götz et al. 2016c.

Heterogeneous price expectations

A change in traders' and farmers' price behavior is at the bottom of price dampening effects induced by export controls. In general, traders' and farmers' price behavior is governed by expectations, which may differ due to the heterogeneity of farmers and traders. In the context of export restrictions, expectations about the exact date that export quotas will be implemented, and about the quota size itself may differ among traders and farmers. As soon as traders expect that export restrictions will be implemented, they will change their price behavior. In contrast, traders who expect that an export restriction will not be implemented might not change their price behavior until the export controls are actually implemented. Also, traders expecting the quota size to be rather small and thus also expecting particularly low domestic prices to prevail might accept a price offer only at a lower price than a trader expecting rather loose export controls.

This implies that a change in the relationship between the domestic and the world market may be observed before the export controls are actually implemented, and that the process of transition is not abrupt but occurs rather gradually over time. This is confirmed by the findings of Götz et al. 2016a by investigating the domestic wheat price effects of export controls in the Ukraine within a smooth transition cointegration approach.

Harvest shortfalls

However, export restrictions are often implemented in the situation of a production shortfall which might be regionally limited. A grain harvest shortfall causes additional domestic price effects. In particular, a harvest shortage decreases domestic supply regionally, inducing price increasing effects, which may raise domestic regional prices beyond world market prices. Export controls may cushion the price increasing effects of harvest shortfalls in the respective regions by reinforcing trade flows from regions with supply surplus to regions experiencing a harvest shortfall. Götz et al. 2016b explicitly takes into account that a harvest failure causes a domestic supply effect and thus impacts the domestic price. Results make it clear that to properly identify the domestic price effects of export restrictions it is essential that the domestic price effects caused by harvest shortfalls are accounted for.

Market uncertainty

The implementation of export controls may imply the dramatic increase in market uncertainty for several reasons. Particularly in the case of Ukraine, export quotas were implemented on short notice, the size of the quota was changed and prolonged several times, and the quota licenses were distributed not in a transparent way. Thus, export restrictions make market conditions unreliable and difficult to foresee, thereby increasing market risk and ultimately leading to additional price volatility. The relationship between export controls and the development of price volatility is addressed by Götz et al. 2013a and 2013b.

Domestic price effects in importing countries

Besides the domestic price dampening effects in the export restricting country itself, export controls may have unintended price increasing effects on the world market price (if the country is a large supplier to the world market). However, export controls also may also influence prices in importing countries which usually acquire large amounts of their imports from the export restricting countries. Svanidze et al. 2016 investigates the effects of the wheat export controls in Russia and Kazakhstan on the neighbouring countries of the South Caucasus and Central Asia.

3 Research approach

Central to our studies is the identification and quantification of the domestic price effects within different time-series econometric models of price transmission and price volatility.

It should be pointed out that it is not possible to define a unified price transmission approach which captures all aspects of export controls as indicated in section 2. Rather, we have developed several individual model frameworks to identify and measure the different features of the wheat export controls on domestic prices. The following section provides an overview on the econometric models and estimation approaches applied in our studies.

3.1 Econometric model frameworks and estimation methods

In general, to identify and measure the domestic price effects of export controls we are utilising a price transmission framework. In price transmission analysis, the relationship between prices is investigated. In particular, it focuses on the degree to which price changes are transmitted and the speed at which deviation from the long-run equilibrium between the respective prices are corrected. Spatial price transmission analysis (Fackler and Goodwin 2001) focuses on prices of markets which are spatially separated, whereas in vertical price transmission analysis the core interest lies in price relationships between different stages of a supply chain (Vavra and Goodwin 2005).

According to the Law of One Price (Fackler and Goodwin 2001), prices in spatially separated markets under perfect competition differ at most by the size of the costs of trade arbitrage between the two markets. Spatial transmission of price changes, e.g. between the world market price and domestic prices or between regional prices, may be influenced by many different factors, for instance political market interventions (e.g. export controls, import taxes, non-tariff barriers, domestic price support), transport and marketing costs (depending on distance, quantity and quality of transport infrastructure, market risk, border effects), macroeconomic factors (e.g. exchange rate) and market structure (Zorya et al. 2012; Kouyatè and von Cramon-Taubadel 2015).

Analogously, the degree and speed of the vertical transmission of price and cost changes between different stages of the food supply chain might be influenced by e.g. the exertion of market power in non-competitive markets, menu costs resulting from the retailer's costs of adjusting quantities and prices, consumers' costs to search for the lowest price relatively to the price change (Loy et al. 2016), contracting costs in vertically coordinated supply chains (Swinnen and Vandeplas 2015), the penetration of private labels versus national brands (Loy et al. 2015a, 2015b; Bonnet and Réquillart 2012), product storage and perishability characteristics (Meyer and von Cramon-Taubadel 2004) the cost share of the raw product in the end consumer good.

To identify the influence of export controls on the domestic price level of wheat we apply a spatial price transmission model capturing the price relationship between the domestic wheat price and the relevant world market wheat price. As the domestic wheat price we choose national average wheat producer price in Djuric et al. 2015 and Götz et al. 2013a, 2016a and region-specific producer prices in Götz et al. 2016b. We also utilize a model depicting the relationship between region-specific producer prices themselves in Götz et al. 2016c. The influence of export controls on the flour and bread price is identified within a model of vertical price transmission from the wheat to the flour price and from the flour to the bread price in Djuric and Götz 2016.

The applied spatial and vertical price transmission models have in common that they allow parameters to change if exports become restricted compared to when trade is freely possible. Thus, the influence of export controls is captured by the change in the parameters of the price transmission regime in our model approach (for further details please see Götz et al. 2016b). This implies the model assumption that all other factors beyond export controls which influence price transmission between spatially separate markets or between stages of the wheat-to-bread supply chain (see above) are constant and do not change in the time period underlying our analyses. Since this assumption does not always hold (as e.g. in Djuric et al. 2015), we complement our price transmission studies by comprehensive qualitative research on the primary additional factors which have changed during the time period underlying our analysis and which influence the price transmission parameter estimates. It is decisive to take those influencing factors into account when interpreting estimated model parameters.

We are utilizing a variety of econometric models which allow the price transmission regime to change (Table 1). In a Markov-switching (vector) error correction model (MS(V)ECM) applied in Götz et al. 2013a; Djuric et al. 2015; Djuric and Götz 2016, the regime switch is abrupt and determined endogenously. It is assumed that the data-generating process underlying the state variable, which governs the regime switches, is unobservable and probabilistic and follows a Markov chain, which is governed by constant transition probabilities (i.e., the state of the market of tomorrow is determined only by the state of the market of today).

In a regime-switching (RS) model which is applied in Götz et al. 2016b, 2016c, the regime switches are also assumed to be abrupt, but to be determined exogenously. In particular, the regime-switching model makes use of the known dates of trade policy changes by allowing for a regime switch at those dates. It should be pointed out that in the RS-TVECM (Götz et al. 2016c) additional 3 regimes are distinguished to capture the influence distance and trade costs on price relationships and the degree of price transmission. The estimation of the RS-TVECM includes the identification of 2 thresholds which are both allowed to change if exports become restricted.

Similar to a MSECM, in a smooth transition cointegration (STC) model as applied in Götz et al. 2016a, the regime switch is determined endogenously. Differing, to allow for regime changes induced not only by an actual but also an expected policy change and trader heterogeneity, the regime switch in the STC model is assumed to be smooth and the transition process to be governed by the observed level of the wheat world market price.

Table 1: Characteristics regime switches in the applied time-series econometric model frameworks

model framework	endogenous	exogenous	abrupt	smooth
MS(V)ECM *(Götz et al. 2013a; Djuric et al. 2015; Djuric and Götz 2016)*	X		X	
STC *(Götz et al. 2016a)*	X			X
RS-long-run price equilibrium model *(Götz et al. 2016b)*; **RS-TVECM** *(Götz et al. 2016c)*		X	X	

Source: Own illustration.

We are utilizing several methods to estimate the different model frameworks. The parameters of a MS(V)ECM are estimated by maximizing the likelihood function with the expectation-maximization algorithm (Krolzig 1997). The STC model is estimated by the Levenberg-Marquardt method (Saikkonen and Choi 2004), which is an iterative estimation procedure which utilises the nonlinear least squares technique. The parameters of the RS model of the long-run price equilibrium between the regional and the world market wheat price are estimated using ordinary least squares (OLS) since the results of the Granger-causality motivates us to assume that the world market price is exogenous for all price pairs. In the estimation of the RS-TVECM with three regimes a particular challenge lies in the correct identification of the thresholds. We follow Greb et al. 2013 and use the regularized Bayesian (RB) technique to estimate those parameters.

Finally, a dynamic conditional correlation (DCC) specification of a multivariate general autoregressive conditional heteroscedasticity (GARCH) approach is used to investigate the export controls' effects on price volatility in Götz et al. 2013b, which is estimated by maximum likelihood method.

3.2 Comparative approach

In several of our studies we are following a comparative research approach. In Götz et al. 2013a we conduct an analysis of the integration of domestic producer price with world market prices for Russia and Ukraine, two countries which have restricted wheat exports in 2007/08, and contrast results with those for Germany and the USA which did not intervene in the wheat export market. Götz et al. 2016b opposes the wheat market of Russia characterized by large distances, with Ukraine distinguished by relatively small distances when identifying the region-specific effects of export controls. Götz et al. 2016c compare the integration of regional grain markets within Russia to the USA. Both countries' grain markets are characterized by large distances. However, they differ strongly in the development of the grain market infrastructure, in particular the transport system, storage facilities and institutions to warrant information and market transparency. Götz et al. 2013b compares Ukraine to Germany when investigating the effects of export controls on price volatility in Ukraine. A comparative approach might offer a deeper interpretation of the estimated parameters. In price transmission analysis the estimated price transmission parameters themselves do allow only to a limited degree to judge how well a market is functioning. This particularly holds for countries as Russia, Ukraine, Kazakhstan and Serbia, which are not well investigated and e.g. information on the market structure and quality of transport infrastructure is very limited. We tried to tackle this issue by investigating markets with extreme characteristics simultaneously and within a similar modelling approach.

4 Influences of wheat export controls on the stability of domestic wheat prices

This section summarizes our findings of the analysis of the effects of export controls in Russia, Ukraine, Kazakhstan and Serbia on the domestic wheat price level and volatility. The results are mainly retrieved from quantitative analyses and are supplemented by insights provided by qualitative studies when data limitations did not allow an econometric assessment (Djuric et al. 2015; Götz et al. 2016a, 2016b, 2015a, 2015b, 2015c and 2013a).

4.1 Domestic wheat price level

In the following we provide an overview on the identified domestic wheat price effects for each of the four countries individually.

Russia

Since the wheat market of Russia is characterized by large distances which implies that price differences between the regions are substantial, we desist to base our analysis on national average price data. Rather, we choose the wheat prices observed in the primary wheat production region, which is also the primary export region with direct access to the world market as our data base to investigate the effects of the wheat export tax imposed during 2007/08 and the export ban implemented in 2010/11.

The wheat export tax was implemented in 2007 in a situation when wheat exports were increasing dramatically, induced by high world market prices. Nonetheless, domestic prices increased beyond the world market price, although domestic production levels were even 7% above average (Rosstat 2014). The increase in the domestic price beyond the world market price level despite a prohibitive export tax is explained, according to experts, by the domestic wheat supply which was at a very low level due to the high wheat exports in the previous months. In addition, some panic buying of wheat arose on domestic market. However, increasing expectations of an above average grain harvest in 2008 caused domestic wheat prices to decrease again in early summer 2008 (Götz and Djuric *forthcoming*).

Results of the MS-VECM (Götz et al. 2013a) suggest that the wheat producer price in the Southern Federal District of Russia, the primary wheat producing region, was insulated from the world market price development by the export tax in 2007/08 by only 10% on average.

Contrasting, significantly stronger domestic wheat price effects were observed during the export ban in Russia 2010/11 (Götz et al. 2016b). The regional analysis of the domestic price effects of the export ban in Russia 2010/11 (Götz et al. 2016b) identifies a price insulating effect of 76% and a price dampening effect of 67% for the region of North Caucasus, which is by wide and large congruent with the Southern district. Further results on the export controls' effects in Russia are presented in sections 6.2 and 6.3 below.

Ukraine

The domestic price effects of the wheat export controls in Ukraine are investigated based on national average prices within Götz et al. 2013a, Götz et al. 2016a and Götz et al. 2016b. Overall, we do not find large differences in the domestic price effects and the results of the three different studies are rather consistent.

The price insulating effect of the wheat export quotas implemented in the time period 2006 to 2009 identified by Götz et al. 2013a and Götz et al. 2016a is very similar amounting to 41% and 39%, respectively (Table 2). The corresponding price dampening effect identified in Götz et al. 2016a amounts to 26%.

This picture is supported by the price insulating and price dampening effects of the export quotas 2006/07, 2007/08 and 2010/11 and the export tax 2011, retrieved from Götz et al. 2016b, with the average value amounting to 40% and 19%, respectively. However, the rather low price insulating effect for the export quota 2010/11, and the high price insulating effect of the export tax 2011 remain a puzzle. We assume that due to the frequent and unexpected changes in the export controls, the distinction of additional regimes might be required to identify the price effects more clearly. Thus, all three studies together suggest a price insulating effect of 40% and a price dampening effect of 19% of the wheat export controls on average. Our results suggest a significantly weaker price insulating and dampening effect for Ukraine, where exports remained possible up to a certain degree, compared to the export ban 2010/11 in Russia when exports became completely forbidden.

Table 2: Price insulating and price dampening effect of export quotas in Ukraine retrieved from different model frameworks

	RS-long-run price equilibrium model *(Götz et al. 2016b)*				**STC** *(Götz et al. 2016a)*	**MSVECM** *(Götz et al. 2013a)*	**Average**
Period of export control	2006/07	2007/08	2010/11	2011 (tax)	2006-2011	2007/08	
Price insulating effect (%)	40	35	4	83	39	41	40
Price dampening effect (%)	12	23	26	10	26		19

Source: Own illustration.

Kazakhstan

In the case of Kazakhstan it was not possible to conduct a quantitative price transmission analysis due to data limitations. Therefore, our results are based on a qualitative analysis (Götz and Djuric *forthcoming*; Götz et al. 2015b).

When the wheat export ban in Kazakhstan was implemented in 2008, the domestic wheat price further increased even beyond the world market price, concurrently to a decreasing world wheat market price. Several factors have led to the further increase in wheat prices in Kazakhstan even when wheat exports were forbidden by the export ban. Firstly, the size of grain production in 2007 was overestimated and prices started to increase markedly when the corrected estimation of grain production was published by the statistical office in early 2008. The immediate implementation of the export ban for wheat did not reduce domestic demand for wheat. Instead, this induced Kazakh traders to process wheat into flour to export. Although flour export remained officially unrestricted, the government imposed indirect measures to prevent large amounts of flour being exported. In particular, a shortage of railway wagons was created and large amounts of flour had to remain in stock. Prices further increased when news on a harvest failure in Eastern Kazakhstan in the following marketing season 2008/09 occurred in the media (UkrAgrConsult 2014; APK-Inform 2014).

Serbia

Similarly to Kazakhstan we find that the export ban implemented in 2007 and 2010 could not prevent that the domestic wheat price increased beyond the world market price. Also, the results of the Markov-switching error-correction model show that the price transmission regime did not change during the governmental interventions (Djuric et al. 2015). This indicates that the export ban was not successful in dampening and insulating the domestic wheat price, which even increased beyond the world market price. We explain the domestic wheat price increases beyond the world market price observed in Serbia during the export ban by two additional governmental policy measures: 1) government purchases of significant amounts of wheat from the domestic market in September 2007 and in April 2008, which boosted domestic wheat demand, and 2) the delayed removal of the 30 % wheat import tariff, which counteracted the price decreasing effects of export restrictions. Furthermore, our results suggest that market instability increased substantially after the cancellation of the export ban. Increased instability was also observed during the export ban when the government changed the crisis policy. This indicates that the governmental market interventions had long-lasting market effects.

4.2 Regional wheat price level and the relevance of harvest shortfalls

In our comparative investigation of the domestic wheat price effects of export controls on the regional level in Russia and Ukraine (Götz et al. 2016b) we explicitly take into account the price effects of a domestic production shortage in Russia during the export ban 2010/11, when a harvest shortfall of 30% on average and up to 60% at the regional level was observed.

Our results confirm a domestic wheat price effect of a harvest failure for all regional price pairs of Russia. This is in line with Baffes et al. 2015 who also show that weather shocks have a strong short-run influence on local prices. The identified regional wheat price effects of the export ban implemented in Russia in 2010/11 demonstrate a pronounced variation. In particular, the price insulating effect varies between 76% and 2%. For the regions Volga and Urals, the Wald-test does not support a price insulating effect, which we interpret as evidence for the low influence of the world market price on price formation in those regions. The price dampening effect varies between 67% and 35% in the 6 regions. The price dampening effect is by far the strongest in North Caucasus (67%), the region which has direct access to the world market and through which the vast majority of wheat exports of Russia at large are operated. Our qualitative analysis of the regional effects of the wheat export tax imposed in February 2015 (Götz et al. 2015c) also finds that the price dampening effects are significantly stronger in North Caucasus compared to the regions Urals and West Siberia.

The modified estimation approach applied to the export ban in Russia 2010/11 is shown to be superior to the conventional approach in existing studies. Comparing results of the two estimation approaches makes it clear that domestic price effects of export restrictions cannot be properly identified without accounting for the price effects of a harvest shortfall.

Even if substantial regional price dampening effects of up to almost 70% of export controls are identified in Russia, the assessment of the effectiveness of export controls to dampen domestic wheat prices has to be put into perspective. Comparing price developments during the export ban 2010/11 and 2012/13, when trade remained freely possible, two periods characterised by a production shortfall of about 30% below the average, it becomes evident that in 2012/13 regional prices exceeded the world market price for a period of mere 3 months.

The observed price dampening effects in Ukraine are significantly lower and exhibit much smaller regional variation. The price insulating effect varies between 13% and 32%, whereas the price dampening effect varies between 1% and 12%. Compared to Russia, distance between the different regions of Ukraine and between the even peripheral grain production regions and access to the world market is rather small.

4.3 Regional wheat price relationships

We utilize a RS-TVECM to analyse the effects of the grain harvest shortfall and the wheat export ban in Russia 2010/11 on the relationship of prices in the 6 primary grain producing regions in Götz et al. 2016c. Strong regional grain harvest shortfalls imply pronounced instability in price relationships, interregional trade flows and even trade direction in the Russian grain market which influence the price transmission parameters. Therefore, we estimate the RS-TVECM based on price observations of the marketing year 2009/10, when trade was freely possible, and based on price observations for the marketing year 2010/11, when the wheat export ban was implemented, separately.

Results suggest that the integration of the regional wheat markets strengthened during 2010/11, which can be explained by the increase in interregional grain trade. In particular, in many cases the long-run price transmission parameter and the regime-specific speed of adjustment increased in 2010/11 compared to 2009/10 when trade was freely possible. We assume that the increase in interregional grain trade was induced by the fact that a harvest shortfall of up to 60% was observed only in some regions, whereas grain production was on average in other regions. The rise in interregional grain trade was reinforced by the implementation of the export ban forcing grain traders in North Caucasus to engage in interregional grain trade within Russia.

Further, we find that the size of thresholds and the band of inaction increased in 2010/11 compared to 2009/10. We trace this back to increasing transport costs and also increasing trade risk of interregional grain transactions resulting from the change in export destinations requiring to involve new trade partners. Obviously, the transport subsidy was too low to prevent that total transaction costs of interregional trade increased during the export ban period. This results confirms that in general the risk of business is particularly high in Russia due to a high degree of fraud and the difficulties to enforce contracts. Preliminary results for the corn market in the USA indicate substantially stronger integration of the regional markets compared to Russia. Also, the influence of distance on the long-run price transmission parameter seems to be significantly stronger in Russia compared to the USA which we interpret as evidence for lower market efficiency of the Russian wheat market.

4.4 Volatility of wheat prices

Our empirical results of the analysis of the development of domestic wheat price volatility in Ukraine (Götz et al. 2013b) indicate that contrasting to the German domestic price and the French world market price, price volatility on the wheat market in Ukraine exhibits high susceptibility to external shocks and low impact of own variance and thus low persistence. This leads to a couple of short periods of time in which excessive volatility prevails, and is reflected in relatively high skewness of the distribution of the conditional variance. Contrasting to the German market, the Ukrainian wheat market did not follow volatility development on the world market 2007/08 and 2010/11, which suggests domestic factors to be of greater importance for observed volatility in this market.

Detailed analysis of the policy environment provides strong evidence for the accordance of phases of high volatility with the occurrence of rumors and the announcement of changes in wheat market trade policy by the Ukrainian government, especially the implementation and extension of the temporary export restrictions.

We conclude that the export controls in Ukraine have not significantly reduced price volatility on the domestic wheat market. On the contrary, our findings suggest that the multiple and unpredictable interference of the Ukrainian government on the wheat export market has substantially increased market uncertainty which led to pronounced additional price volatility in the market.

An increase in price volatility during export controls in Russia and Ukraine is also confirmed by Götz et al. 2013a and by Djuric et al. 2015 for Serbia. However, it should be pointed out that the results of our studies do not allow to draw a strict causal relationship between export controls and price volatility. However, the results of the structural time series approach followed by Rude and An 2015 confirm that trade restrictions are an important factor in determining grain price volatility on the world market.

5 Effects of wheat export controls on domestic flour and bread prices

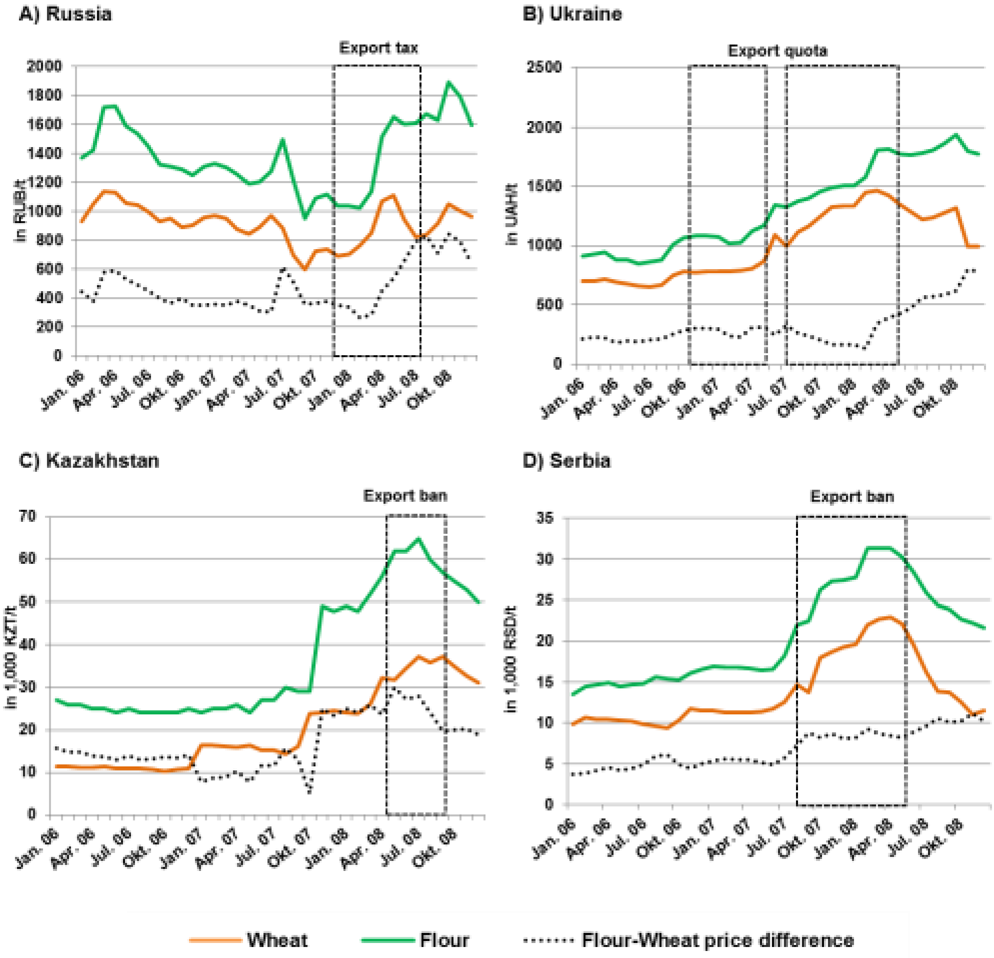
As pointed out above, wheat export controls were implemented in the RUK countries and Serbia with the aim of preventing substantial increases in the bread price. However, bread prices are rarely dampened by export controls for two reasons.

Firstly, wheat has in general a low share in bread production costs, whereas the importance of energy and labour is much higher. By way of an example, wheat accounts for about 10% of bread production costs in Russia (Reuters 2015). Thus, a 50% reduction of wheat prices may lead to a decrease of the bread price of at most 5%, given that the decrease in the wheat price is fully transmitted to the bread end consumer price.

Secondly, price changes are not always fully transmitted along the supply chain. To dampen domestic food price inflation, the price decreasing effects of wheat export controls on wheat prices have to be transmitted by the actors at the different stages of the wheat-to-bread supply chain from the producer to the end consumer. Here, the milling industry, bakeries and retailers play a key role.

The development of the price difference between the flour and wheat price shows that during the periods of export controls the flour-wheat price differential increased in all four countries, at least intermittently (Figure 2). In particular, the fall in wheat price levels in Russia during the imposition of export duties in spring 2008, and in Ukraine during the export quota in 2007-08, were not transmitted to the flour price, with the result that the difference between flour and wheat prices rose sharply. In Serbia, too, the fall in the price of wheat in spring 2008 was only partially passed on by the mills.

Figure 2: Development of wheat and flour prices in the RUK countries and Serbia



Source: Götz et al. 2015b.

Can the rise in the price of flour relative to that of wheat be explained by an increase in production costs? Also, to which extend are changes in the flour price passed on to the end consumer via the price of bread?

To answer these questions for the case of Serbia, we study price transmission along the wheat-to-bread supply chain in Djuric and Götz (2016), focusing on the price behaviour of the mills vis-à-vis the bakeries, and also the price behavior of the bakeries and retailers regarding the end consumers. This is supplemented by analysing the development of the gross margin of the milling industry, the baking industry and retailers.

Concerning the milling sector, results show that widening the gross margin for both small and large industrial mills cannot be justified with the increase of flour production costs. Also, results indicate that large mills widened their gross margins by +30% during governmental interventions with strongly increasing prices, while small mills particularly widened their gross margins by +131% in the aftermath of the governmental interventions. Thus, both small and large industrial mills were able to benefit from increasing wheat prices despite the governmental market interventions both in 2007/08 and 2011.

Furthermore, results indicate the large industrial bread producers and retailers were successful in increasing the end consumer price of bread, which was wrongfully justified by increases in the wheat and flour spot market prices. Unlike small mills, large ones have their own silos for storing wheat. They mainly buy wheat at relatively low prices during harvest time, store it and thus are not affected by price rises over the course of the year. In spite of this, the large mills have publicly defended increases in the price of flour, citing rising spot prices.

The large industrial bread producers, and especially retailers, benefited substantially from the governmental interventions in 2007/08 by being able to increase their gross margin by almost 270%. Thus, in contrast to expectations, bakeries – and even more so the retailers – benefited most from the governmental market interventions, whereas end consumers lost due to significant increases in bread prices. In particular, calculations suggest that poor households' expenditures for bread and cereals increased by over 14% in 2008.

Initial findings for Russia show that here, too, large mills were able to increase profits during the period of export duties. However, the observed rise in bread prices relatively to the flour price in the RUK countries is a result of the increase in wheat and flour prices, as well as in other production costs such as labour and energy. Thus, contrasting to Serbia, the bakery industry in the RUK countries has not profited from export controls (Götz et al. 2015b).

6 Impact on wheat prices in importing countries

As it was pointed out above, export controls may induce unintended price increasing effects in importing countries. The Central Asian countries Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan are depending by nearly 100% on wheat imports from the neighbouring country Kazakhstan due to their landlocked location. The countries of the South Caucasus, Armenia, Azerbaijan and Georgia, are also highly depending on wheat imports from Black Sea region countries, but besides Kazakhstan also from Russia, both countries accounting for over 90% of their wheat imports (Svanidze et al. 2016). Before this background we investigate in Svanidze et al. 2016 the wheat markets of the countries of the South Caucasus and Central Asia and their integration in the wheat market in the Black Sea region and in international markets. Results of the threshold cointegration tests, linear error correction models and nonlinear TVECM indicate that trade costs play a large role in wheat trade of the countries in Central Asia, whereas it is of minor importance for wheat trade of the South Caucasian countries. Further, integration in world markets is confirmed for countries of the South Caucasus but not for the countries of Central Asia. First results indicate that the wheat export ban implemented in Kazakhstan 2008 significantly increased wheat prices in Kyrgyzstan. Further, the difference between wheat prices in Armenia and Azerbaijan to wheat prices in the Black Sea region increased substantially during the Russian wheat export ban 2010/11. However, price increasing effects of export controls in Kazakhstan and Russia are not observed in Georgia. Different to Azerbaijan and Armenia, Georgia has direct access to the world market via the Black Sea and thus can import grains from other countries if necessary.

This study will be extended to a quantitative assessment of the price increasing effect of the export controls on the wheat price in the wheat importing countries. The price transmission model will be modified to capture the influence of the export ban implemented in Kazakhstan 2008 and in Russia 2011/10 by allowing for a respective regime switch.

7 Budgetary versus economic costs of export controls

Given that wheat export controls are of rather low effectiveness in dampening domestic bread price inflation (compare section 5), we raise the question why this policy measure is implemented so frequently in Götz at el. 2015c. Export controls are an appealing instrument to governments since they allow with ostentation to apparently take action to ensure domestic food security at no financial cost. Even budgetary revenues are achieved in the case of an export tax and if licenses for export quotas are sold or auctioneered.

However, from the macroeconomic perspective, large economic costs are induced by export controls, both in the short term and also in the long term in various ways.

In particular, traders and wheat producers experience income losses since export controls prevent them from profiting from high world market prices in the short term. Instead, farmers and traders either keep the wheat in storage or sell it at lower prices on the domestic market.

Also, export controls decrease the market price by increasing the market and price risk. One reason is that the duration and degree of export controls is often changed. For example, the level of the export tax was increased as was the case in Russia from 10% to 40% in 2007, the size of the quota was decreased and the duration of the export quota system was prolonged in Ukraine 2006/07. This makes it uncertain when the temporary export controls will be removed and exports will again be freely possible and may make it impossible for a trader to sign a contract.

The risk that exports become restricted and thus that traders cannot fulfil a contract, is the higher, the more often a government has engaged in export controls, and thus may even become permanent. Therefore, traders will not be able to engage in the futures markets. Price risk also rises if hedging becomes impossible, and it becomes increasingly difficult to manage the price risk. As a result, traders have to offer their wheat at lower export prices due to additional price risk and have to invest in e.g. additional storage facilities to manage the increased price risk.

If wheat production costs increase and/or a risk premium is charged on the wheat price, the profitability of grain production decreases. Incentives to invest in the grain sector decrease and grain producers will produce less grain in the long term. For example, farmers in Ukraine have reallocated their planting areas from more risky wheat to the less risky crops such as corn. The wheat area of Ukraine has decreased by 20% in Ukraine between 2008 and 2012, whereas the corn and sunflower area have increased (APK-Inform 2014). Thus, instead of improving food security, export controls impair food security in the long term, with implications for global food security in the case of a large exporting country as Russia.

8 Summary, conclusions and policy recommendations

The results of our analyses regarding Russia, Ukraine, Kazakhstan and Serbia, have shown that the strongest wheat price dampening effects of wheat export controls were observed in Russia during the wheat export ban in 2010/11, when the domestic wheat price dampening effect differed strongly between the regions, varying between 67% and 35%. This is followed by Ukraine for which the identified price dampening effects of the export quotas and the export tax implemented in the time period 2006 to 2011 vary between 10% and 26% on the national level. However, the effects of the export controls in 2008 and 2010/11 on regional wheat prices fluctuate rather slightly between 1% and 12%.

Our results further make evident that wheat export controls are not always successful in dampening the domestic wheat price. In particular, the export tax of up to 40% implemented in Russia 2007/08 could not prevent that the domestic wheat price increased beyond the wheat world market price. Similarly, the domestic wheat price in Kazakhstan and in Serbia increased to a level exceeding the world wheat market price when an export ban for wheat was implemented in 2008 (Kazakhstan) and 2007/2010 (Serbia). The size of the wheat price dampening effect differs depending on the restrictiveness of the export controls. However, additional case-specific factors play a large role as e.g. the sequencing of governmental market interventions, which may counteract export controls. Also, export controls are ineffective if the domestic market is characterized by a supply deficit.

Even if substantial regional wheat price dampening effects of up to almost 70% of export controls are identified in Russia during the export ban 2010/11, this result has to be put into perspective when assessing the effectiveness of export controls. Comparing price developments in the marketing year 2010/11, when exports were prohibited by a ban and 2012/13, when trade remained freely possible, two periods characterised by a production shortfall of about 30% below the average, it becomes evident that in 2012/13 regional prices exceeded the world market price for a period of hardly 3 months. This suggests that even if exports were not restricted in 2010/11, it can be expected that high domestic wheat prices would have prevailed only for a very limited time period.

Our studies investigating the relationship between wheat export controls and domestic wheat price volatility in Russia, Ukraine and Serbia have made evident that domestic wheat price volatility did not decrease but rather increased when wheat exports became restricted.

Also, analyses of price transmission along the wheat-to-bread supply chain in Serbia have shown that mills, bakeries and retailers have not fully transmitted the price dampening effects along the supply chain. Rather, particularly the large mills managed to widen the gross margin by 30% and bakeries and retailers by 270%. Contrasting, the end consumers were confronted with increasing bread prices, which increased the poor households' expenditures for bread and cereals by over 14% in 2008. Similarly, the mills in Russia increased their margin as well, but increases in the bread price can be explained by raising production costs. From this we can conclude that the effectiveness of wheat export controls to reduce domestic bread price inflation is rather limited and economic access to food is merely enhanced.

Finally we have provided preliminary evidence that the wheat export controls in Russia and Kazakhstan have significantly increased wheat prices in the land-locked countries Kyrgyzstan, Armenia and Azerbaijan. Differing, price increasing effects were not identified for Georgia, which we explain with its favourable location with direct world market access.

At the same time, export controls create considerable market distorting effects by increasing market and price risk, which raises production costs, and decreases the export price, whilst also preventing traders from benefiting from high world market prices. In the long-run wheat export controls reduce profitability and the volume of wheat production and also negatively affect food availability and in this sense even reduce food security. In the case of a large wheat exporting country, even global food security is negatively affected.

Therefore, the government should desist from market interventions by means of trade-oriented measures to influence domestic food prices. Rather, it should focus on consumer-oriented measures. In particular, instead of trying to dampen domestic food prices, it would be a more effective and in the long-run cost-efficient response of the government to allow domestic food prices to increase and instead only focus on the most vulnerable population sections to adapt to high consumer prices within social safety nets. The aim of these policies is that beneficiaries become able to purchase food on the market or in certain selected shops. For example, food vouchers, food subsidies or direct income transfers should be targeted at the household income of poor people. To ensure that such safety-net measures can be implemented in a crisis situation in the short term, the existence of well-targeted social assistance programs, which may be scaled up or the number of eligible households expanded in times of acute crisis, needs to be ensured. However, export controls remain an attractive measure for policy makers since different to social safety net measures, they do not cause any budgetary costs, and instead even generate budgetary income in the case of an export tax.

9 Contributions to the existing literature

In general, there are only a limited number of studies on the domestic price effects of export controls available, while numerous analyses of the export controls' world market price effects exist (e.g. Mitra and Josling 2009; Anderson and Nelgen 2012; Martin and Anderson 2012). Also, the number of analyses on the agricultural sectors of the RUK countries, Serbia and the countries of Central Asia and the Southern Caucasus are very limited as well. One reason lies in the challenges faced to access suitable data sources, particularly time-series data required for price transmission and volatility analyses, which are not publicly available. Usually, personal contacts with members of organizations as the Russian Grain Union, institutions and companies need to be established which require to be capable of the Russian language. With the studies included in this habilitation thesis we are contributing to fill in this research gap. In the following we highlight four of the according to our best knowledge most important contribution of our studies to the existing literature.

Introduction of the smooth transition cointegration model in spatial price transmission analysis

To identify the effects of export controls we make use of a variety of time-series econometric price transmission models which allow their parameters to change between the regimes (compare section 3). One of our advances to the existing literature is the introduction of the STC model (Saikkonen and Choi 2004; Choi and Saikkonen 2004) in spatial price transmission analysis in Götz et al. 2016a, which permits the transition between the price transmission regimes of a long-run price equilibrium model to be smooth and to be governed by a threshold variable. This approach has the advantage that the switch in the price transmission regime may be induced not only by an actual but also by an expected change in the trade policy. Results confirm the gradual nature of the process of transition between the regimes, which reflect trader heterogeneity, wheat storage decisions and the importance of the level of the world market price for determining the implementation of the export controls.

This paper also adds to the few existing studies in spatial price transmission analysis that allow for a regime change in the long-run price equilibrium relationship. Although methodological innovations in spatial price transmission analysis have led to increased model flexibility by allowing for non-linearity in the short-run price transmission parameters, as e.g. in the threshold vector error correction model (TVECM) and the threshold autoregressive (TAR) model, they are based on the assumption that the long-run price transmission is linear and constant. However, multiple long-run price equilibria might exist as well which are characterized by differing long-run price transmission parameters. Relatively few applications of spatial price transmission models allow for regime-dependent long-run spatial price equilibria. For example, long-run price transmission changes in the absence of physical trade flows (Stephens et al. 2012) and is influenced by governmental market interventions (Myers and Jayne 2011) and the composition of trade flows (Götz et al. 2008).

In Götz et al. 2016a we also discuss and compare the regime classification of the models with endogenous switch, i.e. the STC model and the MSECM, to a RS model with exogenous switch regarding regime classification, model parameters and goodness of fit. Accordingly, the STC outperforms the MSECM clearly, but it is only slightly better than the RS model. Furthermore, although the STC proves to be the superior model among the models with endogenously determined regime-switch, regime classification in some periods remains a puzzle. Similarly, the application of the MSECM to the same data base as applied to the STC generates results which do not reflect any identifiable economic reality. This poses a particular challenge if modelling results for several regions are to be compared. Therefore, our studies make evident that it is not possible to determine one superior econometric model framework. Rather, a suitable modelling framework has to be chosen depending on the research question and data availability. For example, the challenges faced with regime classification by the STC and MSECM models with endogenous regime switch motivated us to follow Baylis et al. 2014 and Baffes et al. 2015, and to choose a RS price transmission approach with exogenous regime switch in our multi-region analysis in Götz et al. 2016b and Götz et al. 2016c.

Development of indicators to measure the price dampening effects of export controls

In the course of our studies on the domestic price effects of export controls we have further developed the theoretical framework underlying the price dampening effects of export controls. A price transmission approach has been used in other studies as well (Ihle et al. 2009; Baylis et al. 2014; Baffes et al. 2015). However, based on the parameters of a long-run price equilibrium of two price series, we have developed indicators (see Götz et al. 2016b) to measure and compare the domestic price dampening and the price insulating effects between countries and regions, taking into account the influence of harvest shortfalls.

In future research, these indicators could be supplemented by further ones. In particular, the share of the domestic supply effect and the price insulating effect in the total price dampening effect, which may vary between regions depending on their distance to the world market, could be assessed quantitatively. This requires that the price transmission analysis is also conducted based on price data in levels, neglecting the normalization by taking logarithm.

In the literature, alternative approaches to measure the price effect of export controls are applied. For example, Fellmann et al. 2014 use the recursive-dynamic partial equilibrium model AGLINK-COSIMO model to assess the impact of wheat harvest failures and export restrictions on domestic agricultural prices and quantities in Russia, Ukraine and Kazakhstan and on the world market. Diao et al. 2013 use a general equilibrium model approach to investigate the effects of export controls in Tanzania. Elleby et al. 2015 apply a Bayesian structural time-series model to assess the price impact of grain export controls in India. Based on a range of input prices, non-food prices and international grain prices they simulate the price development assuming the export controls were not implemented. Although Baffes et al. 2015 also utilize an error correction model framework, this model investigates the influence of export controls on price changes while accounting for the influence of weather shocks, by involving a broad variety of variables, including e.g. the normalized difference vegetation index, price of fuel, consumer price index and world market prices.

The advantage of our price transmission approach lies in its parsimony. This makes it particularly applicable in countries with limited availability of data and allows comparing the export controls' effects between several countries, regions and products.

Importance of the regional perspective of the Russian grain market

Grain production in Russia is split between six main grain production regions, characterized by strong heterogeneity. The production regions are partially several thousand kilometres away from each other implying that they are characterized by differing weather and climatic conditions. They also vary strongly in their involvement in trade. North Caucasus has direct access to the Black Sear harbours and is the primary grain exporting region. In contrast, West Siberia and Urals are several thousand kilometres away from the world market and mainly supply wheat to the domestic market.

The region-specific analysis of the domestic price effects of export controls in Russia in Götz et al. 2016b has made evident that the regional variation of those effects is high, demonstrating the importance of a regional modelling approach for Russia. In particular, the price dampening effects vary between about 70% in North Caucasus and 35% in Urals, thus differing significantly from the scenario results produced by Fellmann et al. 2014. Based on a partial equilibrium model they find that a wheat export ban leads to a 6% decrease of the Russian producer price on the national level compared to free trade. They explain this low value by their assumption that only 23% of total wheat production at a national level is exported by Russia. This assumption seems to be realistic against the backdrop of the size of exports actually observed.

However, the share of production exported to the world market varies strongly between the regions. For example, North Caucasus, the region with direct world market access, exports more than 60% of its production (Rosstat 2014). In contrast, West Siberia, although it is second largest wheat producing region, only exports regionally within Russia, it almost never exports to the world market due to its large distance to the ports. The analysis has also made evident that the strong price dampening effects observed in North Caucasus were transmitted to the other regions by interregional trade flows.

Thus, our results suggest that to identify the effects of the export controls on domestic prices in Russia with its strongly heterogeneous grain production regions, it is decisive to follow a regional perspective. This is also relevant for studies investigating the importance of Russia for future global grain supply and food security.

Development of a framework to investigate price effects along the supply chain during wheat export controls

We contribute to the literature addressing the question of the welfare effects of price changes induced by export controls along the food supply chain. In Djuric et al. 2016 we develop an approach which combines price transmission analysis with the analysis of the gross margin at different stages of the supply chain. We simulate price developments along the supply chain assuming laissez-faire policy, making use of parameters of the price transmission model. Our model approach is appealing for its parsimony in data requirements and assumptions compared to alternative approaches as e.g. a general equilibrium model (Diao et al. 2013) or graphical inspection of empirically observed prices (Maletta and Balbi 2014; Nogués 2014; Wong 2014). We assess the welfare effects resulting from price developments during the wheat export ban in Serbia. In contrast to theory, our results suggest that consumers in Serbia experienced welfare losses during the global commodity price peaks in 2007/08 and 2011 despite comprehensive governmental market interventions. In particular, consumers were confronted with increasing flour and bread prices. It becomes evident that the effects of the export restrictions on the end consumer prices for bread and thus food price inflation heavily depend on the price behavior of the intermediates along the industrialized wheat-to-bread supply chain.

We see a further contribution of Djuric et al. (2016) to the literature in providing evidence for the importance of volatility of prices along the food chain for determining price transmission and food inflation. Lloyd et al. (2015) provide an overview on the factors influencing price transmission along the stages of the food supply chain, which ultimately determine the dynamics of food inflation. Focusing on the dimensions of competition in the food sector they point out that market power influences price transmission and the extent of food inflation by changing the food industry markup. However, the potential to increase the markup in a non-competitive environment in the food sector depends on several additional factors as e.g. the nature of the retail demand function, the existence of economies of scale in the food industry cost function, buyer power which could outweigh seller power, and the extend of market power at succeeding stages of the supply chain (“double marginalization”).

In Djuric et al. 2016 we show how a market environment characterized by high price volatility with strongly increasing price levels facilitates the actors along the wheat-to-bread supply chain to increase their markup by over-shifting the cost increases and boosting food price inflation.

In particular, the grain industry of Serbia raised prices to the extent, which can only partially be justified by increasing input prices and thus production costs. This pricing behaviour is especially observed by large processors which dispose over storage facilities falsely sanctifying their price increases with increases in wheat spot market prices which are actually not relevant to them due to own wheat storage. Results of Djuric et al. 2015 imply that the high domestic price volatility was reinforced by the manifold governmental interventions in the domestic wheat market, which also included the implementation of the wheat export ban.

10 Future Research

This section presents four ideas for future research. Two suggestions refer to conference papers included in this thesis and outline how those studies are planned to be extended and finalized. The third idea refers to the combination of the parameters of price transmission analyses with economic modelling frameworks. Finally we suggest to investigate the political economy of export controls in Russia and Ukraine.

Development of an information index to investigate the relationship between volatility and media news on export controls in Ukraine

Our analysis of the volatility effects of export control on domestic wheat price volatility in Ukraine (Götz et al. 2013b) made evident that phases of high wheat price volatility were observed when rumours and announcements of changes in wheat market trade policy spread around in the media. We have planned to further investigate the relationship between media news and wheat price volatility by constructing a news index which is included as an additional variable in the GARCH model. The volatility index could differentiate between different types of news, e.g. on changes in trade policy, forecast of agricultural production etc. First results suggest that actual changes in trade policy as e.g. the implementation of wheat export controls lead to the increase in price volatility only if the implementation was not anticipated by the market participants. In contrast, if the implementation of export controls is foreseen in the long-run additional volatility is not observed. A news index of such kind would allow to identify further reasons inducing an increase of price volatility in Ukraine.

Development of a benchmark to evaluate the efficiency of the Russian grain market

In general, price transmission parameters themselves allow only to a limited degree to assess how well a market is functioning. In the case of Russia it is well know that the grain market infrastructure is characterized by deficient transport and storage system. However, due to strong production variations and large distances, regional grain trade is decisive to equilibrate regional supply with demand. It can be assumed that the peaks of domestic prices due to regional production shortfalls would be reduced, if the grain market infrastructure would be improved. This would be reflected in the size of the parameters of short-run and long-run price transmission. Therefore, we follow a comparative approach and compare the Russian wheat market with the corn market of the USA, both markets which are characterized by large distances and a high importance of interregional trade flows in Götz et al. 2016c. We assume that the corn market of the USA is one of the most efficient grain markets in the world characterized by well-developed transport and storage infrastructure and high market transparency, and serves as a benchmark against which price transmission in the Russian wheat market could be evaluated. This should facilitate to assess how well the Russian wheat market is functioning and to diagnose the scope for its improvement. In future research the comparison of the two markets should be further extended and should encompass not only the long-run price transmission parameter, but also parameters characterizing the short-run price transmission as e.g. the size of thresholds and the speed of adjustment parameters and the scope of opportunities for trade arbitrage. This analysis could be complemented by a comparative analysis within a gravity model (compare Renner et al. 2014).

Combination of price transmission parameters with economic modelling frameworks

The previous section has pointed out the importance of the regional perspective for assessing the domestic price impact of export controls in Russia. Results in Götz et al. 2016c suggest that the integration of regional grain markets in the world wheat market differs strongly and is extremely low in the regions Urals and West Siberia which are far apart from the access to the world market. Thus, the regional perspective and accounting for the regional differences regarding world market integration is essential for conducting realistic simulations for the Russian agricultural market, particularly concerning agricultural trade and global food security. In the existing literature, the Russian market is depicted only on the national level (Fellmann et al. 2013; Salputra et al. 2013). In future research, the existing partial equilibrium model AGMEMOD (Chantreuil et al. 2012) for Russia could be extended to the regional level and account for the region-specific integration in international markets by explicitly integrating the price transmission parameters in the model framework, as done by Grethe et al. 2012.

Political economy of export controls

The implementation of export controls in the RUK countries has also to be seen against the backdrop of the fact that the development of the livestock sector is assigned a high level of political priority. In 2014 the Russian government has stated new self-sufficiency goals in food in its State Support Programme for the Development of Agriculture of the Russian Federation 2013-2020. With regard to meat and meat products the aim is to increase self-sufficiency to about 88%. To reach this aim the Russian government has extended its existing program to support agricultural development amounting to some US$ 46 billion by an additional US$ 11 billion to substitute imports of agricultural products and foods by domestic production.

Since wheat for human consumption and feed wheat show some degree of substitutability, prices of both types of wheat are closely correlated. Thus, if prices of wheat for human consumption are low, prices of feed wheat are also low. Therefore, effective export controls which dampen domestic prices of bread wheat also dampen prices of feed wheat and this in turn has a positive effect on production costs and profitability in the livestock sector.

According to information of the Russian Grain Union, the implementation of grain export controls can be viewed as the outcome of a lobbying process in which the interest groups of the grain sector and of the livestock sector compete to influence the Russian government. If export controls are implemented, the government acts in the interests of the livestock sector.

In future research the political economy of export controls in Russia but also in Ukraine should be further investigated. This should help to better understand why wheat export controls are so widely used although their effectiveness to reduce domestic food price inflation is rather low. This knowledge is also essential when tailoring initiatives to increase awareness of the high welfare costs of wheat export controls in the public and to correctly select the lobby groups in those countries which should be supported.

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3 SCIENTIFIC ARTICLES

3.1 Influences of Wheat Export Controls on the Stability of Domestic Wheat Prices

Domestic Wheat Price Level

Export Restrictions and Smooth Transition Cointegration: Export Quotas for Wheat in Ukraine, GÖTZ, L., F. QIU, J.-P. GERVAIS AND T. GLAUBEN, *Journal of Agricultural Economics, 2016, Vol. 67(2): 398-419.*

Export Restrictions and Smooth Transition Cointegration: Export Quotas for Wheat in Ukraine

Linde Götz[a], Feng Qiu[b], Jean-Philippe Gervais[c] and Thomas Glauben[a] [1]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany, [b] Department of Resource Economics and Environmental Sociology, University of Alberta, Canada, [c] Farm Credit Canada.

Abstract

We extend previous modelling approaches to identify domestic price effects of export controls. We allow for smooth transition between free-trade price transmission regimes and those under export restricting regimes, using a smooth transition cointegration (STC) approach, rather than the more common assumption that regime changes are abrupt. Our approach has the advantage that the switch in the price transmission regime may be induced not only by an actual but also by an expected policy change. Results confirm the gradual nature of the transition between the regimes, which reflect trader heterogeneity and wheat storage decisions. We find that the STC approach outperforms alternative model approaches in terms of both regime classification and goodness of fit, when explaining Ukrainian domestic wheat prices under export controls. In particular, application of the Markov-switching error correction model (MSECM) to the same data generates results which do not reflect any identifiable economic reality (in contrast to Götz et al., 2013).

1 Introduction

During the recent price booms on world agricultural markets from 2007-2008 and 2010-2011, many countries aimed to insulate their domestic markets from price developments on the world market, and to stabilise domestic prices through trade policy interventions. In particular, exporting countries implemented restrictions that reduced or even banned exports, and

[1] The authors would like to thank the JAE Editor, David Harvey, and three anonymous referees for their very helpful comments and suggestions. We acknowledge the support of the Federal Ministry of Food and Agriculture (Bundesministerium für Landwirtschaft und Ernährung, BMEL) and the Federal Office for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung, BLE) through the GERUKA project "Global Food Security and the Grain Markets in Russia, Ukraine and Kazakhstan (Globale Ernährungssicherung und die Getreidemärkte Russlands, der Ukraine und Kasachstans)". The authors are responsible for any errors.

importing countries reduced or even completely eliminated import restrictions to dampen the influence of high world market prices on domestic price levels (Sharma, 2011).

Many studies have addressed the unintended additional price-increasing effects of trade interventions on skyrocketing world market prices (e.g. Mitra and Josling, 2009; Anderson and Nelgen, 2012; Martin and Anderson, 2012). Some articles focus on the export controls' effects on domestic producer prices (e.g. Baffes et al., 2015; Djuric et al., 2015; Götz et al., 2015; Baylis et al., 2014; Götz et al., 2013; Ihle et al., 2009), while other articles concentrate on export controls' impact on end consumer food prices (e.g. Nogués, 2014; Wong, 2014; Djuric et al., 2012).

In this study we investigate the influence that the wheat export quota has on domestic producer prices in Ukraine during price peaks from 2007-2008 and 2010-2011. We choose a price transmission approach to reflect the relationship between the world market price and the domestic producer price for wheat. Similar studies (e.g. Baylis et al., 2014; Djuric et al., 2015, Götz et al., 2013; Ihle et al., 2009) have shown that export restrictions induce a change in the price transmission regime, resulting from a change in traders' price behaviour. These studies assume that the traders adjust their pricing strategy immediately after export controls are implemented, which is reflected by an abrupt regime switch in the model approach.

This paper differs from previous studies in that it allows for a gradual change from the free trade to the restricted trade regime upon the export controls' implementation. We suppose that traders' price behaviour is influenced by expectations and that traders are heterogeneous, which implies that the switch from the free trade to the restricted trade regime is smoothed, although the export controls are implemented abruptly. The system may also remain in a transition mode if the effects of the export controls are partially counteracted by domestic wheat storage decisions, anticipating future increases in domestic prices when export controls are lifted.

We take this into account by using a smooth transition cointegration (STC) model (Saikkonen and Choi, 2004; Choi and Saikkonen, 2004), which allows us to estimate a two-regime long-run price transmission relationship. A further distinguishing characteristic of our STC approach is that we explicitly model the regime switching process by assuming that it is the world market price which determines the smooth transition from the "free trade" regime to the "restricted trade" regime. This is different to the Markov-switching error correction model (MSECM) applied in previous studies (e.g. Götz et al., 2013), which supposes that the variable governing the regime switch is unobservable and probabilistic.

Our paper is structured as follows. Section 2 presents background information on the Ukrainian wheat export quota and explains the economics of export quotas. Section 3 presents the model framework and provides our research hypotheses. Section 4 provides a literature review and explains the differences of our approach. Data, the empirical estimation and results are presented in section 5. In section 6 we evaluate the STC model approach by comparing it to alternative model frameworks. Conclusions are drawn in section 7.

2 The Ukrainian Wheat Export Quota and the Economics of Export Controls

The Ukrainian government quantitatively limited wheat exports during the two recent commodity price spikes through an export quota that was implemented through a governmental licensing system. Export quotas allow exports up to the amount specified by the size of the quota. Export quotas varying between 3,000 tons and 1.2 million tons were in force from October 2006 until May 2008 (Grueninger and von Cramon-Taubadel, 2008), and again from October 2010 until May 2011[2]. However, wheat exports were possible during May 2007. Figure 1 shows the development of the Ukrainian wheat grower price (Milling wheat class 3, ex warehouse; APK-Inform 2011) and the international wheat price (French soft wheat, FOB, Rouen; HCGA, 2011) along with net wheat exports (GTIS, 2011). Ukraine became a net wheat importer during 2003-2004 when the Ukrainian price increased above world market price. However, when the export quota system was effective, wheat imports were almost zero.

Export restrictions aim to dampen the price level prevailing on the domestic market. In general, export restrictions decrease the size of exports and increase supply on the domestic market, reducing the domestic market price compared to the price that would prevail if trade was possible.

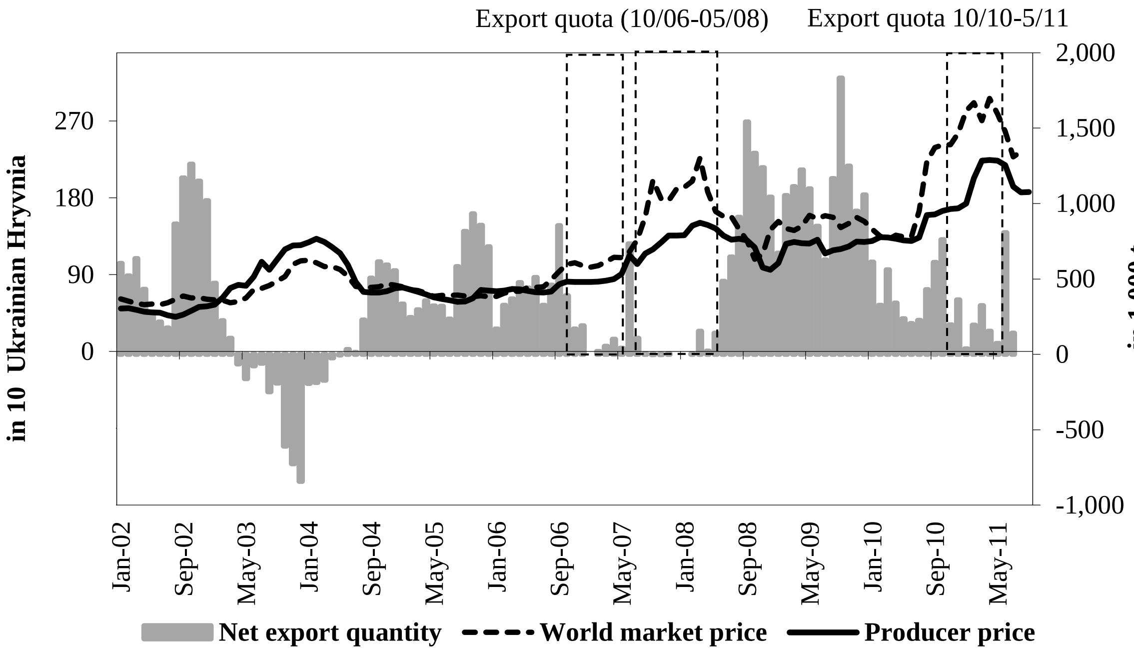
The more exports are reduced compared with the open trade regime, and thus the larger the increase of supply on the domestic market, the stronger is the dampening effect on the domestic price. In general, if export restrictions are imposed after the farmer has already decided on his production, the domestic supply elasticity is rather low and thus the dampening domestic price effect is relatively strong compared to the case where the size of production might be adjusted.

2 There is anecdotal evidence that during the 2010/11 export quota system international companies could barely obtain wheat export quotas, whereas domestic trading companies, presumably linked to high-ranking politicians, received export licenses and could export substantial amounts to the world market.

Figure 1 shows an increased difference between the world market price and the Ukrainian wheat price when exports were restricted compared to when trade was unrestricted. However, the domestic supply effect might have been mitigated as traders increased their wheat storage to avoid selling wheat at low domestic prices. Nonetheless, an increased difference between the world market and the domestic price is observed at all times during the export quota system's implementation. This suggests that domestic prices were dampened at least to some degree while exports were restricted in Ukraine. Also, the domestic wheat price continued to increase in parallel to the world market price, even when the export quota system was in place, indicating the continued domestic influence of world market prices, despite exports being restricted[3].

Further, if arbitrage activities become restricted or even prohibited, domestic prices become to some degree insulated from price developments on the world market, and the importance of domestic factors for domestic price determination increases, whereas the influence of the world market prices decreases.

Figure 1: Development of Producer Price and Export Quantity of Wheat for Ukraine and the World Market Wheat Price 2002-2011



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3 Several reasons might explain why domestic wheat prices remained related with the world wheat market price during export controls even when exports are not observed. One reason might be smuggling, despite export restrictions that keep domestic prices related to the world wheat market price. A second reason might be the temporary nature of export controls. Traders know that export restrictions will be removed in the near future, and therefore the world market price remains highly relevant. In particular, world market prices might influence traders' decisions of whether they should sell their wheat today at relatively low domestic prices or keep it in storage.

Source: Own illustration. Data base: APK-Inform (2011), GTIS (2011), HCGA (2011).

However, traders' and farmers' price behaviour is governed by expectations about the implementation and removal of export restrictions, which may differ due to the heterogeneity of farmers and traders. For example, expectations about the exact date that export quotas will be implemented, and about the quota size itself may differ among traders and farmers. Thus, as soon as traders expect that export restrictions will be implemented, they will change their price behaviour. In contrast, traders who expect that an export restriction will not be implemented might not change their price behaviour until the export controls are actually implemented[4]. Also, traders expecting the quota size to be rather small and thus also expecting particularly low domestic prices to prevail might accept a price offer only at a lower price than a trader expecting rather loose export controls. This implies that a change in the relationship between the domestic and the world market is observed before the export controls are actually implemented, and that the process of transition is not abrupt but occurs rather gradually over time. Also, farmers may increase wheat storage when export restrictions are implemented, expecting to sell wheat on the world market at higher prices in the future.

3 Model Framework and Research Hypotheses

The domestic price effects of export restrictions can be identified and quantified within a price transmission model (Fackler and Goodwin, 2001) that captures the price difference and the transmission of price changes from the world market to the domestic market. We imagine that high world market prices induce a gradual change in the long-run price equilibrium relationship, and that two long-run price equilibria exist.

Consider a logistic smooth transition cointegration (STC) model:

$$y_t = (\alpha_1 + \beta_1 x_t) + (\alpha_2 + \beta_2 x_t) g(x_t - c; \gamma) + z_t, \quad t = 1, 2, ..., T, \tag{1}$$

$$\text{with} \quad g(x_t - c; \gamma) = \left[1 + \exp(-\gamma(x_t - c))\right]^{-1}$$

The variables y_t and x_t are the domestic and the world market price, α_1, $\alpha_1 + \alpha_2$ are the intercept parameters of the "free trade" and the "restricted trade" regime, β_1, $\beta_1 + \beta_2$ are the long-run price transmission parameters of the "free trade" and the "restricted trade" regime,

[4] For example, when Russia implemented the wheat export ban in August 2010, Ukrainian media immediately discussed the possibility of the Ukrainian government establishing its own export quota system. The wheat export quota was announced and implemented in Ukraine in the beginning of October 2010.

respectively, and z_t is the zero-mean stationary error term. The "free trade" regime prevails if $\alpha_2 = \beta_2 = 0$, whereas the "restricted trade" regime predominates if $\alpha_2 \neq 0$ or $\beta_2 \neq 0$.

The transition from the "free trade" to the "restricted trade" regime is not abrupt, but is governed by the transition function $g(x_t - c;\gamma)$ which allows a smooth transition between the regimes. Like other smooth transition autoregressive (STAR) models, the STC can be considered a regime-switching model that allows for two regimes associated with extreme values of the transition function, i.e. $g(x_t - c;\gamma) = 1$ and $g(x_t - c;\gamma) = 0$, and where the transition from one regime to the other is smooth. The regime that occurs at time *t* is determined by the observable transition variable x_t, in our case the world market price, and the associated value of the transition function $g(x_t - c;\gamma)$. Different choices for the transition function give rise to different types of regime-switching behaviour[5].

We choose a logistic transition function as given in (1) where the parameter *c* gives the midpoint between the two regimes, in the sense that the logistic function changes monotonically from 0 to 1 as x_t, the wheat world market price, increases. When x_t is small (relative to *c*), *g* approaches 0 and the behaviour of y_t is given by $\alpha_1 + \beta_1 x_t + z_t$. Similarly, as x_t becomes large, *g* goes to 1 and the behaviour of y_t is then given by $(\alpha_1 + \alpha_2) + (\beta_1 + \beta_2) x_t + z_t$. The parameter γ determines the smoothness of the change in the value of the logistic function, and thus the smoothness of the transition from one regime to the other. As $\gamma \to 0$, the STC model becomes an AR(p) model. When $\gamma \to \infty$, the regime-switching from 0 to 1 becomes instantaneous at $x_t = c$. In the logistic STC model, the two regimes are distinguished by small and large values of the transition variable x_t (relative to *c*).

This type of regime-switching is particularly suitable in our case, where the regimes of the long-run equilibrium are related to booming (high market prices) and more normal world market conditions, respectively.

We suppose that if the world wheat market price exceeds the level c, the Ukrainian government imposes temporary wheat export restrictions. This changes the price behaviour of traders and farmers and leads to a change in the relationship between the domestic Ukrainian and the world

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5 The reader is referred to van Dijk et al. (2002) and Teräsvirta (1994) for detailed discussions on the choice of transition functions.

market price of wheat which is captured by a change of the price transmission regime in our model.

The intercept parameters α_1, $\alpha_1 + \alpha_2$ represent the price difference between the world market price and the domestic price, and the slope parameters β_1, $\beta_1 + \beta_2$ provide the corresponding long-run price transmission of the two regimes. We hypothesize that the long-run price equilibrium under wheat export controls is characterized by 1) a larger value of the intercept parameter due to the increase in wheat supply on the domestic market, and 2) by a smaller value of the slope parameter, reflecting the price insulating effect compared to the free trade regime[6]. The two partial effects together imply that the domestic wheat price is dampened relatively to the world market price. Further, we hypothesize 3) that the transition between the two regimes is of a gradual nature due to trader heterogeneity and expectations governing the price behaviour of traders and farmers, and wheat storage counteracting the export controls' price dampening effect.

4 Literature Review

Price transmission models offer a particularly suitable framework to investigate the price effects of export controls on domestic producer prices by comparing price relationships under the conditions of free international trade with the situation when exports are restricted[7].

A common feature of the price transmission approaches, as applied in Baffes et al. (2015), Baylis et al. (2014), Djuric et al. (2015), Götz et al. (2015), Götz et al. (2013), Ihle et al. (2009) and Serebrennikov and Götz (2015), is to assume that traders change their pricing behaviour immediately when the export controls are implemented or removed.

Djuric et al. (2015), Götz et al. (2013) and Ihle et al. (2009) use a Markov-switching vector error-correction/vector autoregressive model (MSCVEM) where the regime switch is also abrupt and is determined endogenously. Surprisingly, Djuric et al. (2015) do not identify a lasting change in the price transmission regime during the export ban in Serbia, but rather when the export ban was cancelled. This indicates that the expected price dampening effects of the

[6] A similar hypothesis on the long-run price transmission parameter is given by Götz et al. (2013: 215). However, they do not distinguish the export controls' influence on the long-run price transmission parameter from the influence on the intercept parameter in the model. Further, they assume that the transition between the regimes is abrupt (c.f section 3 below).

[7] Alternative model approaches are applied by Fellmann et al. 2014 and Diao et al. 2013, which both use a general equilibrium model approach to investigate the effects of export controls in Russia, Ukraine and Kazakhstan (Fellmann et al. 2014), as well as in Tanzania (Diao et al. 2013).

export ban for wheat in Serbia on the domestic wheat price were offset by inconsistent additional policy measures and their faulty sequencing. Götz et al. (2013) identify three distinct price transmission regimes (“standard”, “crisis” and “post-crisis”) in Russia and Ukraine, with the “crisis” regime prevailing mainly during times of export restrictions, though the majority of the price observations under restricted exports are attributed to the “standard” regime, which mainly prevails under free trade in the case of Ukraine. Parameter estimates suggest that the 2007/8 export quota implemented in Ukraine and the export tax in Russia have reduced the degree of integration of Russian and Ukrainian domestic markets in international markets. Prices were insulated by 40% in Ukraine and about 10% in Russia compared to when trade was freely possible. Ihle et al. (2009) identify two distinct regimes (“high” and “low” margin regime) that correspond with known periods of export bans and periods when trade was not restricted for Tanzania and Kenya. However, additional high-margin episodes are identified during which no export bans were known to have been in effect. The results of these studies indicate that regime classification resulting from a price transmission model with an abrupt regime change of the Markov-switching type is often questionable. These shortcomings in regime classification remain to be addressed.

Baffes et al. (2015), Baylis et al. (2014), Götz et al. (2015) and Serebrennikov and Götz (2015) follow a regional perspective investigating the domestic effects of export controls. Baylis et al. (2014) use a vector error correction model (VECM) and a threshold vector error correction model to investigate the export ban for wheat and rice in India. Götz et al. (2015) apply a regime-switching long-run equilibrium model to the periods of free trade and the export restrictions, separately investigating the wheat export controls in Russia, Ukraine and Kazakhstan. Both identify regionally significantly differing price effects of export controls. Baffes et al. (2015) and Serebrennikov and Götz (2015) investigate the domestic producer price effects of export controls for maize in Tanzania and for wheat in Russia, respectively. Baffes et al. (2015) apply an error correction model framework and find that an export ban exacerbates the influence of domestic weather disturbances on prices in local markets and delays adjustment towards a long-run equilibrium with external markets. Based on a threshold vector error correction model, the results of Serebrennikov and Götz (2015) suggest that the export ban in 2010/11 raised interregional wheat trade within Russia and increased the speed with which deviations from the equilibrium between the regions were adjusted.

In contrast to these previous models, we suppose that traders’ price behaviour is influenced by price expectations, and that traders’ behaviour might differ due to trader heterogeneity, implying that the transition between the free trade and the restricted trade regime is smoothed. To do so, we apply the Smooth Transition Cointegration (STC) model (Choi and Saikkonen 2004) to determine not only the parameters of the long-run equilibrium of the free trade and the restricted trade regimes, but also the parameters governing the transition between the two. The STC was previously introduced into vertical price transmission analysis by Gervais (2011) investigating the US hog/pork supply chain.

In using the STC model in spatial price transmission analysis we add to the few existing studies that allow for a regime change in the long-run price equilibrium relationship. One example is Stephens et al. (2012), who estimate a regime-specific cointegration model for tomato markets in Zimbabwe by distinguishing between two price transmission regimes in the presence and absence of trade. These authors' model specification allows the two regimes to differ in the long-run price transmission.

Myers and Jayne (2011) investigate spatial maize price transmission between South Africa and Zambia, and propose a multiple-regime threshold model with changing price transmission regimes, allowing for multiple long-run price equilibria. The regime switches are assumed to depend on the magnitude of trade flows between the regions, temporary governmental market interventions, and whether transport capacity constraints are binding.

Götz and von Cramon-Taubadel (2008) develop a procedure to estimate a regime-dependent VECM, which allows both the short-run and the long-run price transmission to differ between regimes. Non-linear threshold cointegration is confirmed by the Gonzalo and Pitarakis (2006) test, which uses the share of domestic apples in total wholesale trade as the threshold variable for apple price data from two German wholesale markets.

Finally, it should be pointed out that the exponential smooth transition autoregressive (ESTAR) error correction model approach followed by Ghoshray (2010) to investigate price transmission between international wheat prices differs from the smooth transition cointegration model applied in this study. In general, a smooth transition error correction model allows for gradual regime switching in the speed of adjustment parameter (Kapetanios et al., 2006), whereas the parameters of the long-run equilibrium are assumed to be constant. The choice of this threshold model with a smooth rather than an abrupt change between the regimes is motivated by the potential variability of transaction costs influenced by trade volumes. Their results confirm cointegration for all price pairs, indicating highly integrated world wheat markets.

5 Data and Empirical Estimation

We begin our analysis by conducting a test on linear cointegration versus smooth transition cointegration using the method developed by Choi and Saikkonen (2004). Given that the hypothesis of linear cointegration is rejected, we estimate the logistic STC regression model using the method proposed by Saikkonen and Choi (2004). Finally, we apply the ADF unit root test on the residuals of the logistic STC regression model.

5.1 Data

We use weekly observations for international and Ukrainian domestic wheat prices from March 23, 2001 to September 9, 2011. The Ukrainian domestic wheat price is measured as the ex-warehouse price of class III milling wheat (APK-Inform, 2011). The French soft wheat price (class 1, FOB, Rouen; HCGA 2011) is used as the world market price for Ukraine[8]. The prices are converted into USD per ton using exchange rates provided by the European Central Bank. Figure S1 in the appendix shows the development of the Ukrainian domestic and international wheat price series, while figure S2 in the appendix presents a plot of the Ukrainian against the international wheat price. The depicted price relationships lead us to suspect a regime-switching pattern between the Ukrainian and international wheat prices. This suggests an impact on price linkages resulting from government intervention.

Table 1: Unit Root Tests for Price Data

		World market price (x_t)	Ukrainian price (y_t)	Δ International price (Δx_t)	Δ Ukrainian price (Δy_t)
Dickey-Fuller Test					
Single Mean	Lags				
ρ	3	-3.15	-6.81	-319.74	-252.802
(Pr < ρ),		(0.64)	(0.29)	(<0.001)	(<0.001)
τ_μ	3	-1.19	-1.75	-9.95	-9.23
(Pr < τ_μ)		(0.68)	(0.40)	(<0.001)	(<0.001)
Trend					

8 The ideal candidate to serve as an international wheat price relevant for the domestic Ukrainian wheat price is a FOB price at one of the ports of the Black Sea. Due to export restrictions, wheat was not exported from any Black Sea port for some weeks. Thus, a continuous time series of a Black Sea export price is not available for the time period underlying our analysis. According to traders' information, wheat prices at the MATIF (commodity futures market) in France play an increasing role for price determination in the Black Sea region. The MATIF dominates all spot market prices at the port of Rouen, the primary French harbour through which wheat is exported to the world market. Ukrainian class III wheat is usually used for human consumption, particularly for bread production; in some years the wheat is of lower quality and may be used in livestock production. We use French soft wheat (class 1) as the relevant world market price since it is heavily traded and primarily used for bread production.

ρ (Pr < ρ),	6	-8.54 (0.54)	-12.98 (0.26)	-319.78 (<0.001)	-8.54 (<0.001)
τ_{μ} (Pr < τ_{μ})	6	-2.05 (0.58)	-2.66 (0.25)	-9.94 (<0.001)	-253.78 (<0.001)
KPSS Test					
Single Mean	6	4.81	2.93	0.07	0.10
Trend	6	0.30	0.26	0.07	0.08

Note: ρ is the statistic for the basic Dickey-Fuller test and τ_{μ} is the statistic for the augmented Dickey-Fuller test. The 10%, 5%, and 1% critical values for the KPSS-single mean test are 0.35, 0.46, and 0.74, respectively. For the KPSS-trend test these values are 0.12, 0.15, and 0.22, respectively.

Source: Own calculations.

All analyses are conducted based on the data series in logarithm form. We begin by assessing the time series properties of price series using the standard Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and the KPSS test from Kwiatkowski, Phillips, Schmidt, and Shin (1992). Table 1 presents the test results. The ADF unit root tests fail to reject the unit root hypothesis, and the KSPP tests reject the stationarity null for both series. Meanwhile, test results reject the unit root hypothesis and are not able to reject stationarity for the first difference of price series. Hence, the price series may be considered as I(1) processes.

5.2 Test of Linear versus Smooth Transition Cointegration

The null hypothesis of linearity can be expressed as equality of the autoregressive parameters in the two regimes of the STC model in (1). That is, $H_0 : \alpha_2 = \beta_2 = 0$, whereas under the alternative hypothesis of $H_1 : \alpha_2 \neq 0$ or $\beta_2 \neq 0$. The testing problem is complicated by the presence of unidentified nuisance parameters under the null hypothesis. Choi and Saikkonen (2004) develop a nonlinearity test that extends the approaches developed by Luukkonen et al. (1988) and Granger and Teräsvirta (1993), and can be applied in the context of STC. In particular, their test relaxes the exogeneity requirement for the regressors and follows the common practice of cointegrating regression and permits both serial and contemporaneous correlations between the regressors and the model's error term. To allow for this feature, the test uses the leads-and-lags approach proposed by Saikkonen (1991) and Stock and Watson (1993) for linear cointegrating regressions.

Choi and Saikkonen (2004) propose a set of tests based on the first- and third-order Taylor series approximation of the transition function g . The authors argue that a third-order Taylor expansion is superior to a first-order version, since it has more power when β_2 in (1) is small. We thus adopt the third-order Taylor approximation and rewrite the transition function as:

$$g(x_t - c;\gamma) \approx b\gamma(x_t - c) + d\left[\gamma(x_t - c)\right]^2 + h\left[\gamma(x_t - c)\right]^3. \qquad (2)$$

The testing procedure involves estimating the corresponding auxiliary regression using OLS:[9]

$$\begin{aligned} y_t &= \alpha_1 + \alpha_2 \left\{ b\gamma(x_t - c) + d\left[\gamma(x_t - c)\right]^2 + h\left[\gamma(x_t - c)\right]^3 \right\} \\ &\quad + \beta_1 x_t + \beta_2 x_t b\gamma(x_t - c) + \sum_{j=-K}^{K} \pi_j \Delta x_{t-j} \\ &= \omega + \phi_1 x_t + \phi_2 x_t^2 + \phi_3 x_t^3 + \sum_{j=-K}^{K} \pi_j \Delta x_{t-j} + \eta, \quad t = K+1, ..., T-K \end{aligned} \qquad (3)$$

The null hypothesis of linearity is $\phi_2 = \phi_3 = 0$ and the Lagrange-Multiplier (LM) statistic is $\tau = \hat{\Phi}'[\hat{\sigma}_e^2 (M^{-1})_{xx}]^{-1}\hat{\Phi}$, where $\hat{\Phi} = [\hat{\phi}_2 \ \hat{\phi}_3]'$ are the OLS estimates of $[\phi_2 \ \phi_3]$, $\hat{\sigma}_e^2$ is the variance estimator based on the residuals of the corresponding OLS estimation constrained by $\phi_2 = \phi_3 = 0$, M is the sample moment matrix for the auxiliary regression, and $(M^{-1})_{xx}$ is the element of the inverse of the sample moment matrix associated with $[x_t^2 \ x_t^3]'$. Under the null hypothesis, $\tau \xrightarrow{d} \chi^2(p+1)$, where *p* (= 1 in our case) is the dimension of the model.

The STC relationship test results are presented in Table 2. For the Ukrainian case, under all levels of lags and leads (K), the test rejects the null of linearity in favour of the STC framework. We thus use the STC model for the long-run relationship between the Ukrainian and world market wheat prices. As a comparison, we also test linearity of the relationship between German and US wheat prices with their corresponding world market prices. Neither of the tests are able to reject the linearity assumption. This is consistent with our priors, since these two countries did not implement trade restrictions during the food crisis. In the next step, we estimate the STC relationship for Ukraine. To decide if the Ukrainian and the world market prices are indeed cointegrated, and thus if a long-run equilibrium exists, we test the stationarity of the residuals

9 Choi and Saikkonen (2004) argue that the motivation for using the third-order instead of the first-order approximation is to improve the power of test statistics; they suggest using third-order approximation only for the transition of the intercept term and using the first-order approximation for the transition involving the regressors.

obtained from the above STC regression. The results are presented in Table 3. The KPSS test does not reject the null of stationarity at a 5% level. We also conduct the ADF unit root tests for the residuals. However, since the residual variance is made as small as possible, the procedure is prejudiced toward finding a stationary error process. Hence, the test statistic used to test the unit root must reflect this fact, and an ordinary ADF-table is inappropriate. We thus use the critical values provided by Enders (2010), which are interpolated using the response surface in MacKinnon (1991). The results reject the null of the unit root. We therefore conclude that the Ukrainian and international wheat prices are cointegrated via a smooth transition mechanism.

Table 2: Test Results, Linear vs. Smooth Transition Cointegration

	Ukrainian vs. world market price	German vs. world market price	US vs. world market price
Lags and Leads $\sum_{j=-K}^{K} \alpha_j \Delta x_j$	**Statistic τ (3rd order Taylor approx.)**		
K=1	12.83	1.13	0.88
K=2	11.99	1.05	0.39
K=3	12.17	0.87	0.54

Note: The tau statistic follows a chi-square distribution with two degrees of freedom. The null hypothesis is a linear cointegrating vector and the alternative is STC. The critical value is $\chi(2)_{0.05} = 5.99$.

Source: Own calculations.

Table 3: Stationarity Test Results for Residuals of the STC model

	Lags	Statistics
Engle-Granger Cointegration Test	3	-32.88
KPSS, Single Mean	6	0.41

Note: The 10%, 5%, and 1% critical values for KPSS-single mean test are 0.35, 0.46, and 0.74, respectively. The 10%, 5%, and 1% critical values for the Engle-Granger cointegration test (with two variables, sample size 500, and including a constant in the cointegrating vector) are -3.05, -3.35, and -3.92, respectively.

Source: Own calculations.

5.3 Estimation of the STC Long-run Relationship

If the null hypothesis of linearity has been rejected we estimate the STC equation (1) in the next step. We adopt the STC regression framework developed by Saikkonen and Choi (2004), where regressors are I(1) and errors are I(0), and the regressors and errors are allowed to be dependent both serially and contemporaneously. Previous studies (e.g. van Dijk et al., 2002) usually suggest using a nonlinear least square (NLLS) technique to obtain the estimates of the parameters in (1). Saikkonen and Choi (2004) indicate that although the nonlinear least squares estimator is consistent, the asymptotic distribution involves a bias if regressors and error are dependent, which makes the NLLS estimator inefficient and unsuitable for hypothesis testing. These authors propose a Gauss-Newton (G-N) type estimator that utilises the NLLS estimator as an initial starting value and expand the model by including leads and lags as extra regressors. In this paper we adopt their iterative estimation procedure and utilise a damped G-N method, known as the Levenberg-Marquardt (L-M) method. Given that the initial values of the parameters are close to the final optimal values, the L-M method has proven to be more efficient and can almost always guarantee quadratic final convergence. Also, as discussed, the results of our estimation could be sensitive to the initial values of γ and c. Van Dijk et al. (2002) suggest normalising the transition function by dividing γ by the sample standard deviation of the transition variable x_t to make γ approximately scale free. We follow this approach and replace the transition function given in (1) with a normalized version:

$$g(x_t - c;\gamma) = \left[1 + \exp(-\frac{\gamma}{\hat{\sigma}_x}(x_t - c))\right]^{-1} \quad (4)$$

Table 4 presents the (iterated) L-M estimates of the cointegration model for the Ukrainian and world wheat markets. The STC results from Table 4 are consistent with the institutional background and with our conceptual framework. When comparing the results from STC models with and without lags and leads, we find no significant difference. This may indicate that regressor-error dependence is not an issue in our sample set. Parameter estimates for the STC long-run equilibrium relationship are presented in (7), which are retrieved from the STC with no lags and leads:

$$\hat{y}_t = \begin{cases} -0.86 + 1.14x_t, & \text{if g=0 (regime "restricted trade")} \\ 1.27 + 0.70x_t, & \text{if g=1 (regime "open trade")} \end{cases} \quad (5)$$
$$\text{with } g(x_t - c;\gamma) = 1/\{1 + \exp[-3.87(x_t - 5.21)/0.16)]\}$$

The results confirm a regime-switching behaviour in the long-run relationship between the Ukrainian domestic and world market price, depending on the level of world market price. The “open trade” regime is characterised by an intercept parameter of -0.86 and a long-run price transmission parameter of 1.14. The “restricted trade” regime is characterised by a higher intercept parameter of 1.27 and a lower long-run price transmission parameter of 0.70 compared to the "open trade" regime, as economic theory suggests. In sum, the change in the intercept parameter and the long-run price transmission result in a price dampening effect on the Ukrainian wheat price of 35% relatively to the world market price. The estimated mid-point value for the transition variables is 5.21 in logarithms, or 183. Thus, if the world market price for wheat exceeds USD 183/ton, the Ukrainian government implements export controls. The system switches to the "transition" mode and the relationship between the two markets gradually passes from the "open trade" into the "restricted trade" regime. The transition process is smooth due to the heterogeneity of the traders and its speed is determined by the smoothness parameter with a value of 3.87. Since farmers' and traders' price behaviour is influenced by price and policy expectations, a regime switch may occur even if the implementation of export controls is only expected due to observed or expected high world market price, but not yet realised.

Figure 2 shows the value of the transition function and the corresponding long-run price transmission and the intercept value as a function of the level of the world market price. It becomes evident that the value of the transition function is equal to 0 if the world market price is below the level of USD 160/ton, implying that the long-run price transmission parameter is equal to 1.14 and the intercept amounts -0.86. If the world market price exceeds USD 227/ton, the transition function is equal to 1 and the long-run price transmission and the intercept parameter are equal to 0.7 and 1.27, respectively. If the world market price exceeds USD 160/ton, but is below USD 227/ton, then the system stays in transition and the parameters change smoothly. Similar to the "restricted trade" regime, the "transition" phase is characterised by a lower long-run price transmission and a higher intercept parameter compared to the "open trade" regime. However, the "transition" phase is characterised by a higher long-run price transmission and a lower intercept parameter compared to the "restricted trade" regime.

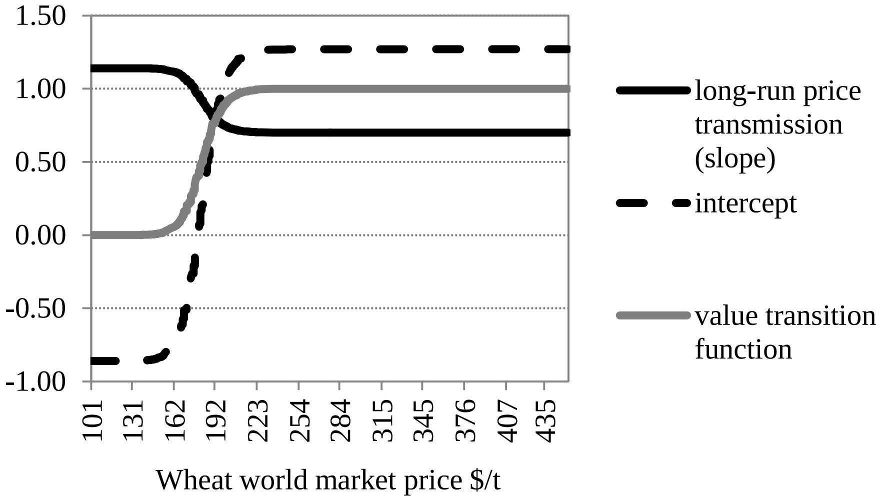
Table 4: Estimates of the Smooth Transition Cointegrating Model

Parameter	Estimate	Approx. Std. Err.	Approx. Pr > |t|
γ	3.87	1.73	0.03
c	5.21 ($183)	0.05	<0.01
α_1	-0.86	0.49	0.08
α_2	2.13	0.67	<0.01

β_1	1.14	0.10	<0.01
β_2	-0.44	0.13	<0.01

Source: Own calculations.

Figure 2: Value transition function, price margin and long-run price transmission elasticity versus international wheat price



Source: Own illustration.

6 Model Comparison

To assess the performance of the modelling approach we compare the STC model results with a regime switching (RS) model and a MSECM framework as applied by Götz et al. (2013). In contrast to the STC model approach, which supposes that the regime switches are smooth and the transition process is governed by the level of the international wheat price, the regime switch in the RS and the MSECM is abrupt.

In the RS model, however, the regime switches are determined exogenously. In particular, the RS model makes use of the known dates of the trade policy changes by allowing for a regime switch at those dates. Wheat exports were officially restricted by an export quota from October 6, 2006 until May 30, 2008, and from October 5, 2010 until June 30, 2011, it is assumed that the “restricted trade” regime prevails in the RS model.

Similar to the STC model, the point in time of the regime switches is determined endogenously within the MSECM framework, though here it is assumed that the threshold variable, which governs the regime switches, is unobservable and probabilistic.

We compare the results of the STC model, RS model, and MSECM regarding regime classification, model parameters, and goodness of fit.

Regime classification and model parameters

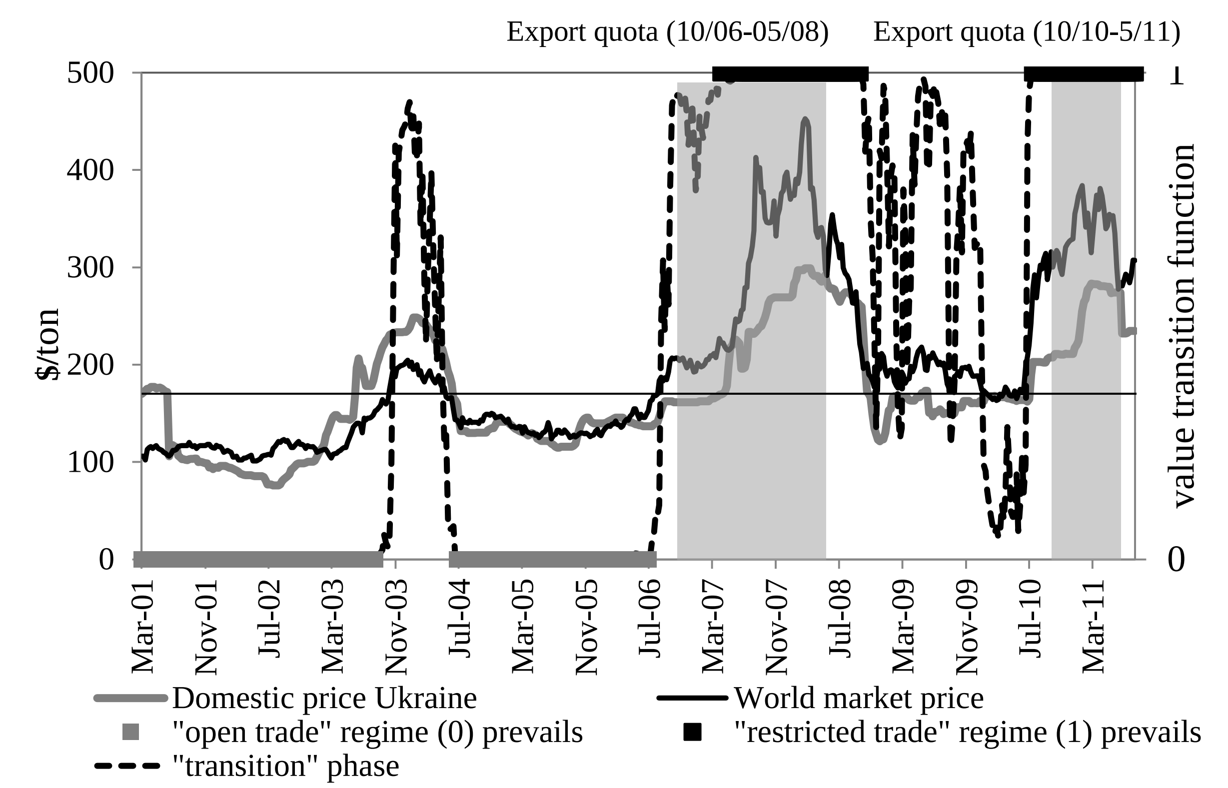
We start with comparing the regime classification of the STC model with the RS model which is followed by a comparison with the MSECM model. Finally we contrast the overall dampening effect of export controls on the domestic wheat price resulting from the three modelling approaches.

Figure 3 allows us to compare regime classification of the STC model with the RS model. It presents the development of the domestic wheat price in Ukraine and the corresponding world market price. The known time periods when the export quota was implemented in Ukraine is indicated by the grey areas. The value of the transition function of the STC model varies between 0 and 1 as indicated by the right-hand axis. When the value of the transition function is equal to 0 the “open trade” regime prevails, when it is equal to 1 the “restricted trade” regime prevails. If the transition function takes values between 0 and 1, which is indicated by the dashed black line in Figure 3, the transition phase prevails with gradually changing parameters.

The prevalence of the “restricted trade“ regime in the RS model is given by the exact dates when the export quota system was implemented in Ukraine (corresponding to the grey areas), and the “open trade” regime prevails otherwise.

The STC has the advantage over the RS that it also allows us to capture changes in the price transmission regime, which are not caused by actual but by expected policy changes (see section 2). For example, the system changed to the “restricted trade” phase in July 2010, several weeks prior to the implementation of the export quota system in Ukraine in October 2010 (Figure 3). The regime change was observed when the implementation of an export ban was discussed by the Russian government. Further, chances that export restrictions would also be implemented in Ukraine were discussed by Ukrainian media (APK-Inform). Obviously, price expectations and the price behaviour of traders anticipating export controls changed, reducing their willingness to pay for wheat on the domestic market and decreasing the influence of the world market price. Therefore, domestic wheat prices were dampened relatively to the world market price and Ukrainian wheat prices became insulated prior to the actual implementation of the export controls.

Figure 3: Regime Affiliation According to Model Results



Source: Own illustration. Data base: APK-Inform (2011), HCGA (2011), own calculations.

The second advantage of the STC over the RS is that it allows the system to stay in a “transition” phase, which is characterised by a intercept value which is smaller and a long-run price transmission parameter which is higher compared to the “restricted trade” regime (Table 5). We observe the transition phase when the price behaviour of traders changes such that the price transmission regime switches gradually, which we explain by trader heterogeneity. In addition, the system may remain in “transition” phase when the effects of the export quota system are counteracted by wheat storage. In particular, the “transition” phase is observed when the export quota system was introduced in October 2006 to last a rather short period of 3 months until December 2006. Thus, traders might have kept wheat in storage to sell it on the international market at higher prices after the export quota was removed. Wheat storage counteracts the price dampening effects of export controls. This might explain why domestic price effects of the export quota were rather modest at the beginning, and our model remained in “transition” mode. However, in December 2006 the extension of the export controls until June 2007 was announced. In February 2007, export controls for barley and maize were cancelled and they were also cancelled for wheat in May, but were reintroduced again in June 2007 and ran until October. It seems that the repeated prolongation of the export controls depressed the traders’ price expectations to sell wheat on the international market. Also, wheat stores have to be discharged prior to the new harvest. Thus, at least some of the stored wheat has to be sold on the domestic market if exports are restricted. These factors might have induced a regime switch from the “transition” phase to the “restricted trade” regime.

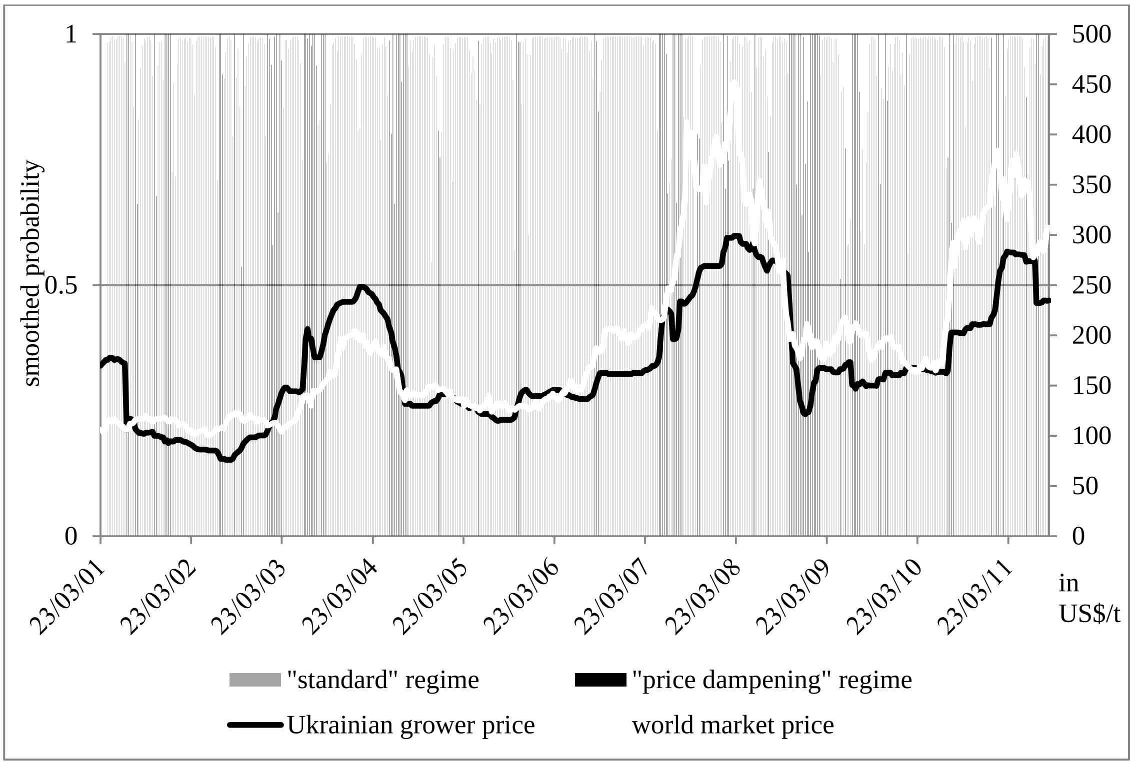
It should be pointed out that the STC remains in transition phase November 2003 until July 2004 when Ukraine was suffering from a serious harvest shortfall and turned into a wheat importer. It remains a puzzle why the system remained in transition after the removal of the export quota system in 2008 until the renewed implementation of the export quota in 2010. However, the comparison of the goodness of fit of the STC with alternative models below will show that the STC is superior.

In the following we compare the regime classification of the STC with the MSECM. Both model frameworks have in common that the point in time of the regime switches are determined endogenously, but differ in the assumptions about the underlying processes, as was explained above. We estimate a MSECM for the time period 2001-2011 by maximizing the likelihood function with the expectation-maximization algorithm. Since a long-run price equilibrium model with 2 regimes, which is directly estimated within a Markov-switching framework, suffers from serious autocorrelation and heterogeneity, we choose an unrestricted MSECM similar to Götz et al. 2013, which allows not only the short-run but also the long-run price transmission parameters to vary by regime. The regime-specific parameters of the long-run price equilibrium are retrieved indirectly from the parameters of the MSECM and their statistical significance is determined by the delta-method (see Götz et al. 2013).

We use a MSECM specification with 2 regimes and 3 lags which is free of autocorrelation and heteroscedasticity, but suffers from non-normality. The regime classification of the MSECM is presented in Figure 4 and the parameter values are given in Table 5. The majority of observations (76%) is attributed to “regime 1”, characterized by a lower constant and a slightly higher slope coefficient compared to “regime 2”. Only 24% of all observations are assigned to “regime 2”.

When wheat exports were limited by export controls (October 6, 2006 until May 30, 2008, and from October 5, 2010 until June 30, 2011) 29% of the 122 price observations are attributed to “regime 2” by the MSECM. This model completely fails to identify different regimes which have anything at all to do with the export quotas, or even trading status.

Figure 4: Regime classification MSECM



Source: Own illustration.

In comparison, the STC classifies 71% of the 122 prices observed when wheat exports were restricted by an export quota to the "restricted trade" regime (the remainder (29%) being contiguous with the actual periods of the quota policy). Also, the "restricted trade" regime of the STC and the RS model is characterized by a lower long-run price transmission parameter and an increased intercept (Table 5). The changes in the parameter estimates reflect economic theory which suggests that export controls dampen the domestic price relative to world market prices, and insulate domestic from world market price developments.

Table 5 further presents the price dampening effect of the export controls on the domestic wheat price[10] identified in each model approach. The size of the price dampening effect is highest in the STC amounting to 26%, compared to 15% in the RS and 8% in the MSECM approach.

Summarizing, given empirical evidence that Ukrainian prices were affected by the export quota system throughout its implementation, regime classification using the STC clearly better reflects the observed and theoretically expected price features compared to the MSECM. This

[10] As pointed out in section 3, the price dampening effect is the result of two partial effects, the change in the intercept as well as the slope parameter. We use the respective parameters of the free trade regime and the controlled trade regime of each model approach to calculate the price dampening effect. It is estimated as the % change in the relative difference between the world market price and the domestic price in Ukraine when trade becomes restricted compared to when trade is freely possible.

result provides strong evidence for the advantage of the STC over the MSECM in the explicit modelling of the regime switching process.

Table 5: Comparison parameter estimates STC, RS and MSECM

	STC (2001-2011)			**RS** (2001-2011)		**MSECM** (2001-2011)	
regime/ phase	open trade	transition phase	restr. trade	open trade	restr. trade	regime 1	regime 2
intercept	-0.86*	-0.86<x <1.27	1.27***	0.77***	1.03	0.425	0.53 (+25%)[3]
slope (price transm.)	1.14***	1.14>x >0.7	0.70** (-39%)[2]	0.84***[1]	0.77***[1] (-8%)[2]	0.875***	0.879*** (+1%)[3]
price dampen-ing effect	26%			15%		8%	

[1] t-values based on heteroscedasticity-consistent (Eicker-White) standard errors

[2] change in % compared to the open trade regime; numbers in absolute values

[3] change in % compared to the standard regime; numbers in absolute values

Source: Own calculations.

Goodness of fit

To assess how well the STC model fits the data, we contrast the observed domestic wheat price for Ukraine with the fitted values that were estimated based on the model parameters retrieved from the STC model, and compare it with the RS model and the MSECM. The sum of squared residuals (SSR) and the Akaike information criteria (AIC)[11] are presented in Table 6 as two indicators of the goodness of model fit.

Both the SSR and the AIC are lowest for the STC model. This is followed by the RS model which is characterized by slightly higher SSR and AIC compared to the STC model. In contrast, the SSR and the AIC are significantly higher for the MSECM. Thus, the goodness of fit of the STC model is slightly better compared to the RS model, but clearly outperforms the MSECM.

Table 6: Comparison goodness of fit STC, RS and MSECM

[11] The AIC is calculated as $AIC_{\sigma} = n * \log(\sigma_z^2) + 2 * k$ with σ_z^2 the residual variance and k the number of parameters estimated by the model.

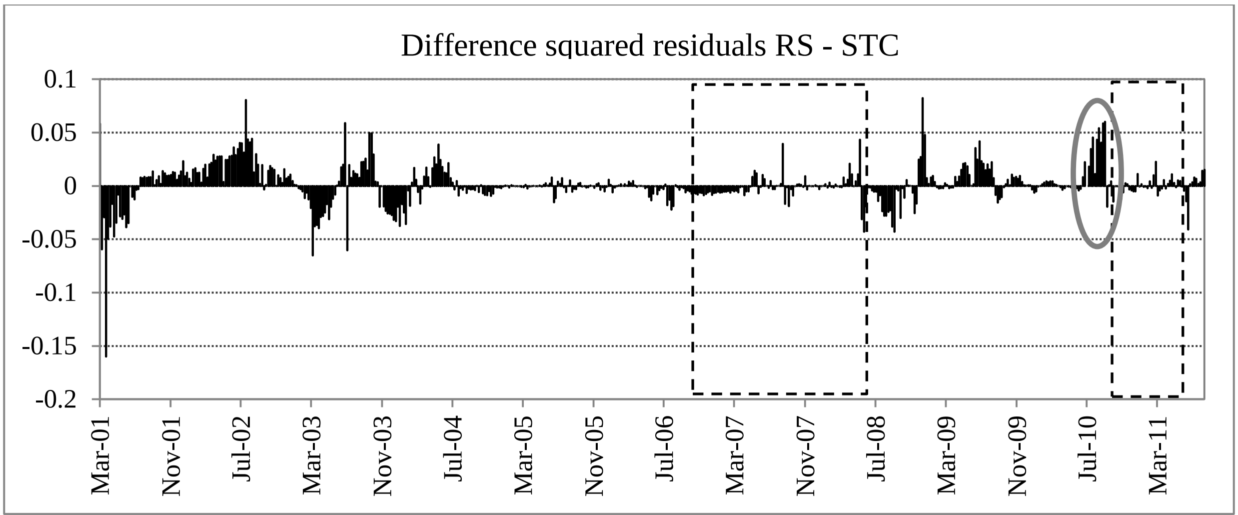
	STC	RS	MSECM
Sum of squared residuals	16.4	17.1	25.0
Akaike Information Criteria	-819.7	-814.7	-688.0
Number of parameters	6[1]	4	22[2]

[1] the STC estimates 4 regime-specific coefficients of model variables (2 per regime) and 2 parameters characterizing the transition process

[2] the MSECM estimates 18 regime-specific coefficients of model variables (9 per regime) and 4 regime transition probabilities

Source: Own calculations.

Figure 5: Difference of the Sum of Squared Residuals RS - STC, 2001-2011



Note: Diff. > 0 if Squared residuals RS > Squared residuals STC; Diff. < 0 if Squared residuals RS < Squared residuals STC.

Source: Own calculations.

Figure 5 presents the difference between the squared residuals of the RS and the STC model over our data period. It is striking that the squared residuals of the STC model are significantly smaller compared to the RS model several weeks before the export quota system was implemented in 2010 (grey circle in Figure 5). At that time, the “open trade” regime changed to the “transition” mode, although export controls were not yet implemented. This provides further evidence that farmers’ and traders’ expectations that export controls would be implemented indeed led to a change of the price transmission regime several weeks before the export quota system was actually implemented in 2010. In addition, it confirms that the transition process is not abrupt but happens gradually, which we explain with trader heterogeneity.

7 Conclusions

In this paper we extend previous modelling approaches to identify the domestic price effects of export controls by allowing for smooth transition between the price transmission regimes prevailing when trade is freely possible versus when exports are restricted. Results of the smooth transition cointegration (STC) approach (Choi and Saikkonen (2004); Saikkonen and Choi (2004)) confirm theoretical expectations that export controls dampen domestic prices relatively to the world market price. Our results for the Ukrainian export quota experience indicate that the long-run price transmission decreased by 39% and that the intercept increased by 48% compared to the open trade regime. The two effects together result in a dampening effect of 26% on the Ukrainian grower price. The STC approach also identifies a smooth transition process, reflecting trader heterogeneity and price expectations governing price behaviour. Also, the system may remain in transition when the effects of export controls are buffered by speculative wheat storage.

The validity of the STC results is supported by the results from a regime switching (RS) model (which assumes that changes are abrupt) which also indicates that the Ukrainian wheat price was dampened relatively to the world market price though to a significantly lower degree (15%) than those estimated using the STC model. In contrast, comparable results obtained from a Markov-switching vector error-correction/vector autoregressive model (MSECM) do not appear to reflect any identifiable economic reality.

This suggests that the STC approach has the advantage over the RS model that it allows an expected policy change to induce a switch in the price transmission regime, and that the regime transition is allowed to happen gradually. This is supported by the evidence provided by comparing the goodness of fit of the STC and the RS model.

Comparing regime classification and goodness of fit of the STC with the MSVECM suggests that the STC outperforms the MSECM in regime classification. This result clearly reflects the primary importance of the world market price as a factor that determines the regime switches and the gradual nature of the regime transition process.

To judge if the export quotas were successful in insulating Ukrainian domestic wheat prices from world market prices, the effects of export restrictions on both domestic prices and world market prices have to be taken into account. Martin and Anderson (2012) estimate that almost

30%[12] of the increase in world wheat prices from 2006-2008 was caused by trade-oriented crisis policy interventions, i.e. the increase in export barriers by exporters, as well as the removal of import barriers by wheat importing countries worldwide.

This implies that the dampening effect that the export quota had on the domestic price in Ukraine was overcompensated by the increasing effect of the changes in border protection rates on world market prices. Given our estimated average price dampening effect of export controls in Ukraine by 26% and the 30% increase in world market prices due to trade-related measures (Martin and Anderson 2012), the domestic wheat price in Ukraine would have increased even 4% less, and without causing any additional welfare costs, if no country worldwide had engaged in price insulating behaviour from 2006-2008.

The welfare costs caused by the export quotas for Ukraine in the short-run result from foregone exports, reduced wheat export prices (due to risk premium charged by importers) and wheat grower prices, costs incurred by loaded ships locked in harbours, and the losses resulting from delayed or reduced investments in the Ukrainian grain production sector. In the long-run, investments in the grain sector decrease and income possibilities are foregone. Thus in the long-run, wheat export controls do not increase but rather reduce food security, with implications for global food security in the case of a large grain exporting country as Ukraine.

[12] For comparison, Anderson and Nelgen (2012) estimate that 19% of the world wheat price increase was caused by price insulating behaviour.

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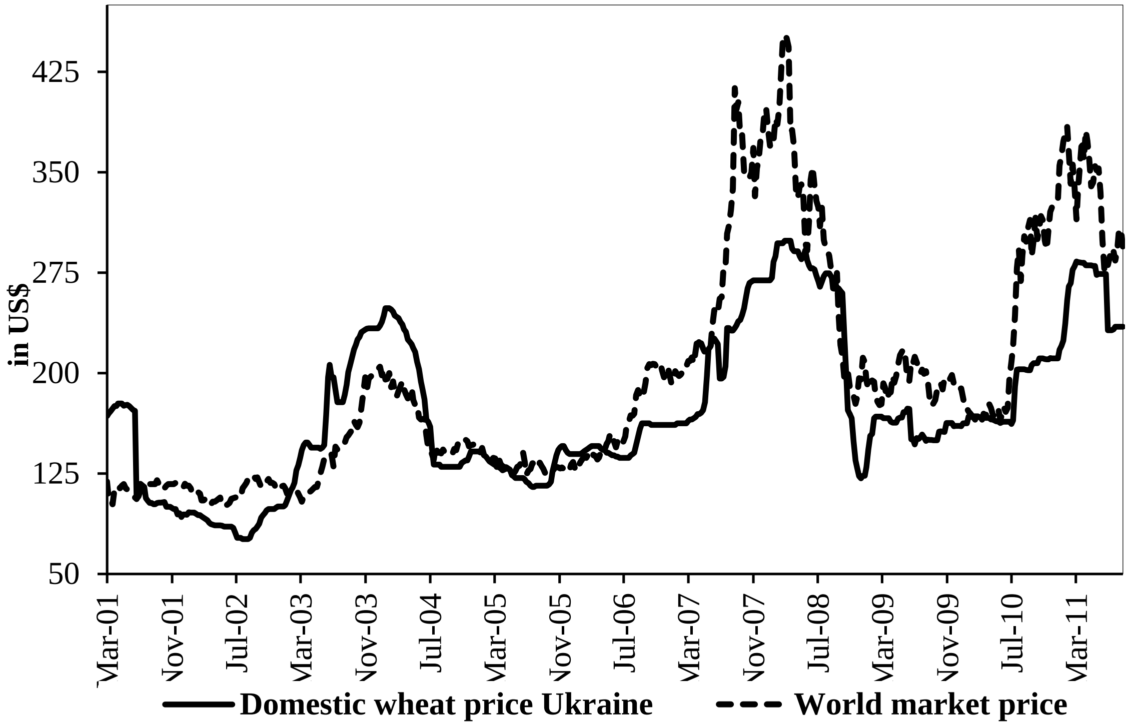
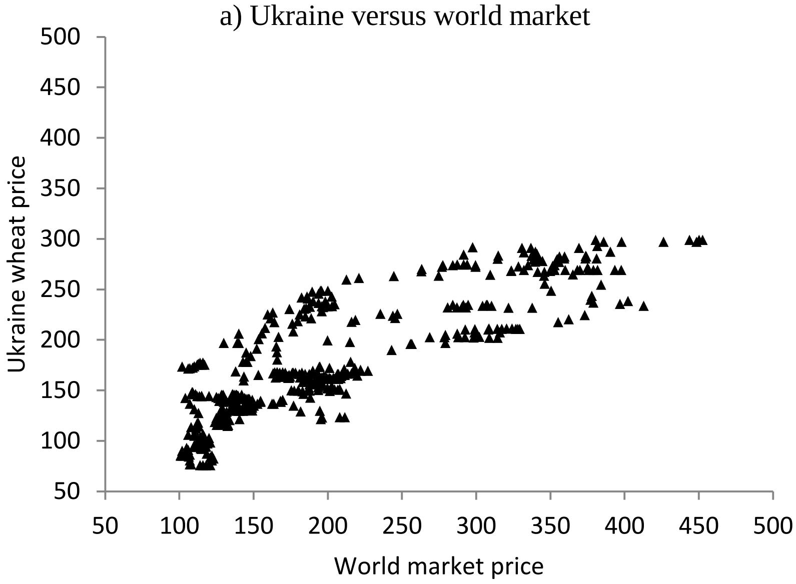
Annex

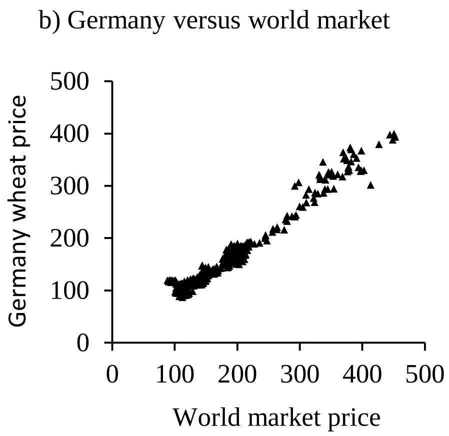
Figure S1: Weekly Time Series of the Ukrainian Domestic Wheat Price and the World Market Price for Wheat used for Price Transmission Analysis

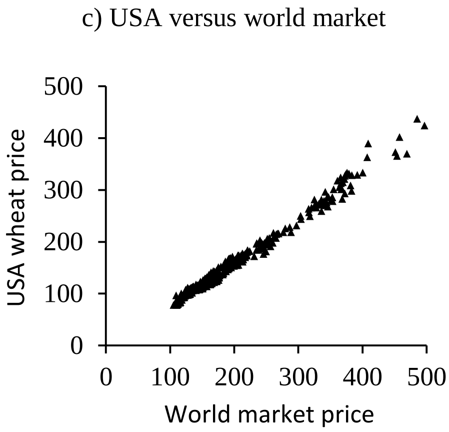


Source: Own illustration. Data base: APK-Inform (2011), HCGA (2011).

Figure S2: Domestic and Corresponding Wheat World Market Prices (in USD/t)







Source: Own illustration. Data base: AMI (2011), APK-Inform (2011), HGCA (2011), USDA (2011).

Notice: We also plot the domestic wheat prices for Germany (average warehouse delivery price of bread wheat; AMI, 2011) and the USA (average elevator prices of hard red winter wheat of East Central Colorado of the USA; USDA 2011), two countries that had no active government intervention in grain export activities during the two food price crisis periods, against their corresponding international wheat prices for comparison. Similar to Ukraine, we choose the French soft wheat price (class 1, FOB, Rouen; HCGA, 2011) as the relevant international wheat price for Germany. We use the FOB price of hard red winter wheat at the USA Gulf port (HGCA, 2011) as the relevant world market price relevant for the USA. The depicted price relationships lead us to suspect a regime-switching pattern between the Ukrainian and international wheat prices. When the international wheat price is low (<200 USD), the correlation coefficient of Ukraine's wheat price with respect to the international price amounts to about 0.7; when the international wheat price is high (>200 USD), this correlation coefficient is about 0.5 (with a significance level of 0.01 in both cases). However, we do not observe such switching behaviour for Germany and the USA.

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

EFFECTS OF WHEAT EXPORT RESTRICTIONS ON DOMESTIC MARKETS IN RUSSIA AND UKRAINE DURING THE FOOD CRISIS

Linde Götz[a], Thomas Glauben[a] and Bernhard Brümmer[b]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany, [b] Georg-August University of Göttingen, Göttingen, Germany.

Abstract

Studies investigating the effects of wheat export controls on the domestic market in the exporting country itself are scarce. This paper quantitatively investigates the domestic market impact of wheat export controls in Russia and Ukraine during the 2007/2008 global food crisis. We investigate the effects of the export controls on the relationship between the world market and the local farmers' price within a price transmission approach. Using a Markov-switching vector error-correction model, we contrast our estimation for Russia and Ukraine with Germany and the USA, two countries that did not intervene in their wheat export markets. An explicit "crisis" regime during times of export controls is exclusively identified for Russia and Ukraine. We find that export restrictions temporarily reduced the degree of integration of Russian and Ukrainian domestic markets in world wheat markets, which pushed the growers' prices below their long-run equilibrium level. Further, domestic markets were disconnected from their equilibrium and market instability increased. These effects were even more pronounced and long lasting in Ukraine, where wheat exports were controlled by an export quota, as compared to Russia, which used an export tax. The negative market effects discouraged private investors, thereby preventing Russia and Ukraine from maximizing their grain potential and contributing to global food security.

1 Introduction

Many governments have intervened in the agricultural export markets during the world market price peaks in 2007/2008 and 2010/2011. In the case of wheat, 15 countries restricted exports in 2007/2008, including such large wheat exporters as Argentina, Kazakhstan, Russia, and Ukraine (Mitra and Josling 2009).

Russia and Ukraine justified restrictions on wheat exports with the officially stated aim to reduce exports that were induced by the extraordinarily high world market prices in order to secure sufficient wheat supplies in the domestic markets. In particular, Russia implemented export taxes for wheat in 2007/2008, and, in light of an extremely small wheat crop, completely banned wheat exports in 2010/2011. In Ukraine, wheat export quotas were introduced within a governmental license system during both price peaks. The purpose of this paper is to quantify the impact of Russia's and Ukraine's grain export controls on their domestic wheat markets within a price transmission model.

Essentially, export restrictions of large exporting countries have a negative impact on food security in two ways (see Mitra and Josling, 2009 and Sharma, 2011 for an overview). First, there is a direct effect on world market supplies through the restrictions of the export limiting country. In phases of high international prices, the world market price increases further, with amplified effects on the food security of the poor in net wheat importing countries. The second consequence is an indirect effect on the domestic market of the export restricting country. By hindering or even banning exports to the world market, supply on the domestic market increases which reduces the domestic market price and increases the difference between the world and domestic market price. This reduces production and investment incentives of the domestic market, and, in the longer term, hinders agricultural development. This effect will be amplified if the restrictions are introduced and managed in a discretionary and non-transparent way, leading to increased uncertainty and instability for farmers and investors in the affected country. The latter effect is of particular importance in the case of Russia and Ukraine since they have large grain production potentials due to fertile soils and high availability of land.

Russia's and Ukraine's wheat production initially decreased after the transformation from plan to market in the nineties. Declines were seen in both acreage used for wheat production and in yields. The impressive supply response after the food price crisis of 2007/2008 highlighted the role of these two countries in global wheat production, with substantial exports of wheat contributing to global food security (FAO/EBRD, 2008).[1] It is generally expected (e.g. Liefert et al., 2010) that Russia and Ukraine will further increase their role as major wheat exporters. By 2019, the share of the whole region (including Kazakhstan) in global wheat trade could amount to almost 40%, equivalent to more than 50 million t. This makes the analysis of the impact of export restrictions for wheat a particularly relevant topic.

[1] For Russia, the additional land potential is estimated to amount to 6 million ha, according to FAO/EBRD (2008). The additional land potential for Ukraine is estimated to amount at a maximum of 10 million ha by USDA (2008) and 3 million ha by FAO/EBRD (2008). Wheat yields in Russia are expected (FAO/EBRD, 2008) to increase from 2.1 t/ha (2008/2009) to a yield level similar to that of Canada (2.3 t/ha), and in Ukraine from 2.8 t/ha to a yield level similar to France (6.3 t/ha).

The impact of export restrictions on world market prices during the recent price peaks has received substantial attention in the literature (e.g., Martin and Anderson, 2011; Yu et al. 2011). However, the literature on the effects of export restrictions on domestic markets in the export restricting country is relatively scarce. Exceptions are World Bank (2008), von Cramon and Raiser (2006), Brümmer et al. (2009), Djuric et al. (2011), and Ihle et al. (2009). We review the key results from these studies in more detail below.

This paper is unique in various aspects. First, we quantitatively assess the domestic market effects of the temporary restriction of wheat exports in Russia and Ukraine by studying the impact of the export controls on the relationship between the world market and the local farmers' prices. We choose a price transmission approach (Fackler and Goodwin, 2001) as our model framework and evaluate the model results with regard to the integration of the local into the world wheat markets, the equilibrium between the local and the world markets, and the price stability of the local markets. Germany and the USA, two countries which did not intervene in their grain export markets during the food crisis, are included as two reference cases in our analysis to facilitate the correct identification of these effects. The study is based on weekly wheat grower price data for Russia, Ukraine, Germany, and the USA and world price data from January 2005 to May 2009.

Second, given the heterogeneity of world market conditions and domestic policies over the sample period, the model for analyzing price transmission between domestic and international markets should capture changes between a number of regimes governing the market integration processes at a given point in time. We use a Markov switching vector error-correction model (MSVECM), which makes it possible to identify a possible change in the price transmission regime during the food crisis and therefore enables us to capture the impact of the export controls. To the best of our knowledge, none of the studies on world market price transmission covering the food crisis (e.g., Cudjoe et al. (2010) and Dawe (2008) allows for a possible change in the price transmission regime.

2 Literature Review

As mentioned above, only few studies investigate the domestic market effects of temporary wheat export controls in the exporting country itself. The World Bank (2008) estimates that foregone farm revenues due to export quotas in Ukraine amount to 1.6 billion US$ in 2007/2008 in the case of wheat. It is noted that the milling industry took advantage of the situation on wheat markets and increased the wheat-flour margin with the export quota system. Von Cramon and Raiser (2006) investigate the Ukrainian wheat export quota introduced in September 2006. They find that the export quota is a costly tax on producers and investors in the agricultural sector that may have increased poverty while benefitting only millers and feed producers. Brümmer et al. (2009) investigate the influence of an unstable policy environment on vertical price transmission between wheat and wheat flour within Ukraine (2000-2004). Using a MSVECM, they identify changes in the market regime which govern the relationship between wheat and wheat flour prices, whose timing coincides with political and economic events in Ukraine, inter alia a regional trade ban within Ukraine and a de facto export ban. Our study is different because it explicitly captures the market effects of the export restrictions on the transmission of world wheat market prices. Djuric et al. (2011) analyze how a de facto export ban and large domestic buy-outs of the Serbian government during the food crisis 2007/2008, have affected the domestic wheat market. Results of a MSECM price transmission approach suggest that, although the long-run price elasticity did not change during the crisis, the market equilibrium was disrupted and the market stability was reduced. Further, the export restrictions were effective only during a short time period since the Serbian wheat grower prices even increased above the world market level during the export ban. The study by Ihle et al. (2009) analyzes spatial price transmission on the maize market between Tanzania and Kenya (2000-2008); it covers three periods in which export bans were in effect in Tanzania. The results of a Markov switching vector autoregressive model framework (MS-VAR) specify two differing price transmission regimes and divide the sample period into a sequence of distinct regime episodes. The “high” margin regime (in contrast to the “low” margin regime) corresponds well with the known periods of export bans; however, additional high-margin episodes are identified during which no export bans were known to have been in effect.

Several studies focus on spatial price transmission between international and domestic markets during the food crisis 2007/2008, mainly to assess the poverty and welfare effects of the food crisis in developing countries. For example, Cudjoe et al. (2009) analyze price transmission between global, national, and regional markets in Ghana to assess the welfare impacts of the 2007/2008 food crisis. The results of a threshold vector error correction model suggest that the degree to which price changes in world markets are passed on to regional markets within Ghana depends on the pattern of price transmission between local markets. Thus, world market price transmission varies for different food crops and different regional markets, ranging between 40% and 100%. Dawe (2008) analyzes the pass through of price increases from the world market to domestic markets for seven large Asian countries. The study finds domestic rice prices increasing by an average of one-third of the increase observed in world market prices in countries which stabilized domestic prices relative to world market prices by commodity-specific policies.

A further strand of literature investigates world market price transmission for wheat markets in general. The study by Goychuk and Meyers (2011) is the only one which investigates the current integration of wheat markets in Russia and Ukraine with world wheat markets. It is based on monthly FOB wheat prices of Russia and Ukraine as well as USA, Canada and France (2004-2010). Using the Johansen maximum likelihood cointegration test, they find the Russian (but not the Ukrainian) and the French wheat prices to be cointegrated. Significant long-run and short-run price transmission is identified within an error correction model. The study by Goodwin and Grennes (1998) investigates wheat market integration of Tsarist Russia with world markets, accounting for trade costs by implementing a threshold model. Other studies on market integration in Russia investigate regional food markets using end consumer prices (e.g. Berkowitz et al., 1998; Gardner et al., 1994; Gluschenko, 2010; Goodwin et al., 1999; Loy and Wehrheim, 1999); they focus mainly on the impact of the economic reforms during transition on regional market integration within Russia.

A further study on world wheat market integration is Goshray (2002) investigating price transmission in international wheat markets of five countries (Argentina, Australia, Canada, the EU, and the USA) regarding asymmetry using threshold autoregressive (TAR) and momentum threshold autoregressive (M-TAR) models. World wheat markets are found to be highly integrated, with only slight evidence of asymmetry. In cases in which price transmission is identified as asymmetric, the author traces this back to differences in wheat quality.

Thompson et al. (2002) investigate how liberalizing reforms of the EU common agricultural policy (CAP) affect the degree of price transmission between the wheat markets in France, Germany, and the UK. Major policy reforms of the EU's CAP were implemented during this period, with the explicit objective to re-couple EU markets to international price signals. The authors find that the speed of adjustment to the long-run equilibrium and thus world market integration increased during this period.

Barassi and Ghoshray (2007) analyze the long-run price relationship between wheat exports of the USA and the EU from 1981 until 2000. This relationship might have changed due to the implementation of the reform of the EU common agricultural policy (CAP) in 1992, which lowered price support by the EU to levels closer to USA prices. Their results provide evidence for a long-run equilibrium (cointegration) relationship between wheat export prices of the USA and the EU, but only in the time period after the CAP reform, but not before. This implies that the CAP reform has led to more integrated wheat markets between the USA and the EU.

World wheat market price transmission is also analyzed by Imai et al. (2008), who investigate the extent to which price changes on the agricultural world markets were transmitted to domestic prices in India and China. They find that transmission is incomplete due to governmental market interventions, which hinder spatial arbitrage.

3 Wheat Market Interventions in Russia and Ukraine

The recent food price peaks triggered policy interventions in many countries, including trade restrictions in several grain exporting countries. Russia and Ukraine restricted their grain exports with the officially stated goal of mitigating the increase in domestic wheat and bread prices. Grain export market restrictions are a typical feature of grain policy in Russia and Ukraine. The restriction of wheat outflows from producing regions was a distinctive feature of the grain market policy in Russia and Ukraine during transition (Liefert and Liefert, 2008; Brümmer et al., 2009). In both countries, grain production and consumption underwent drastic changes during the transition period. In the former Soviet Union, grain production had been heavily subsidized to keep bread prices low and increase livestock production by providing feedstock to the then rather inefficient livestock industries. For the whole Soviet Union, consumption was well above production of wheat so that the block was consistently a net importer of wheat.

With transition, both consumption and production of grain in Russia tumbled because of the drastic reduction of grain for the livestock industries. Still, Russia remained a net importer of wheat throughout the nineties, albeit at a reduced level. In the past decade, Russia's net trade position in wheat switched to that of a net exporter, with annual exports coming close to 20 million tons at its peak. Ukraine, on the other hand, one of Europe's traditional 'bread-baskets,' was exporting wheat before the transition, and has consistently remained a net exporter over the past two decades. However, the instability of production in Ukraine seems to have increased over time so that even Ukraine became an occasional net importer of wheat (most notably in the marketing year 2003/2004). In 2008/2009, Russia ranked second with wheat net exports amounting to 18.2 million tons, corresponding to 13.1% of world wheat exports. Ukraine ranked sixth, with wheat net exports of 12.9 million tons and a 9.3% share in world wheat exports (USDA PSD online, 2010). These drastic structural changes put grain, and particularly wheat, markets in the focus of agricultural policy. Both countries share a long (and mixed) history of policy interventions in this area.

Thus, it is not surprising that Russia and Ukraine also interfered in their wheat export markets during the recent food price peaks on world markets. Russia implemented export taxes for wheat in 2007/2008, whereas wheat and wheat flour exports were completely banned in 2010/2011. In Ukraine, wheat export quotas were introduced within a governmental license system[2]. In contrast, wheat exports did not receive special policy interventions during the food price peaks of 2007/2008 and 2010/2011 in Germany and the USA, which serve as a reference case in our analysis.

An export tax makes exports less profitable and lowers domestic prices, depending on the size of the tax, which may be in specific or ad valorem form. An export tax can become even prohibitive if the level of the tax is set so high that exports become unprofitable. An export quota quantitatively limits exports to the size of the quota. For an export quota to be effective it needs to be binding, meaning that export demand exceeds the size of the quota. Under an export ban, exports are simply forbidden such that no quantity of the respective product is exported (for more details see Sharma, 2011; Mitra and Josling, 2009).

In the following, the governmental wheat export market interventions in Russia and Ukraine during the price peak in 2007/2008 are described in detail (APK Inform, 2010). Russia initially implemented export taxes at 10% in November 2007; they were increased to a prohibitive level of 40% in December 2007 and maintained until May 2008. The export restrictions were announced early and the initial export taxes of 10% introduced in November 2007 were to be effective until April 2008. However, export taxes were increased to 40% in December 2007. In February 2008, the government announced that the export taxes would be extended for additional three months, until July 2008. Wheat exports to other CIS countries (e.g., Kazakhstan and Belarus) were prohibited in April 2008. Export taxes finally were removed in July 2008.

Ukraine established export quotas varying between 3,000 tons and 1.2 million tons from October 2006 until May 2008. For about 12 months, the wheat export quota was as low as 3,000 tons. License-based export quotas for wheat were announced at the beginning of October 2006 and were set at 400,000 tons in the middle of October for November and December 2006.

[2] Export restrictions were the most important policy measures on wheat markets in Russia and Ukraine during the food crisis of 2007/2008 (World Bank, 2008). We assume that additional policy measures such as temporary intervention purchases in Russia, the provision of food aid in Ukraine, and the control of the consumer price for wheat and flour by fixing the trade margin in both countries had a minor if any effect on the wheat grower price in both countries.

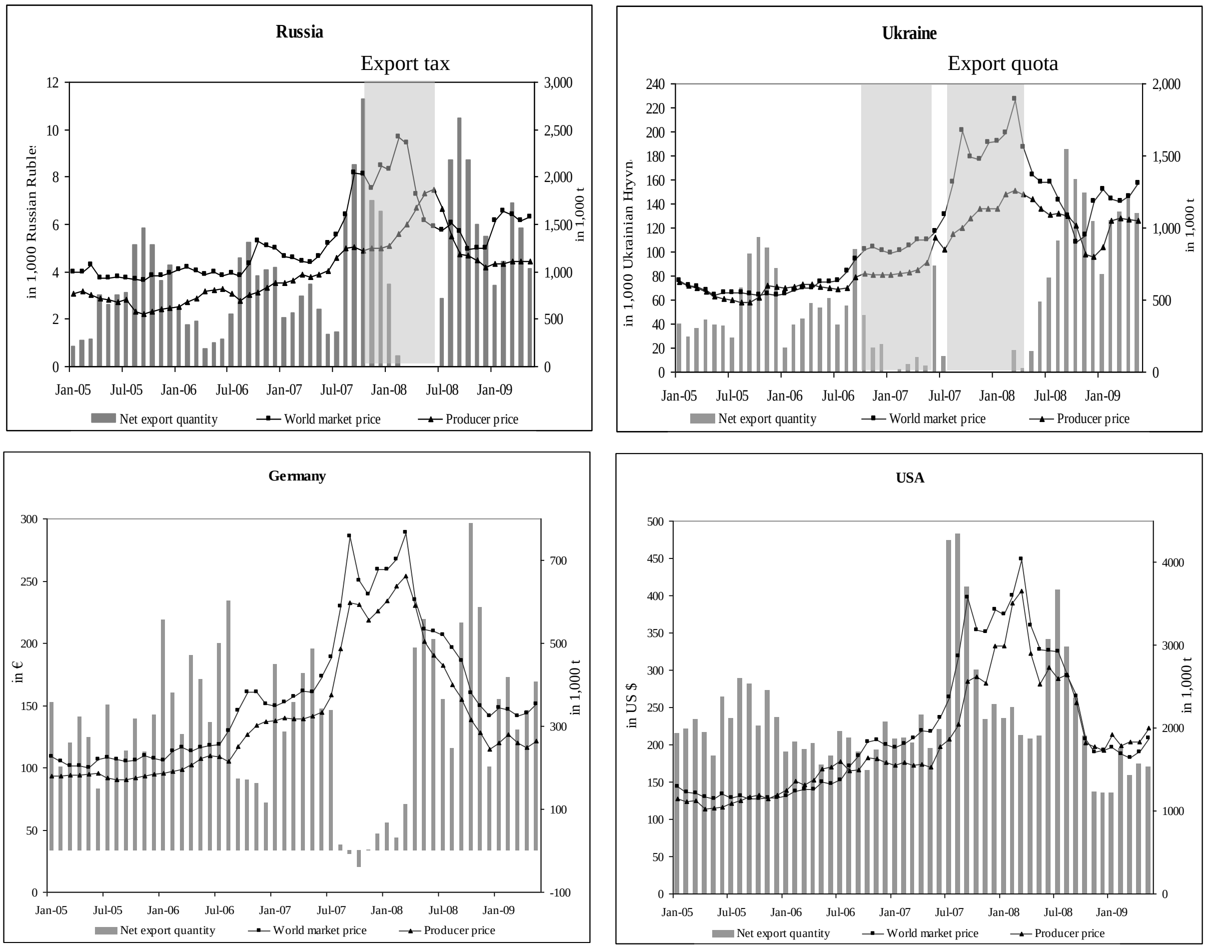
However, in December 2006 the size of the export quota was reduced to the prohibitive level of 3,000 tons, valid for the period from January 2007 until July of that year. In February 2007, the government announced a significant increase of the quota to 230,000 t; however, this increase was not realized. The export quota was abandoned in May 2007; thus, wheat could be exported without restrictions. In light of an intense drought which affected about 60% of the Ukrainian wheat fields, a prohibitive export quota of 3,000 t was reintroduced in July 2007, which was effective until September 2007. An expansion of the export quota by 200,000 tons was announced in September 2007, but not realized until March/April 2008, when the export quota was increased by 1 million tons. In May 2008 - about 2 months earlier than in Russia - the export restrictions were finally removed in light of an expected extraordinarily large harvest.

4 Wheat Prices and Exports during the Food Crisis

Figure 1 illustrates the development of the monthly net wheat export quantities and producer prices for Russia (Figure 1a) and Ukraine (Figure 1b) and wheat world market prices from 2005 - May 2009. Shaded areas are overlaid for the period during which the export restrictions were in force. We compare the data for Russia and Ukraine to analogous data for Germany and the USA, two countries that did not intervene in their wheat export markets during the food crisis (Figures 1c and 1d).

The 10% export taxes implemented in November 2007 in Russia reduced wheat exports significantly and effectively prohibited any further wheat exports after the export taxes were increased to 40% in December 2007. Substantial net wheat exports were observed again in July 2008, when the export taxes were abolished. The export quota in Ukraine also reduced wheat exports, which were practically banned by the reduction of the export quota to 3,000 tons, valid from January 2007 to May 2007 and again from July 2007 to June 2008 (altogether 16 months). Although Germany and the USA did not intervene in their wheat export markets, significant changes in the wheat export quantity during the food crisis can be observed. When wheat world market prices peaked, Germany's net wheat exports shrank dramatically to almost zero and even became negative from August 2007 until the end of April 2008. This was caused by an extremely small wheat harvest in Germany. In contrast, the USA's net wheat exports did not drop during the food crisis. Instead, two net export peaks in the USA can be observed, lasting from July 2007 to October 2007 and from June 2008 to September 2008.

Figure 1: Development of World Market Price, Producer Price, and Exports of Wheat for Russia, Ukraine, Germany, and the USA



The difference between the world wheat market price and the grower price in Russia and Ukraine increased when the export restrictions were in place. The wheat growers' price did not completely follow the upward trend in the wheat world market price, and the price difference increased[3] from August 2007 to March 2008 in Russia and from August 2006 to March 2008 in Ukraine. The price difference started to decrease when export restrictions were still valid, but a bumper harvest and thus the removal of the export restrictions were expected by the market participants. Even so, in Russia the grower price increased beyond the world market price from May 2008 to July 2008. In contrast, a substantially increased price difference between the world market price and the grower price during the food crisis cannot be observed for Germany and the USA.

[3] It is interesting to note that the price difference started to increase even before the export restrictions were implemented in both countries. This might be attributed to the exertion of market power by the wheat traders vis-à-vis the growers. In any case, the margin increased further when the export restrictions became effective.

5 Methodological Approach and Data

We investigate the impact of the wheat export controls on the domestic markets in Russia and Ukraine by quantitatively estimating the influence of the export controls on the relationship between the world market and the local farmers' prices. The analysis is conducted within a non-linear price transmission approach to capture the impact of the export controls on this price relationship. We use a Markov switching, vector error-correction model (MSVECM), which is related to the Markov switching vector autoregression framework developed by Hamilton (1989). A MSVECM was introduced by Krolzig et al. (2002) to analyze business cycles, and was recently used for the analysis of price transmission by Brümmer et al. (2009). An MSVECM is a special case of a general regime switching model, which can be applied to price transmission analysis when several price transmission regimes govern the market, and the timings of the regime changes (i.e., changes in the state of the market) are unknown. This is an advantage in comparison to the linear error correction model, which is adequate only when parameter constancy is a reasonable assumption (i.e., when the market is characterized by only one price transmission regime). For Russia and Ukraine, we hypothesize that more than one price transmission regimes is observed during the period of this analysis, with timings of the regime switches which are not generally known a priori. Even if the presence of export interventions can be observed, the timing of the regime switches may be unobservable since regime switches may be caused by reasons other than export controls. For example significant changes in trade are observed for Germany and the USA even in the absence of export controls. Furthermore, regime switches may be induced by the announcement (or even rumors) of a change in the export control, even if the change is yet to be implemented.

The state variable indicates the prevailing regime at a given point in time. Since this state variable is unobserved, a stochastic process for the state variables needs to be assumed. In the case of the MSVECM, one assumes that the data generating process underlying the state variable follows a Markov chain, which is governed by constant transition probabilities (i.e., the state of the market of tomorrow is determined only by the state of the market of today). Equation (1) shows the notation of a general unrestricted MSVECM, with regime-dependent behavior in all short-run parameters, including the intercept.

$$\Delta p_t = v(s_t) + \alpha(s_t)(\beta(s_t)' p_{t-1}) + \sum_{i=1}^{k} A_i(s_t)\Delta p_{t-i} + u_t \qquad (1)$$

where p_t denotes a vector of wheat prices, v is the vector of intercept terms, α is the vector of the speed of adjustment coefficients, and β is the long-run cointegrating vector. The A_i are matrices containing the short-run parameters of the system, capturing the autoregressive part of price movements. The error terms u_t fulfill the usual properties (i.e., zero mean and constant variance); however, their variance can also vary between the regimes.

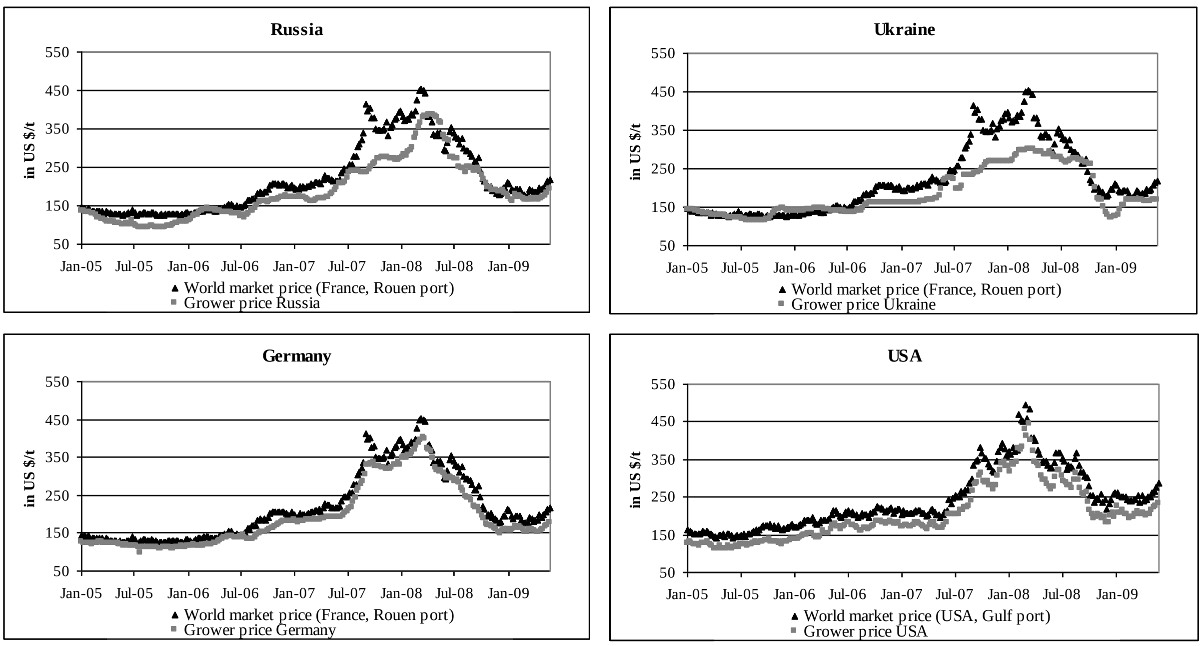
s_t is the (unobserved) state variable, which in our case takes the values s_t=1, 2, or 3 (at most), indicating the regime in which the system is. The probability of being in state s in period t might depend on the full history for all variables. However, the simplifying Markov assumption (2) is made in estimating the MSVECM:

$$\Pr(s_t \mid S_{t-i}, \Delta p_{t-1}, \beta' p_{t-1}) = \Pr(s_t \mid s_{t-1,} \Pi) \tag{2}$$

where the square matrix Π contains the (row-wise) probabilities [π_{ij}] for switching from the regime in row i to the regime in column j, conditioned on the regime in the previous period.

The parameters of a MSVECM are estimated by maximizing the likelihood function with the expectation-maximization algorithm (Krolzig, 1997). The parameters characterizing the unobserved state variable and the probability of a change of one regime to another regime (transition probability) are first estimated, based on starting values for the parameters to be estimated. In the next step, the starting values are updated based on the parameters estimated in the first step within an iterative procedure. This procedure is stopped when the parameter estimates of two consecutive estimations do not differ significantly.

Figure 2: Price Pairs Analyzed Concerning Price Transmission



We use 230 weekly observations for the world market price and the grower prices from week 1 (January) in 2005 to week 22 (May) in 2009 for Russia, Ukraine, Germany, and the USA (Figure 2). Grower prices are measured as ex warehouse prices of milling wheat of class III of the Southern District of Russia[4] and Ukraine (APK-Inform, 2009), average warehouse delivery price of bread wheat of Germany (AMI 2009), and average elevator prices of hard red winter wheat[5] of East Central Colorado of the USA (USDA, 2009), respectively. We use the FOB price of wheat (classification "other wheats") in Rouen, France (HGCA 2009) as the relevant world market price for Russia, Ukraine, and Germany[6]. We use the FOB price of hard red winter wheat at the USA Gulf port (HGCA 2009) as the relevant world market price for the USA. All prices are absolute prices and are converted by weekly exchange rates into US $/t. The occasional missing values[7] are proxied using multiple imputation procedures that are based on the program Amelia II (Honaker et al. 2009) in R[8].

6 Empirical Results

Subsequent to explaining the estimation strategy, the regime classification and model parameter estimated are presented.

6.1 Estimation strategy

Prior to the model estimation we conduct the ADF stationarity test and the Johansen cointegration test. The test results indicate that the four data series are I(1) and that the four

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4 The Southern District of Russia is the only major grain producing district of Russia that is directly adjacent to the Black Sea. The Southern District has two large ports (Novorossiysk and Tuapse) through which the vast majority of Russia's grain exports by sea is handled (APK Inform, 2010). Due to the proximity to the ports, we assume that wheat markets/prices are less influenced by high transport and transaction costs resulting from poor infrastructure and insufficient market price information (Liefert and Liefert, 2008) than in more isolated regions. Thus, we expect that the influence of the export ban on the domestic wheat market and changes in world market price transmission might more easily be identified on wheat markets in the Southern District than in one of the other major grain producing districts (Central, Volga, and Siberian District), which are more distant to the ports.

5 Hard red winter wheat is the primary type of wheat that is exported by the USA (Beuerlein, 2010).

6 EU wheat is exported to the world market primarily via this harbor. A time series of market prices at a Black Sea harbor, or alternatively, wheat export prices for Russia or the Ukraine were not available for the time period under consideration, simply because exports were banned temporarily by the export restrictions during the 2007/2008 food crisis.

7 The number of missing values is 34 for the FOB Rouen price, 13 for the FOB Gulf price, 8 for the wheat grower prices in Germany, and 25 for the wheat grower prices in the USA. The series for the grower prices in Russia and Ukraine are complete.

8 Amelia II performs multiple imputations with the Expectation Maximization Bayesian algorithm. Several values are calculated for each missing value in the data set. The missing values in the dataset are filled in with estimates retrieved from different imputations that reflect the uncertainty about the missing data (Honaker et al., 2009).

price pairs are cointegrated[9]. The differences in the log-likelihood function values between the preferred Markov switching model and the linear VECM indicate that the non-linear MS(V)ECM is superior to the linear model for all four models. The significance level for the conventional LR test against the corresponding χ^2 distribution[10] is less than 1%, and the upper bound for this significance level according to Davies (1987) also is less than 1% (see Chi^2 value given in Table 1).

The MS(V)ECM is estimated in its unrestricted form (Stock and Watson 1993; Pesaran and Shin 1999), which is more flexible than the restricted model framework. It allows that both the short-run price transmission parameters and the parameters specifying the long-run equilibrium, in particular the long-run price transmission, might have changed in the time period underlying this analysis. The parameters characterizing the long-run equilibrium are not estimated directly but can be retrieved indirectly from the parameters of the MS(V)ECM, and their statistical significance is determined by the delta-method (Greene 2003:70).

The MS(V)ECM is estimated with varying numbers of regimes and lags, as well as with variations regarding the Markov switching in the intercept, the short-run price transmission, the autoregressive parameters, and the error variances. The optimal model specification is selected according to the Schwarz model selection criteria. For Ukraine, three regimes are identified, while for Germany and the USA a specification with two regimes is preferred. For Russia, the Schwarz criterion indicates marginal superiority of the specification with two regimes over the one with three regimes. Since the difference is close to zero, we look at further information criteria. Both the Akaike (AIC) and the Hannan and Quinn (HQ) criteria suggest a specification with three regimes (Table 1). Since this specification also exhibits a much more robust behavior with regard to changes in the lag specification, we chose the three-regime model for Russia.

If high contemporaneous correlation (correlation coefficient >0.5) between the residuals of any two equations of the VECM endangers the efficiency of our estimates, we test for weak exogeneity of the world market price in the system. If the null hypothesis of weak exogeneity cannot be rejected, we estimate a univariate MSECM which depicts contemporaneous price transmission in the model. We find high contemporaneous correlation and weak exogeneity[11]

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9 Full test results for this preliminary analysis are omitted from the paper and are available from the authors upon request.

10 The conventional LR-Test is not admissible in the presence of nuisance parameters, i.e., parameters which are not identified under the null. In the context of MS models, the transition probabilities are nuisance parameters. Davies (1987) gives an upper bound for the significance level of the conventional LR test

11 The error probabilities of rejecting the respective hypothesis within an LR-test are 0.571 for Russia, 0.284 for Germany, and 0.901 for the USA.

of the respective world market price in the models for Russia, Germany, and the USA. Thus, an MSECM is estimated for these three cases, whereas an MSVECM is estimated for Ukraine.

We find the MSIAH to be the optimal type of the MS(V)ECM which allows the intercept (I), the short-run price transmission, the autoregressive parameters (A), and the variances/heterogeneity (H) to switch between the regimes. The residuals of the selected models are free from autocorrelation, non-normality, and heterogeneity with the exception of the model for Ukraine, for which we observe non-normality (p-value<0.01).

6.2 Regime classification and transition parameters

As explained above, our preferred model consists of three different states of market integration and thus three different price transmission regimes for Ukraine and Russia, and two for Germany and the USA. Figure 3 presents the smoothed regime probabilities, varying between 0 and 1. These smoothed probabilities take into account the full sample information. Each observation corresponds to a particular week, e.g. observation number 155 corresponds to week 50 in 2007. Thus, Figure 3 indicates the probability of the most likely regime to which one observation is attributed. The corresponding transition probabilities, i.e. the probability that one regime switches to another regime, are presented in Table 1.

As a general result, our analysis demonstrates that domestic wheat markets in Russia and Ukraine were characterized not only by a higher number of different states of market integration than in Germany (three states) and the USA (two states), but also by a significantly higher number of switches between the regimes. These can be interpreted as clear signs of higher market and price instability. Figure 3 makes evident that the regime switches in Russia were particularly frequent when the export tax was applied (November 2007 - July 2008), and in Ukraine when the export quota was effective (July 2007 - May 2008). Fewer regime switches are observed between October 2006 and May 2007, when the export quota system was also effective.

A “standard” regime of 134 observations (Table 1) is observed for Russia, which occurs throughout the entire period underlying this analysis (Figure 3a). This “standard” regime is supplemented by the “crisis” regime (66 observations) in June 2007, directly before Russia’s wheat exports increased but when the export tax was not yet established. The “crisis” regime is observed when the export tax is effective and also after its removal. In addition, a third regime ("post-crisis[12]") comprising 22 observations occurs most often after the cancellation of the export tax.

Similarly, a "standard" regime comprised of 173 observations is observed for Ukraine, which remains the dominant regime almost throughout the whole time period underlying the analysis (Figure 3b). This regime is supplemented by a second regime ("crisis") of 35 observations occurring at several points in time when the export quotas were effective (July to September 2007; February to March 2008), as well as when they were temporarily banned (May and June 2007). This regime ("crisis" regime) also occurs at some points in time in the aftermath of the crisis (after July 2008), when the export controls had been abolished (January and February 2009). The third regime ("post-crisis") predominantly occurs in the aftermath of the food crisis starting in October 2008.

In contrast, our model distinguishes two price transmission regimes for Germany (Figure 3c) and the USA (Figure 3d). The "standard" price transmission regime is dominant in the period before the food crisis unfolds, comprising 134 and 187 observations for Germany and USA, respectively. For Germany, a regime switch is observed in mid July 2007, when wheat world market prices skyrocketed and Germany's wheat net wheat exports dropped to almost zero, which we label as the "crisis/post-crisis" regime. When Germany's net wheat exports increased again at the end of April 2008, the price transmission regime switched back to the "standard" regime. However, after a few weeks the price transmission regime switched back to the "crisis/post-crisis" regime, which remains the dominant price transmission regime even in the aftermath of the food crisis until the end of May 2009. For the USA the "standard" regime switches to another price transmission regime ("crisis/post-crisis" regime) from the beginning of December 2007 until the end of April 2008, and again from the end of October 2008 until the middle of February 2009. These two regime switches occur directly in the aftermath of the USA's wheat export spikes lasting from July to October 2007 and from June to July 2008.

12 The label "post-crisis" refers to the fact that this regime is most frequently observed in the time after the crisis, not that this regime is immediately succeeding the "crisis" regime.

Figure 3: Regime Classification for a) Russia, b) Ukraine, c) Germany, and d) USA

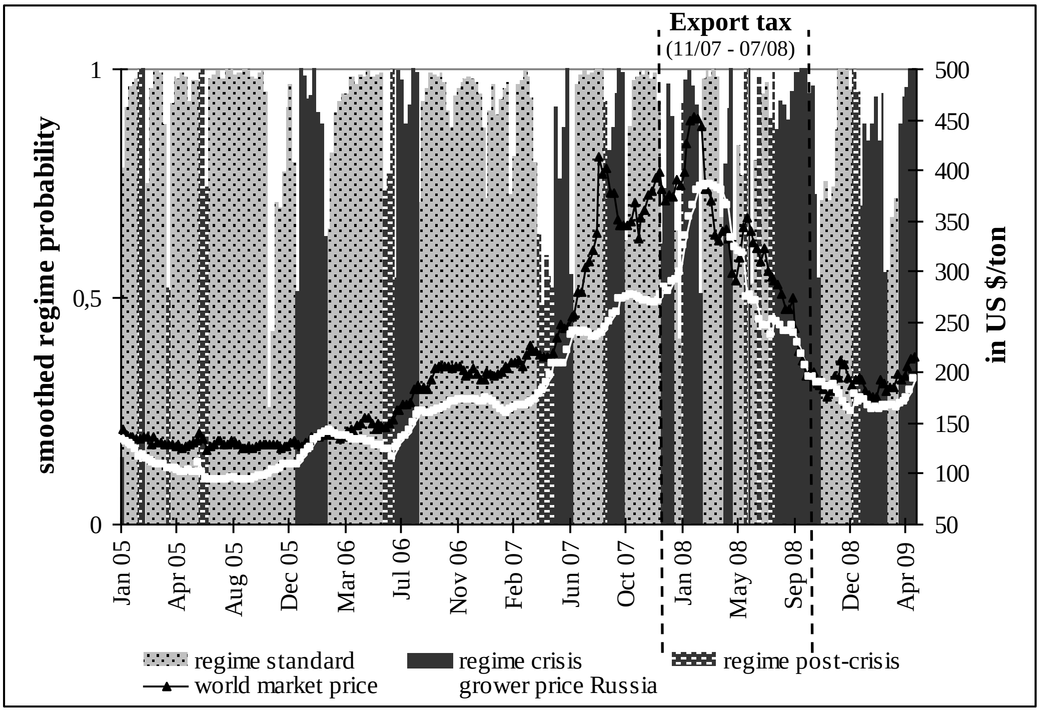


Figure 3a: Russia

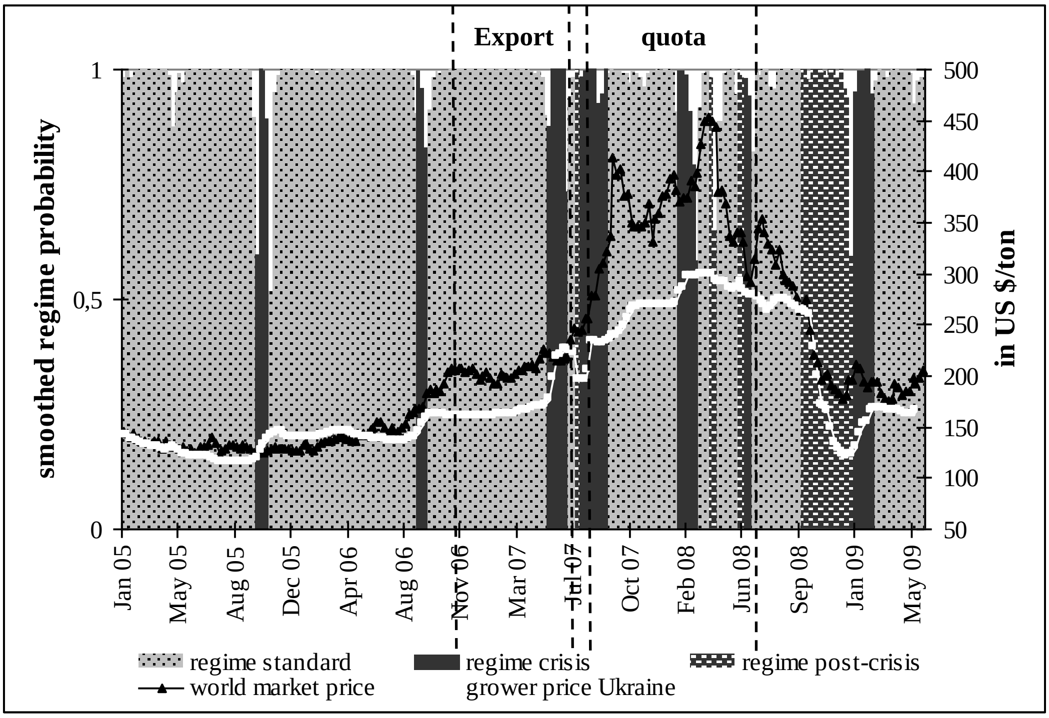


Figure 3b: Ukraine

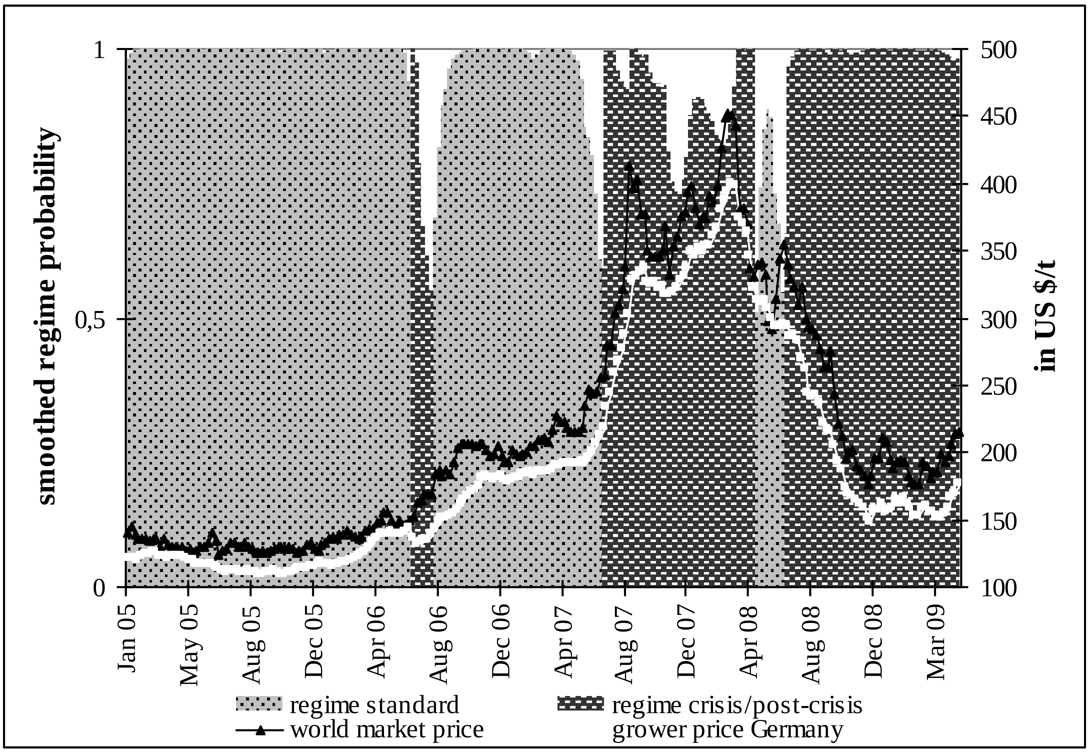


Figure 3c: Germany

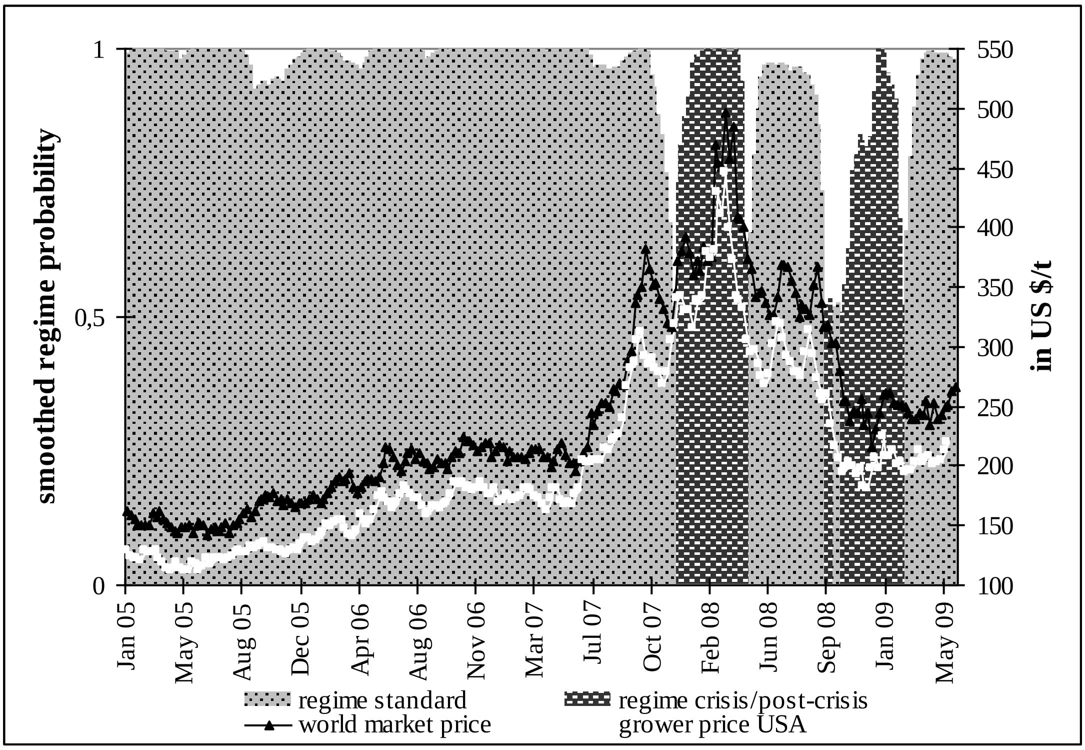


Figure 3d: USA

Table 1: Transition Probabilities

	From regime	To regime		
		„standard“	„crisis“	„post-crisis“
Russia	**„standard“**	0.868	0.042	0.091
	„crisis“	0.184	0.795	0.021
	„post-crisis“	0.194	0.402	0.404
Ukraine	**„standard“**	0.949	0.026	0.025
	„crisis“	0.22	0.78	1.53E-05
	„post-crisis“	0.063	0.159	0.777
		„standard“	**„crisis/post-crisis“**	
Germany	**„standard“**	0.973	0.027	
	„crisis/post-crisis“	0.029	0.971	
USA	**„standard“**	0.986	0.014	
	„crisis/post-crisis“	0.066	0.934	

The estimated transition probabilities generally indicate a relatively high degree of persistence for the standard regimes in all four countries. The lowest value for staying in the standard regime is observed for Russia (0.87), and the highest for the USA (0.99). For both USA and Germany, i.e., those countries which did not impose export restrictions, we find generally high regime persistence for the second regime, too. This looks different for the case of Russia and Ukraine. Here, the crisis regime still has a substantial probability to persist (0.80 and 0.78 for Russia and Ukraine, respectively). However, in both cases we also find a substantial probability of about 20 per cent for a regime change to the standard regime. The post-crisis regime in Russia is least persistent. The most likely successor is the crisis regime, with 40 per cent probability. In Ukraine, the regime sequencing is similar. However, we find a much higher persistence of the post-crisis regime, possibly affected by the much more extended period over which the trade restrictions were in place.

6.3 Model parameter estimates

The regime-specific model parameters and some additional regime characteristics are presented in Table 1. We present these results in three major categories: integration, equilibrium, and stability.

Market integration

The degree of integration of the domestic markets in the world market is characterized by the parameters of the long-run equilibrium, the contemporaneous price transmission, and the speed of adjustment[13]. With regard to the long-run price transmission, we find for Russia and Ukraine that the long-run price transmission elasticity was reduced by 10% and 41%, respectively, in the "crisis" regime when compared to the "standard" regime. In the "post-crisis" regime, long-run price transmission strengthened slightly by 1% (compared to the "standard" regime) for Russia but was still weaker than the "standard" regime by 4% for Ukraine. Our results suggest that the long-run price transmission weakened in the "crisis/post-crisis" regime for Germany and the USA, by 9% and 8%, respectively. We identify highly significant contemporaneous price transmission in all model regimes for Russia, Germany, and the USA. It is striking that the contemporaneous price transmission is higher in the "crisis" regime than in the "pre-crisis" regime and is highest in the "post-crisis" and "crisis/post-crisis" regime in all three cases.

The speed of adjustment of deviations from the long-run equilibrium accelerated in the "crisis" regime compared to the "standard" regime for Russia (218%) and Ukraine (225%), and increased even further in the "post-crisis" regime to a level of 918% and 479% of the speed of adjustment observed in the "standard" regime, respectively. The speed of adjustment even increased for Germany (255%) and the USA (258%), though to a lower degree than for Russia and Ukraine. In general, it can be observed that the speed of adjustment is lowest in Ukraine and highest in the USA in the different regimes, indicating that world market integration is strongest in the USA and weakest in Ukraine.

[13] The speed of adjustment is the speed with which deviations from the long-run equilibrium between the grower and the world market price are corrected by price adjustments of the grower price.

Table 2: Main Estimates of the MS(V)ECM

	Russia (South District)			Ukraine			Germany		USA (Colorado)	
	standard	crisis	post-crisis	standard	crisis	post-crisis	standard	crisis/post-crisis	standard	crisis/post-crisis
MS(V)ECM specif.	MS(3)ECM(2)			MS(3)VECM(1)			MS(2)ECM(1)		MS(2)ECM(1)	
LR-linearity test	156.896***			309.944***			73.176***		48.743***	
Nb. of observ.	138	66	132	173	35	20	132	96	188	40
Integration										
Long-run equilib.:										
Intercept	-0.492	0.684**	-0.432***	0.711	2.631	-1.757***	-0.288	-0.901***	-0.615***	-1.09***
Slope=long-run elastic. (change[a])	1.053***	0.862*** (-10%)	1.043*** (+1%)	0.837***	0.555*** (-41%)	1.248*** (-4%)	1.038***	1.133*** (-9%)	1.076***	1.16*** (-8%)
Cont. price transm. (% change[a])	0.056**	0.281*** (+161%)	1.685*** (+236)	-	-	-	0.141***	0.351*** (+91%)	0.676***	0.683*** (+1%)
Speed of adjustment (change[b])	-0.038***	-0.121*** (+218%)	-0.387*** (+918%)	-0.024***	-0.078** (+225%)	-0.139*** (+479%)	-0.06	-0.213 (+255%)	-0.236***	-0.844*** (+258%)
Equilibrium										
Regime-specific Avg. ECT[c]	0.030	-0.063	0.004	0.016	-0.392	0.243	-0.031	0.006	0.002	0.006
Stability										

*** significance level<0.01; ** significance level=0.01; * significance level=5%;

[a] For the changes in the long-run price transmission elasticity, we show the change compared to the standard regime against the benchmark of perfect transmission in percentage points.

[b] % change is presented relatively to the regime standard

[c] Notice that the avg. ECT of one model is equal to 0. The regime-specific avg. ECTs of the different regimes of one model given in this table do not exactly sum up to 0 due to rounding error

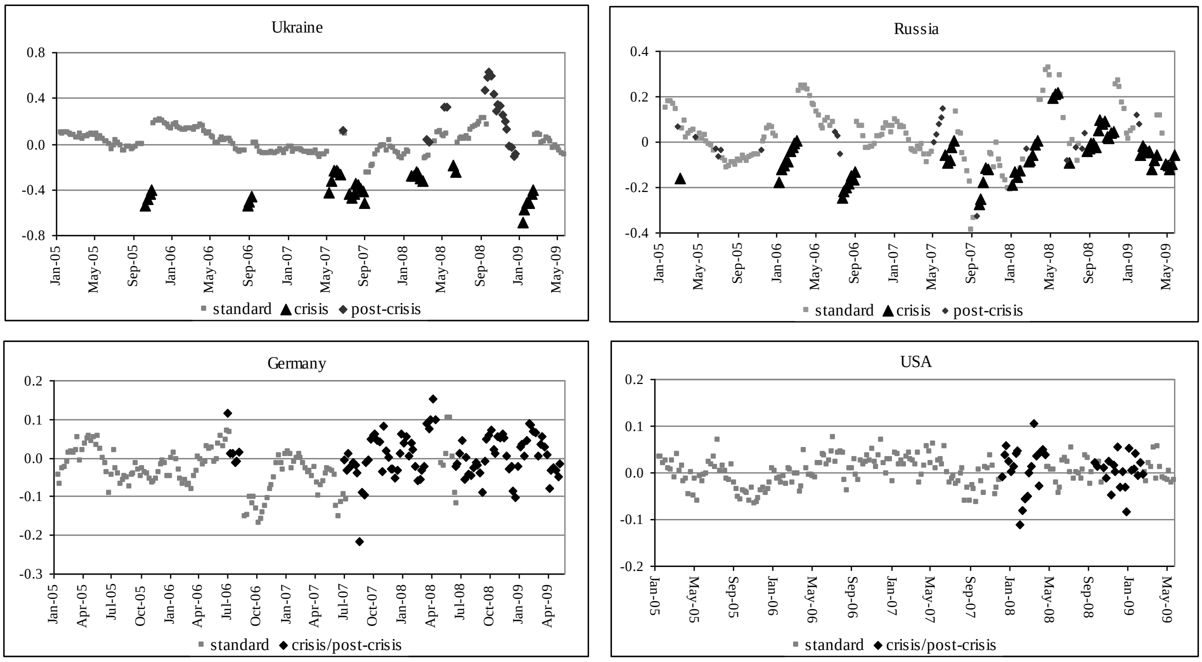
Market equilibrium

The equilibrium between the local market and the world market is characterized by the size of the error correction term (ECT) (i.e., the size of the deviation from the long-run price equilibrium between the grower and the world market price itself). If the market is in equilibrium, ECT=0. The larger the size of the |ECT|, the more the price deviations exceed the equilibrium levels in the respective markets. ECT>0 indicates that the grower price is higher than its equilibrium level, whereas ECT<0 is a sign that the grower price is lower than its equilibrium level. The ECT is calculated for all observations t based on the cointegration vector $\beta(\beta_0, \beta_1)$, which is retrieved from the estimated parameters of the unrestricted model as follows:

$$ECT_t = \ln p_{t-1}^{grower} - \beta_0 - \beta_1 * \ln p_{t-1}^{world} \qquad (3)$$

The estimated ECT_t are depicted graphically in Figure 4 for each model framework. The visualizations of the respective regime affiliation and the regime-specific average values of the ECT are presented in Table 2.

Figure 4: ECT Terms of the Three Regimes for Ukraine and Russia (“standard,” “crisis,” “post-crisis“), and Germany and the USA (“standard,” “crisis/post-crisis”)



Regarding the average size of the ECT, we find it to be slightly positive in the regime “standard,“ dropping substantially to a negative level in the “crisis” regime but increasing again to a positive level in the “post-crisis“ regime for Russia and Ukraine. For Ukraine, the ECT of the “post-crisis” regime even exceeds the level in the “standard“ regime. Thus, the grower price is particularly below its equilibrium level in the “crisis” regime in Russia and even more so in Ukraine. The ECT for Germany turns from a negative value before the crisis to a positive value in the “crisis/post-crisis“ regime. For the USA, the regime-specific average ECT term is slightly positive even in the regime “standard,“ but further increases in the “crisis/post-crisis“ regime.

Market stability

The regime-specific standard error of the model is one parameter which characterizes the stability of a market. The estimated standard error for the “crisis” regime is substantially higher than for the “standard” regime for Russia (+80%) and even more so for Ukraine (+284%). This suggests that wheat markets in Russia and Ukraine were destabilized during the crisis despite export controls, which further amplified in the “post-crisis” regime for Ukraine (+462%). We also find a heightened standard error in the “crisis/post-crisis“ regime as compared to the “standard” regime for Germany (+122%) and the USA (+56%).

The regime-specific average domestic price change also reflects the average price change trend in each of the regimes; however, the “crisis” and “post-crisis” (“crisis/post-crisis”) regimes are not solely characterized by increasing and decreasing price changes, respectively, as indicated by the % of positive price changes in each regime.

7 Discussion of Results

The results of this study indicate that the governmental interventions on wheat export markets in Russia and Ukraine in 2007/2008 have temporarily reduced the degree of integration of the domestic markets in world wheat markets, disconnected domestic wheat markets from their equilibrium, and increased market instability. These effects were even more pronounced and long-lasting for wheat markets in Ukraine, where the government had restricted wheat exports by an export quota, as compared to Russia, where wheat exports were restricted by an export tax. In addition, the analysis of the regime classification confirms that the occurrence of three different states of market integration (and thus price transmission regimes) is related to the implementation of temporary wheat export restrictions in Russia and Ukraine, which reduced wheat exports significantly. The occurrence of two states of market integration can be observed for Germany and the USA, even in the absence of any governmental market interventions. The regime change seems to be related to substantial changes in the wheat trade position, i.e. the strong reduction of wheat exports, which even became negative, in the case of Germany, and an export boom in the case of the USA.

An explicit “crisis” regime is exclusively observed and identified for Russia and Ukraine. This “crisis” regime is mainly characterized by significantly lower long-run price transmission and higher speed of adjustment and higher standard error when compared to the “standard” regime. Furthermore, the export restrictions disturb the domestic markets and drive the grower price below its equilibrium level in the “crisis” regime, suggesting that wheat producers are disadvantaged. Low integration in the world market implies that the high prices are transmitted only partially to domestic markets; thus, wheat producers can benefit from high world market prices only to a limited degree. Investment incentives in wheat production to increase production efficiency and wheat production (e.g., by investing in fertilizer, high quality seeds, and new agricultural technology) which could result from high world market prices, are foregone. The faster speed of adjustment is related to the large price increases during the crisis. Large price changes induce substantial arbitrage activities, directly (e.g. through trade) or indirectly (e.g. by storage), the latter particularly when trade is restricted. The regime-specific standard error of the model indicates that export restrictions in Russia and Ukraine could not prevent the decrease in market stability to a level lower than that for Germany and the USA observed during and in the aftermath of the food crisis. Heightened market price volatility also increases market uncertainty, with negative repercussions on investments incentives for farmers and traders.

Our analysis identifies increased contemporaneous price transmission and faster speed of adjustment in the “post-crisis” and “crisis/post-crisis“ regime than in the “standard” regime as common developments in wheat markets in Russia, Ukraine, Germany, and the USA. Furthermore, in all four countries, the average wheat grower price increases beyond its equilibrium level in the “post-crisis” regime. These developments suggest the strengthened integration of domestic markets in world wheat markets in the aftermath of the food crisis and also an improved price negotiation position of wheat producers vis-á-vis wheat traders in general. Furthermore, market instability has increased in all four countries in the “post-crisis” or “crisis/post-crisis“ regime compared to the “pre-crisis” regime, which might point to a general long-term increase in volatility on global wheat markets.

Are the observed market effects of the export controls in Russia and Ukraine more of a short-run or long-run nature? In the case of Russia, long-run price transmission and thus market integration improved, the regime-specific avg. ECT decreased and therefore the market was closer to its equilibrium, but market instability increased in the “post-crisis” compared to the “standard” regime. However, since market instability is higher in the “crisis/post-crisis” regime compared to the “standard” regime for Germany and the USA as well, we do not trace back the increase in market instability in the “post-crisis” compared to the “standard” regime to the export controls in Russia. Rather it seems that market instability and volatility have increased on wheat markets in general during and in the aftermath of the food crisis. In the “post-crisis” regime compared to the “crisis” regime, market integration strengthened, the market was pushed closer to its equilibrium, and market instability decreased. Therefore, we conclude that the observed market effects of export controls with regard to market integration, equilibrium and stability are of a short-run nature for Russia.

In the case of Ukraine, our results provide some evidence for long-run domestic market effects, particularly with regard to an increase in market instability. As for Russia, we observe an increase of market instability in the “post-crisis” compared to the “standard” regime, although to a much larger degree; as pointed out above, an increase in market instability in the “crisis/post-crisis” compared to the “standard” regime is also observed in Germany and the USA. Furthermore, and again unlike Russia, results suggest a weakening of market integration and an amplified disequilibrium in the “post-crisis” compared to the “standard” regime in Ukraine. Though, similar developments are observed for Germany and the USA, except that the market is closer to its equilibrium in the “crisis/post-crisis” regime compared to the “standard” regime. Furthermore, and similar to Russia, market integration strengthened and the market was pushed closer to its equilibrium in the “post-crisis” compared to the “crisis” regime. Though, and different to Russia, market instability increased substantially in the “post-crisis” compared to the “crisis” regime; a similar development is not observed in Germany and the USA. Summarizing, an amplified disequilibrium in the “post-crisis” compared to the “standard” regime and a substantially increased market instability in the “post-crisis” compared to the “crisis” regime provide some evidence for long-run direct market effects of export controls in Ukraine.

The graphical analysis in Section 3 demonstrated that the wheat price in Russia temporarily overshot the world market price May-July 2008, when the export tax of 40% was still imposed but Ukraine had already abolished its export quota in May 2008. Thus, toward the end of the period of effective export taxes, the export restriction became ineffective with regard to its aim to reduce domestic wheat prices below the world market price. Even more, the domestic price level rose beyond the world market price[26]. This demonstrates that careful sequencing of the political measures is required for export restrictions to successfully decrease the domestic price level.

More indirect negative effects of the export controls on wheat markets in Russia and Ukraine are caused by high political uncertainty. Multiple irregular adjustments of the duration of these measures as well as the level of the tax and the size of the quota were implemented on short notice in both countries, but particularly in Ukraine. Such actions might result in delivery contracts that cannot be fulfilled, which negatively affect exporting countries' international reputations. In addition, exporters might face extra costs (e.g., for transport to the harbor and quality control in the event that loaded ships are not allowed to leave the harbor). For example, when the grain export quota was established in Ukraine in 2010, ships already loaded when the export quota was announced could not depart for 15 days. As a result, 472,000 t of cereals sat in storage temporarily on ships in Ukrainian harbors (APK Inform 2010). This reduces profitability of wheat exports implying that investments and production of wheat decrease.

The possibility of corruption is an additional indirect negative aspect of export restrictions. This is particularly important when export quotas are distributed within licenses. A wheat trader of a large international trading company located in Ukraine reports that corruption is playing a significant role in the wheat export license system established in Ukraine in 2010/2011. Corruption increases market risks and induces negative incentives for investments.

8 Concluding remarks

What do these findings imply for policy makers? Grain prices are expected to further increase in the next years (OECD-FAO 2011), and the next price peak on the world markets will come, the only question is when it will arise. Even if the export controls have less long-run direct market effects, as in Russia, high political uncertainty and the possibility of corruption induce negative investment incentives. Thus, investors will downsize and delay planned investments in grain production and infrastructure as long as the governments do not only announce but do not prove to refrain from grain export controls.

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[26] Experts confirm that this was caused by traders' behavior. In anticipation of an early removal of the export restriction, and a world market price higher than the domestic market price, traders did not supply wheat on the domestic markets but kept it in storage. Thus, the trade volume on domestic markets was very low, resulting in an increase in the wheat price on the domestic market even beyond the world market price. The exceeding of the domestic price was also observed during an export ban imposed by the Serbian government on the wheat market in 2007/2008. Similarly to Russia, the export ban was removed July 1, 2008 (Djuric et al. 2011).

The European Bank of Reconstruction and Development (EBRD), which finances large-scale private investments in the grain sectors in Russia and Ukraine, confirms that grain export restrictions in Russia and Ukraine have made investors rethink their commitments in these regions and that investments have been downscaled and delayed (Reuters 2011). In particular, investments in the grain sector in Ukraine have been reduced by 550 million Euros due to the export quota in 2010/2011 (EBRD 2011). This is particularly problematic since it is estimated that investments of 1000-2000 US$ per ha are required to fully utilize Ukraine's grain production potential (Harmgart 2011).

Classic safety nets may be more attractive alternatives if the governments in Russia and Ukraine wish to attempt to mitigate the impact of rising world market prices on the domestic poor. Such measures are the most direct way of coping with the negative consequences of increasing wheat and bread prices for those in need without risking the loss of export opportunities for farmers and traders. These direct measures, however, might hold little attraction if the politicians attach a much higher weight to those market actors in the domestic downstream sector who actually gain from these direct interventions.

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Are Export Restrictions an Effective Instrument to Insulate Domestic Prices against Skyrocketing World Market Prices? The Wheat Export Ban in Serbia, DJURIC, I., L. GÖTZ AND T. GLAUBEN, *Agribusiness: an International Journal, 2015, Vol. 32(2): 215-228.*

ARE EXPORT RESTRICTIONS AN EFFECTIVE INSTRUMENT TO INSULATE DOMESTIC PRICES AGAINST SKYROCKETING WORLD MARKET PRICES? THE WHEAT EXPORT BAN IN SERBIA

Ivan Djuric[a], Linde Götz[a] and Thomas Glauben[a]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany.

Abstract

This paper analyzes how the market interventions of the Serbian government, among them an export ban, affected the domestic wheat market during the global commodity price peak in 2007/08. We choose a flexible Markov-switching error-correction model as the framework for our price transmission analysis. The results show that the price transmission regime was not changed by the export ban. Thus, the export controls were not successful in dampening the domestic wheat price level. We make evident that the expected price decreasing effects of the export ban were offset by inconsistent additional policy measures and their faulty sequencing. Further, the governmental market interventions had even long-lasting destabilizing market effects. Market instability was increased particularly after the cancellation of the export ban.

1 Introduction

World market prices for agricultural raw products have risen dramatically in recent years, which led to several global commodity price peaks. During the so-called food crisis in 2007/08, Free on Board (FOB[1]) U.S. Louisiana Gulf prices for wheat, corn and rice increased by 182 %, 236 % and 202 %, respectively, from June 2006 until June 2008 (USDA, 2011).

Many governments have tried to insulate domestic agricultural prices from skyrocketing world market prices by implementing trade-related policy measures (FAO, 2008). Exporting countries have implemented export restrictions within export taxes, export quotas or export bans. By decreasing exports, governments aimed to increase domestic supply which should dampen domestic prices (Sharma, 2011; Mitra & Josling, 2009). Examples are the large grain exporting countries such as Russia, which implemented a wheat export tax (2007/08) and an export ban

[1] FOB -The seller has to deliver goods on board of a vessel designated by the buyer (INCOTERMS, 2010).

(2010/11), Kazakhstan with a wheat export ban in 2008, and Ukraine which issued wheat export quotas during 2006/08 and 2010/11 (Goychuk & Meyers, 2013; Götz et al., 2013a; Welton, 2011). On the other hand, grain importing countries reduced their trade barriers. By cancelling or reducing import tariffs additional incentives to import were created which aimed to increase domestic supply and to bring down domestic prices, as observed in Morocco, Indonesia and Turkey (Demeke et al., 2011).

In this paper we focus on Serbia, a small wheat-exporting country and an EU-accession candidate, which also intervened on its domestic wheat market in 2007/08 by implementing a wheat export ban. The wheat market is of a great importance for Serbian agricultural and food processing sectors. Wheat is besides corn the most important grain export product of Serbia, accounting for 11 % of total grain exports in 2009. Wheat is also the primary input for the feeding industry and cattle production.

This paper is unique in investigating the effects of Serbia's export ban on the domestic wheat market in 2007/08. Our research questions are: Through which crisis policies did the government intervene on the domestic wheat market? How did the export ban affect the domestic wheat market, particularly market prices? Were crisis policies effective?

We conduct our analysis with a price transmission approach utilizing a Markov-switching error-correction model (MSECM), which considers that the state of Serbia's wheat market may have altered due to governmental market interventions during the 2007/08 crisis. Our data base comprises weekly wheat grower price data from Serbia and the port FOB price of wheat in France (Rouen) as a measure for the world market price.

The paper is organized as follows. Section 2 describes Serbia's wheat policy measures during the 2007/08 crisis, and provides the theoretical expectations of their impact on the domestic market. Section 3 provides a literature review. Section 4 explains the methodology and data set utilized in the price transmission analysis. Section 5 presents our empirical results, and Section 6 summarizes and provides conclusions.

2 Governmental grain market interventions during the price peak in 2007/08

In this section we describe the chronological sequence of Serbian governmental wheat market interventions during the global commodity price peak. Furthermore, we discuss what are the expected domestic market and price effects from a theoretical point of view.

The overview of the implemented market interventions is based primarily on interviews with 5 key experts, traders and politicians who were involved directly or indirectly in lobbying, creating or implementing these measures. The interviews were conducted in-person, while some further information was retrieved by e-mail from the experts. Additional information was gathered from the news media (AgraFood East Europe, USDA GAIN reports, specialized agricultural websites, etc.).

The Serbian government started to intervene on the domestic wheat market in response to a dramatic increase in wheat exports prior to the 2007 harvest. In particular, wheat exports[2] skyrocketed from June until the beginning of August 2007 (Figure 1). The significant increase in foreign demand for Serbian wheat was induced by the low price of Serbian wheat relative to world market prices. Therefore, the government justified wheat market interventions by their need to secure a sufficient supply for domestic consumption and to prevent large increases of domestic food prices.

The government began to intervene on domestic wheat markets by implementing export controls (Serbian official Gazette No. 73/07, 97/07 and 126/07) on August 4, 2007 (Figure 1, A[3]). The export restriction was first announced as a 3-month program, that is, it would last until December 2007. Although the Ministry of Agriculture, Forestry and Water Management (MAFWM) announced the introduction of export quotas for wheat, export quotas were actually not issued. Thus, wheat exports were de facto banned completely (USDA, 2007). In addition, the Directorate of Commodity Reserves (DCR)[4] announced the purchase of about 60,000 t of wheat from Serbian producers in September 2007 to ensure sufficient wheat stocks (B). Consequently, by increasing demand, wheat prices surged by about 30 % within one month. This imposed pressure on the government to consider the renewal of the export restrictions. Third, on October 26, 2007 the government officially extended the wheat export restrictions for a further 90 days, and additionally issued export quotas of 80,000 t for wheat flour (C). In the aftermath of this announcement, wheat prices stabilized for a few weeks at a very high level. Fourth, on February 29, 2008 the wheat flour export restrictions were officially extended until June 15, 2008 (D), and the wheat flour export quota was increased by 20,000 t.

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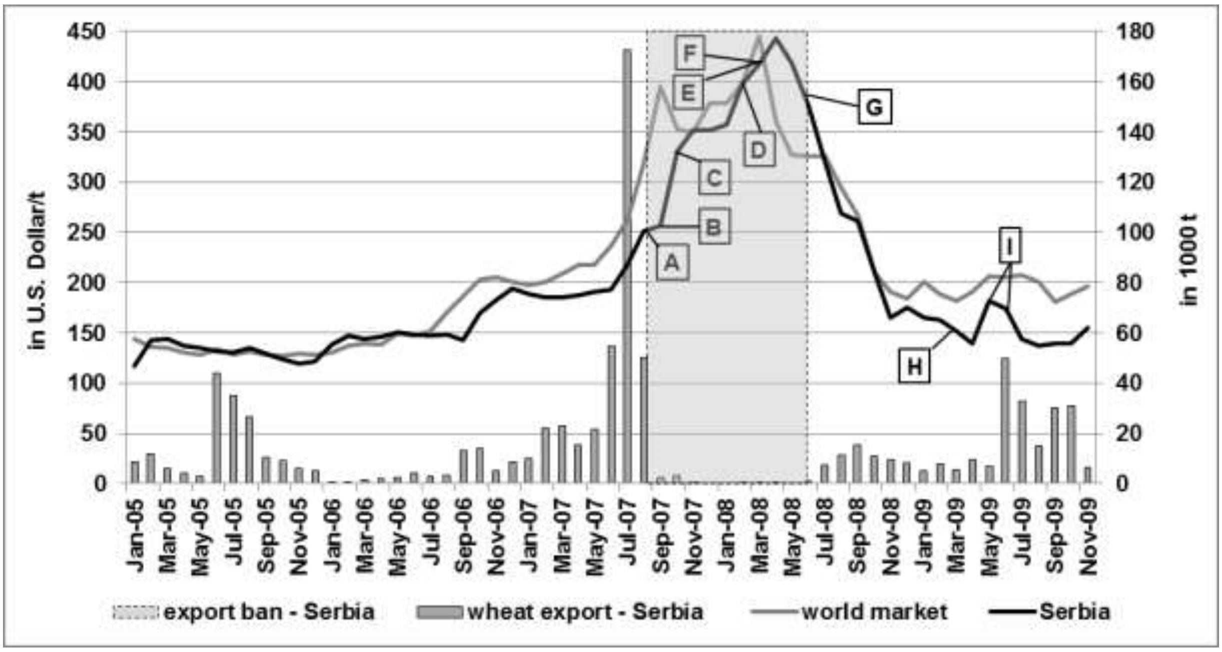
[2] The main export destinations were EU member countries such as Germany, Cyprus, Austria, Slovenia and Romania, with about 74 % of the total wheat export occurring in the first half of 2007, and Bosnia and Herzegovina accounting for about 17 %.

[3] All of the following labels refer to figure 1. Each label represents the time order of the policy measure being implemented.

[4] The DCR is the official governmental body responsible for national commodity reserves. The Serbian Ministry of Trade and Services has direct control over this institution.

Figure 1: Monthly Serbian and "world market" (Rouen, France) wheat prices, Serbian monthly wheat export and implemented policy measures, 2005/09.



Note: Labels in figure 1 are explained within the text. Each label represents the time sequence of the policy measure being implemented (A - first, B - second, etc.). Presented export quantities are equal to net wheat export. During the observed period of 2007/2009, Serbia imported wheat only in October and November 2007 (total 450 t), September/December 2008 (total 2,964 t), and April, July, September and October 2009 (total 1,183 t).

Source: GTIS , Serbia's Grain Fund (Serbian wheat prices) and HGCA (French wheat prices), own illustration.

Fifth, at the beginning of March 2008, the DCR decided to purchase about 40,000 t of wheat from the domestic market. The governmental purchase was realized at extremely high prices (E). This further pushed Serbian wheat prices up to a level of 452 U.S. Dollar/t (April 2008), and beyond the world market price of 369 U.S. Dollar/t. In March and April 2008, Serbian wheat prices were about 20 % higher than world market prices. According to experts' information (V. Sakovic[5], several personal interviews, 2009/11), the market was very thin and only small quantities of wheat were traded. Only a few wheat processing companies who ran out of stock bought at these high prices, whereas most companies utilized wheat from their own stocks. Sixth, despite extremely high domestic wheat prices, the regular wheat import tariff of 30 % was not removed until the end of March 2008. Finally, the government cancelled the wheat import tariff for the quota of 200,000 t (F). Consequently, Serbian wheat prices started to fall steeply although wheat was not imported, according to the Serbian official trade statistics.

5 Mr. Vukosav Sakovic is the leading national expert on grain markets in Serbia and the president of the Serbian Grain Fund "Zita Srbije".

Finally, on June 15, 2008 the Serbian government removed the grain export ban (G). At that time, the wheat market was characterized by increased uncertainty. The substantial wheat price decrease in the fall of 2008 was caused by the above average wheat harvest in July 2008, and the large stocks of wheat harvested in 2007 of about 350,000 t, which could not be exported due to the export ban. This led to a domestic wheat supply exceeding annual domestic consumption by about 600,000 to 800,000 t of wheat. Concurrently, regional demand for Serbian wheat was low due to the above average harvest in 2008 in the whole region. Another reason for Serbia’s low wheat exports was the low quality of the 2008 wheat harvest, which was classified as class II (in terms of protein content and sedimentation value), and was less suitable for milling. This reduced Serbia’s competitiveness compared to other regional suppliers such as Hungary and Romania. Therefore, Serbian wheat exports remained low even in 2008, further increasing domestic stocks. Serbia’s wheat market was further destabilized in the aftermath of the crisis by the governmental storage of 40,000 t of wheat in private silos that were purchased in April and May 2008. This reduced the wheat demand of the silos’ owners, and thus domestic wheat demand during the 2008 harvest, further depressing wheat prices in the Serbian market. Additionally, the DCR lent substantial amounts of wheat to processing companies (H), which further decreased market demand for wheat such that wheat prices dropped to a record low price level and further destabilized the market. Since the price of wheat seeds and fertilizers was very high in 2008, farmers reduced costs by decreasing fertilizer input. Thus, 50 % less fertilizer was used in wheat production compared to the previous year. This increased uncertainty about the size of the expected wheat harvest was exacerbated by a strong draught in May and June 2009, one month before the harvest, which also had a price-increasing effect (I). Finally, the wheat harvest in 2009 was the second-largest harvest in a row, thereby stabilizing prices and removing uncertainty.

From a theoretical point of view, we expect the following market and price effects caused by the previously described market interventions: Since the Serbian export ban made legally exporting wheat from Serbia impossible, wheat supply on the domestic wheat market is supposed to have increased, thereby exerting decreasing effects on the domestic wheat price. This implied that the difference between the domestic and the world market increased. Also, reduced trade insulates domestic prices from price developments on the world market and the importance of domestic factors for domestic price determination increased, whereas the influence of the world market price decreased. Thus, changes of the world market price are transmitted less completely from the world market to the Serbian wheat market.

Besides, substantial governmental purchases of wheat are assumed to have increased wheat demand on the domestic market, which has a price increasing effect on the domestic wheat price. This counteracts the price decreasing effects of the export ban. Also, since an import tariff is a trade restriction that hinders imports by reducing their profitability, we suppose that it induced further price increasing effects on the domestic wheat market in Serbia. If instead the wheat import tariff was removed when domestic prices exceed world market prices, incentives for additional wheat imports were created, decreasing the domestic price towards the level of the world market price.

Summarizing, several market intervention instruments with partially opposed price and market effects were applied to the wheat market. We aim to capture these effects within a highly flexible model which allows for multiple prices regime changes.

3 Literature review

We investigate the effects of the governmental policy interventions on the Serbian wheat market within a price transmission model, focusing on the relationship between Serbian growers and the world market price.

Our model approach is based on the Law of One Price, which assumes that two spatially separated markets are in their equilibrium if the difference between the prices in these two markets equals at most the size of the costs of trade between these markets (Fackler & Goodwin, 2001). This condition is also known as the spatial arbitrage condition. Exogenous shocks, e.g. a decreasing supply due to bad weather in one market, might lead to high price differences exceeding trade costs, and thus to a temporary disequilibrium. However, if markets are functioning well, arbitrage activities, particularly trade between these two markets, imply that the prices are driven back to their equilibrium level and the market equilibrium is restored (Fackler & Goodwin, 2001); this requires trade to be fully liberalized and unrestricted.

As it was pointed out in the previous section, export restrictions have price effects on the domestic market price. Götz et al. (2013a) investigate the domestic impact of export restrictions imposed by Russia and Ukraine during the 2007/08 global food crisis. For the spatial price transmission analysis, they apply a Markov-switching vector error-correction model. They found that crisis policies in both countries decrease domestic prices, insulate domestic prices from price developments on the world market, and negatively impact market stability. Wheat producers and traders experience welfare losses, and incentives for private investments are diminished. Export restrictions are criticized for their additional price-increasing effects on the world market (Martin & Anderson 2012; Sheldon 2012, Dawe & Slyton 2011; Dollive, 2008). In general, an export quota and an export ban are not permitted by the WTO, and only an export tax is in line with WTO regulations. However, temporary export restrictions "applied to prevent or relieve critical shortages of food stuffs or other products essential to the exporting contracting party" are exempted from this rule (Sharma, 2011). Even small countries have a price-increasing effect on the world market if many small exporting countries implement export controls simultaneously (Martin & Anderson, 2012). Anderson and Nelgen (2012) and Martin and Anderson (2012) investigate the feedback effects of price-insulating behavior on the world market price. According to their calculations, the world wheat market price increased by about 70 % between 2005/06 and 2008. These authors estimate that between 19-29 % of this price increase was caused by the feedback effects of increasing export barriers by exporters, as well as removing import barriers by importing countries worldwide. Export restrictions not only influence price levels but also price volatility. Götz et al. (2013b) find for Ukraine that the export quota system did not reduce price volatility on the domestic market. Rather, the multiple and unpredictable political interference of the Ukrainian government on the wheat export market have substantially increased market uncertainty, thereby increasing market risk and ultimately leading to additional price volatility. In general, border and domestic policies have a significant role in influencing price transmission and market integration (Sharma, 2003; Thompson et al., 2002). According to Mundlak and Larson (1992), agricultural policy interventions create a gap between world and domestic prices, which generates cross-country variations in agricultural prices. Only a few studies account for the impact of policy interventions on price transmission. Rezitis et al. (2009) investigate the impact of the Common Agricultural Policy (CAP) reforms on the lamb sector in Greece by applying a Markov-switching vector error-correction model. Their results are indicating that the CAP reforms had a significant impact on the lamb price disruption which placed the members of the Greek lamb sector in the unfavorable position during the transition period following the reform. Esposti and Listorti (2013) investigate the impact of trade policy interventions on horizontal price transmission in the EU during the period of price bubbles (e.g. 2007/08). They estimate the vector error-correction model and vector autoregressive model to identify the cross-market transmission between wheat and corn prices on three different markets (Bologna, Rome and Rotterdam). The results are indicating that the policy interventions were effective in compensating the impact of the price bubble which caused market turbulences by increasing the price spread between different commodities and markets. Listorti (2009) studies price transmission between the EU and the international soft wheat market (1978-2003) within a non-linear vector error correction model. The influences of the European CAP and the implementation of the Uruguay Round Agreement on Agriculture (URAA) are captured by a long-run equilibrium regression allowing for structural breaks in the constant as well as the long-run price transmission parameter. Results suggest the URAA to have strongly improved international price transmission.

4 Methodology and Data

The economic interpretation of price equilibrium can be explored in the statistical framework of a cointegration analysis, where the cointegration relationship represents the long run equilibrium. If the prices are found to be cointegrated, the system can be written as a vector error-correction model (VECM) as defined by Engle and Granger (1987). A linear VECM is based on the assumption that all parameters of the model are constant.

Parameter constancy of the model cannot be assumed, however, due to the various changing governmental interventions on the Serbian wheat market (see section 2) and therefore, several price transmission regimes might be observed during the time period being analyzed. Thus, a linear VECM is not appropriate for our analysis. The underlying assumption of non-linear regime-dependent VECM models is that at least a subset of the model parameters is allowed to change between different regimes. Regime-dependent models found broad application in the price transmission literature because of their flexibility. In particular, Balke and Fomby (1997) provided some of the first descriptions of the threshold cointegration framework which was introduced in spatial price transmission by Goodwin and Piggott (2001). Threshold models found extensive application in the spatial price transmission analysis (e.g. Abdulai, 2006; van Campenhout, 2007) and were extended towards flexible thresholds (e.g. Myers and Jayne, 2012). Alternative estimation methods for threshold models were suggested by Greb et al. (2013) and Balcombe et al. (2007). Smooth transition models (Teräsvirta, 1994) are more generalized models. The main difference, compared to the threshold models, is that the transition between the regimes is smooth instead of abrupt. Smooth transition models found broad application in the spatial price transmission literature (e.g. Ubilava & Holt, 2013; Götz et al., 2013b; Serra et al., 2011).

In contrast to the previous models, Markov-switching (MS) models allow for the distinction between different price transmission regimes where the threshold variable, which governs the regime switches, is unobserved, and thus probabilistic. This characteristic makes the MS model particularly suitable for our analysis. Even though the exact dates of the implementation of the grain export ban are known, market participants might react at different points of time. The price behavior of market participants is determined by expectations, and thus some might change their price behavior even before the new policy measure is introduced (or abolished), while others might react with a certain delay. Therefore, we choose the MS model as a suitable framework for our analysis. The MS models can be traced back to Hamilton (1989), who extended the approach of Goldfeld and Quandt (1973) about the switching regression model. A characteristic of the MS models is the assumption that the parameter changes are governed by a Markov chain. Krolzig (1997) developed the Markov-switching vector error-correction model (MSVECM) as a special case of the more general Markov-switching vector autoregression model. The MSVECM is widely used in the analysis of business cycles and financial research. Recently, Brümmer et al. (2009) introduced this model into price transmission analysis.

In this study we use the following form of unrestricted MSECM[6] specification:

$$\Delta p_t^S = \nu(S_t) + \alpha(S_t) p_{t-1}^S + \delta(S_t) p_{t-1}^W + \sum_{i=1}^{k} A_i(S_t) \Delta p_{t-i}^S + \sum_{j=1}^{l} B_j(S_t) \Delta p_{t-j}^W + \varepsilon_t \qquad (1)$$

where Δ is a first difference operator, p_t^S represents the respective Serbian wheat price, ν is the intercept term, α is the speed of adjustment, i.e. the speed at which the deviations from the equilibrium are corrected in the following period. δ represents the short impact of the world wheat prices (p_t^W) on the domestic Serbian prices. Matrices A_i and B_j contain the short run parameters of the system. ε_t is the error term. The core element of the MSECM specification is the state variable $S_t = 1, ..., M$, which is an unobserved variable indicating which of the M possible regimes governs the MSECM at time t.

The basic idea of a Markov-switching model is to assume that the data-generating process underlying the state variable S_t is following a Markov chain:

$$\Pr(S_t \mid S_{t-i}, \Delta p_{t-1}, \beta' p_{t-1}) = \Pr(S_t \mid S_{t-1}, \Pi) . \qquad (2)$$

The Markov property (2) implies that the probability of the system switching to a new state (S_t) depends only on the previous state S_{t-1}. Thus, the probability of a regime switch is independent of the system's history. The square matrix Π contains the (row-wise) probabilities $[\pi_{ij}]$ for the

6 Since Serbia is a small wheat exporter and has little influence on the world wheat market price, we estimate a univariate unrestricted Markov-switching error-correction model (MSECM), assuming that the world market price is not influenced by the domestic Serbian wheat grower price. Our model also allows for contemporaneous price transmission.

transition from regime i to regime j, conditioned on the regime in the previous period. The Markov chain is assumed to be ergodic, ensuring a stationary distribution of the regimes, and to be irreducible, implying that any regime can be reached from any other regime.

Estimating a MSECM is based on maximizing the likelihood function with the Expectation-Maximization algorithm developed by Dempster et al. (1977). Later, this algorithm was significantly improved by the suggestions of Hamilton (1990) and Kim (1994). A detailed explanation of the solution algorithm is provided by Krolzig (1997).

In general, the estimation procedure is divided into two steps. First, the parameters characterizing the unobserved state variable and transition probabilities are estimated conditional on the starting values of the coefficients being estimated. In the second step, the starting values are updated based on the estimated parameters in the first step within an iterative procedure. The procedure is stopped when the estimated parameters of two consecutive estimations do not differ significantly. The estimation procedure is available in the MSVAR package (Krolzig, 2006) for the matrix programming language Ox (Doornik 2002).

We conducted our analysis based on the unique dataset of the weekly Serbian wheat grower price measured as the Free Carrier[7] (FCA) silo selling price (SGF, 2010), and the port, Free On Board (FOB) price of wheat (French soft wheat, class 1) of Rouen in France (HGCA, 2009) as a measure for the world market price[8] (Figure 3).

Our dataset covers 255 observations from January 2005 until November 2009. All prices are converted by weekly exchange rates into U.S. Dollars. The missing values are imputed based on the Amelia program (Honaker et al., 2009) in R.

5 Empirical Results

Prior to estimating the model we conduct the unit root and cointegration tests. The results of the ADF test and the KPSS test suggest that both data series are integrated at the order of 1

7 FCA -The seller hands over the goods, cleared for export, into the custody of the first carrier (named by the buyer) at the named place (INCOTERMS, 2010).

8 The ports of the Black Sea are the closest trade places of the world market for Serbia. FOB wheat prices of Russia or Ukraine would ideally serve as the world market price in our analysis. However, Russia and Ukraine restricted their wheat exports temporarily during the observed period. This explains why a continuous weekly FOB wheat price series does not exist for any of the Black Sea ports. Also geographically close to Serbia is the Budapest Commodity Exchange in Hungary, though Hungarian prices are mainly of regional significance (FAO, 2011). Therefore, we choose an EU FOB price as the relevant world market price. France is the major grain exporter of the EU and grain is exported to the world market primarily through the port of Rouen. Thus, wheat FOB prices at Rouen represent the main benchmark for the EU (European Commission, 2014; IGC, 2014).

(Table 1, A). Johansen's test on cointegration finds that the Serbian wheat grower price and the wheat world market price are cointegrated (Table 1, B). Economically, this implies the existence of a long run equilibrium between these two markets and the integration of the Serbian and the world wheat market. Thus, the preconditions for utilizing the error-correction model are given (Engle & Granger, 1987). Comparing the maximized log-likelihood function values of the linear VECM (426.66) and the MSECM (506.38) suggests that the non-linear MSECM is superior.

The results of the τ-Test of Hansen and Johansen (1999) indicate that the long run equilibrium relationship is not stable throughout the entire time period underlying our analysis, thereby justifying the estimation of the MSECM within a more flexible, unrestricted framework (Figure 2). The unrestricted framework allows not only the short run, but also the long run price transmission parameters to change by regime. The long run equilibrium parameters are retrieved indirectly from the parameters of the MSECM (Stock & Watson, 1993; Pesaran & Shin, 1999), and their t-values are calculated by the delta method (Patterson, 2010).

Table 1: Unit root and Johansen's cointegration tests

A) Unit root tests

series	Augmented Dickey-Fuller test			KPSS test		
	test statistic	specification	5 % critical value	test statistic	specification	5 % critical value
$\ln p_t^S$	-1.6234	1 lag, constant	-2.86	0.8152	10 lags	0.463
$\ln p_t^R$	-1.1854	1 lag, constant		1.1932	10 lags	
$\Delta \ln p_t^S$	-12.3740	0 lag	-1.94	0.2599	10 lags	0.463
$\Delta \ln p_t^R$	-13.7565	0 lag		0.2343	10 lags	

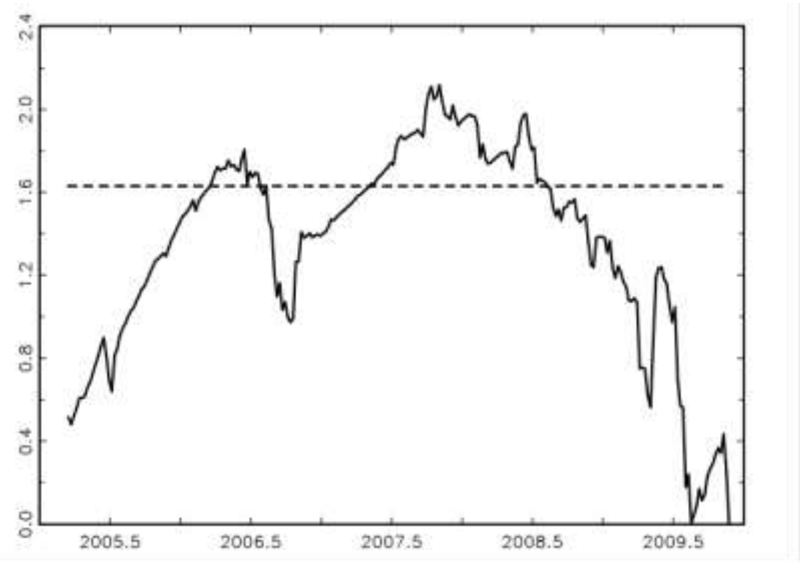
B) Johansen's cointegration test

number of cointegrating vectors		specification	rank test	p-value	5 % critical value
H_0	H_1				
0	1	2 lags, constant	23.35	0.0164	20.16
1	2		1.63	0.8402	9.14

Note: Number of lag length is selected according to the AIC. The 5 % critical value in the KPSS test is the same for levels and first differences.

Source: own calculation.

Figure 2: Recursive τ - statistic



Note: A value above the dotted line indicates the rejection of the parameter constancy hypothesis at the 5% level of significance.

Source: own calculation.

The MSECM is estimated for different specifications with regard to the number of regimes, autoregressive parameters and lagged short run price transmission parameters. Also, intercept, short run price transmission, autoregressive parameters and variances may differ between regimes. The final model specification is selected according to the Schwarz Criteria (SC) and the Hannan and Quinn (HQ) model selection criteria. Both criteria suggest a model with 2 regimes and 1 autoregressive parameter (MS(2)-ECM(1)). The optimal model is of the MSIAH type, which allows the intercept (I), the short run price transmission, the autoregressive parameters (A), and the variances/heterogeneity (H) to switch between the regimes. The model diagnostics indicate that no autocorrelation is present, and that homoscedasticity and normality of the residuals are given.

Table 2 presents selected parameter estimates[9] of the MS(2)-ECM(1), which we interpret as indicators for the degree of market integration, state of market equilibrium, and market stability. The two regimes "normal" and "adjustment" can be characterized as follows.

Table 2: Selected parameter estimates of the MS(2)-ECM(1)

Market characteristic	Indicator	"normal" regime	"adjustment" regime
Integration (long run price transmission)	Elasticity	1.174* (0.174) [a]	0.870** (0.130) [a]
	Constant	-0.997	0.606
Equilibrium			
Deviation from equilibrium	Regime specific Avg. ECT	-0.0002	-0.009
Adjust. dynamics	Speed of adjustment [b]	-0.029**	-0.284** (+969%)
Stability			
Price fluctuation	Residual standard error [b]	0.016	0.066 (+313%)

[a] Difference from the perfect price transmission (β=1), in absolute values.

[b] Regards the most probable price transmission regime prevailing in this time period.

* Indicates the statistical significance at the 5 % level; ** indicates statistical significance at the 1 % level.

Source: own illustration.

[9] Complete model parameter estimates are given in the appendix.

We find that the long run price transmission elasticity improved in the "adjustment" regime compared to the "normal" regime, since the difference from perfect price transmission (when $\beta=1$) was reduced. Thus, our results suggest that the degree of market integration was strengthened in the "adjustment" regime.

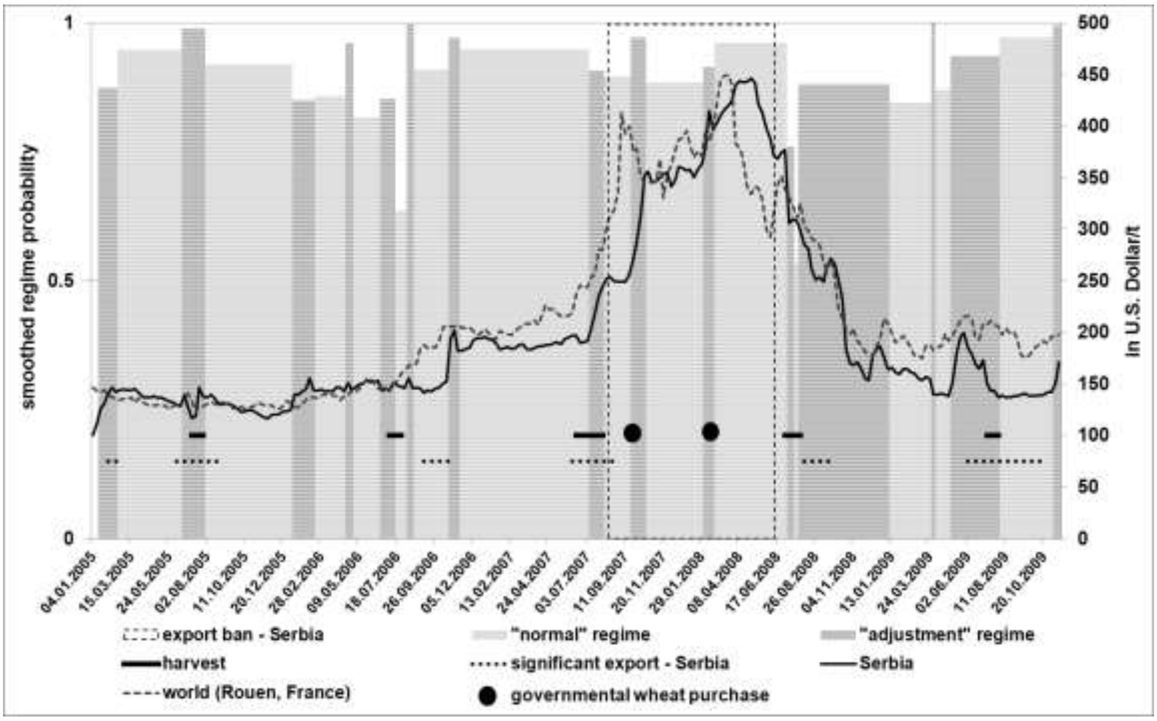
The market equilibrium is characterized by the size of the deviation from the equilibrium, which is given by the error-correction term (ECT)[10], as well as by the speed at which these deviations are corrected in the following period, which is given by the speed of adjustment. We find a strong increase in the regime-specific ECT in the "adjustment" regime. This indicates that the price of wheat on the Serbian market fell substantially below its equilibrium level, thus pushing the Serbian wheat growers in an unfavorable situation in the aftermath of the crisis. Also, the speed of adjustment rose by 969 % in the "adjustment" regime compared to the "normal" regime. We argue that the faster correction of deviations from the equilibrium, i.e. the higher speed of adjustment, is induced by intensive arbitrage activities of the Serbian wheat traders induced by large world market price changes. Another important parameter is the regime-specific standard error measuring stability of the market. The estimated standard error for the "adjustment" regime is substantially higher (+ 313 %) than in the "normal" regime, indicating that instability of the market increased significantly during the "adjustment" regime, and thus especially after the export restrictions were cancelled.

Figure 3 shows the regime classification of our model, and provides the smoothed regime probabilities for each observation. Thus, the figure indicates the probability of the regime to which one observation is most likely attributed. Each observation corresponds to a particular week.

In general, Figure 3 illustrates that the domestic wheat market in Serbia is characterized by a high number of switches between the two price transmission regimes, thereby indicating high volatility. We call the dominant regime during the whole time period of our analysis the "normal" regime; it contains 164 observations and has an average duration of less than 9 weeks. The "normal" regime is supplemented by a second regime which we call the "adjustment" regime; it comprises 89 observations and has an average duration of less than 5 weeks.

[10] The equilibrium between the Serbian and the world wheat market is characterized by the size of the deviation from the long run price equilibrium (error-correction term - ECT). The market is said to be in its equilibrium if the ECT=0. If the ECT>0, then domestic prices are above the equilibrium, whereas ECT<0 means that domestic prices are below the equilibrium.

Figure 3: Regime classification for MS(2)-ECM(1).



Source: own illustration based on the model specification.

The state of the market changed from "normal" to "adjustment" several times before, during and in the aftermath of the export ban (August 2007- June 2008). Before the food crisis, regime changes were observed in times of the wheat harvest, when significant amounts of Serbian wheat were exported (e.g. June, July and August 2005; September and October 2006; June, July and August 2007) or in periods of bad weather (e.g. June 2005 or April 2006), which are decisive for the size and quality of the forthcoming wheat harvest. Surprisingly, a change in the price transmission regime was not observed in times of the export ban; instead, the market primarily remained in the "normal" regime. A lasting regime change was observed not until the export ban was cancelled in June 2008, when the "adjustment" regime became the dominant regime for 26 weeks. This indicates that the export ban did not influence the relationship between the domestic Serbian grower price and the world market price, and was not successful in insulating domestic prices from world market price developments.

During the wheat export ban, the normal regime shortly changed to the "adjustment" regime, characterized by high instability, in October 2007 and February 2008, when the extension of the export ban was officially announced. The "adjustment" regime also prevailed in September 2007 and March 2008, when the government was purchasing wheat from the market (Figure 3). This can be interpreted as evidence that governmental market interventions and their announcement cause substantial instability and uncertainty in the market.

The estimated transition probabilities show the highest degree of persistence for the “normal” regime (0.885). Nevertheless, the “adjustment” regime also has a high probability of persisting (0.788). However, the probability of switching from the “adjustment” regime to the “normal” regime is higher than vice versa (Table 3).

Table 3: Transition probabilities

From regime	To regime	
	“normal“	**“adjustment“**
“normal“	**0.885**	**0.115**
“adjustment“	**0.212**	**0.788**

Source: own illustration based on the model specification.

To summarize our model results, we can say that the wheat export ban was not successful in insulating domestic prices from price developments on the world market. Therefore, we do not observe a change of the price transmission regime in times of the export ban. However, short-lived regime changes are observed in times of additional governmental market interventions and their announcement creating market instability. Model results provide evidence for rather strong effects on domestic prices in the aftermath of the export ban. We observe a longer lasting change in the price transmission regime characterized by high market instability.

6 Conclusions

During the global food crisis of 2007/08 the Serbian government intended to dampen and to insulate domestic prices from rapidly increasing prices on the world market by inhibiting wheat exports. These aims were followed by implementing a wheat export ban, which was supplemented by multiple governmental purchases of wheat on the domestic market and the removal of the wheat import tariff.

Though, the results of the Markov-switching error-correction model show that the price transmission regime did not change during the governmental interventions. This indicates that the export ban was not successful in dampening and insulating the domestic wheat price, which even increased beyond the world market price. Our results are in contrast with theoretical expectations, according to which the transmission of prices from the world market to domestic market should decrease and the price difference between the domestic and the world market price should increase. This is supported by Götz et al. (2013a), which find that export restrictions in Russia and Ukraine decreased price transmission between the domestic and the world market. We explain the domestic wheat price increases beyond the world market price observed in Serbia during the export ban by 2 additional governmental policy measures: 1) government purchases of significant amounts of wheat from the domestic market in September 2007 and in April 2008, which boosted domestic wheat demand, and 2) the delayed removal of the 30 % wheat import tariff, which counteracted the price decreasing effects of export restrictions. Furthermore, our results suggest that market instability increased substantially after the cancellation of the export ban. Increased instability was also observed during the export ban when the government changed the crisis policy. This indicates that the governmental market interventions had long-lasting market effects.

Overall, our analysis provides further arguments against the implementation of the export restrictions. Restrictions on exports do not only create substantial welfare losses to farmers and traders (Liefert, et al., 2012), and reduce incentives for investments in the grain sector (Götz et al., 2013a), with negative effects to global food security, and have additional price increasing and price destabilizing effects on the world market price (Martin & Anderson, 2012). Though, our results make evident that export restrictions are also prone to policy failures and that the expected price dampening effects of export restrictions can be easily offset by inconsistent policy measures (e.g. wheat purchases) and their faulty sequencing (e.g. late removal of the wheat import tariff). The far-reaching global consequences of export restrictions should make their application mandatory for regulation at a multilateral level by the WTO (Martin & Anderson, 2012).

Instead of aiming to price insulate domestic agricultural prices, governments should allow domestic prices to go up, and help the poor consumers to cope with high food prices. Consumer-oriented crisis measures as e.g. food subsidies, food vouchers and direct income transfers can better be targeted and are more effective.

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Annex

Parameter estimates of the MS(2)-ECM(1)

"normal" regime	coefficients	Standard error	p-value
$\boldsymbol{v}$	-0.0292	0.0198	0.1418
$\Delta \boldsymbol{p}_{t-1}^{S}$	0.0751	0.0811	0.3555
$\Delta \boldsymbol{p}_{t-1}^{R}$	-0.0180	0.0407	0.9449
$\Delta \boldsymbol{p}_{t}^{R}$	0.0026	0.0379	0.6587
$\boldsymbol{p}_{t-1}^{S}$	-0.0293	0.0102	0.0043
$\boldsymbol{p}_{t-1}^{R}$	0.0344	0.0110	0.0020
Regime specific standard error	0.0159		
"adjustment" regime			
$\boldsymbol{v}$	0.1721	0.1308	0.1900
$\Delta \boldsymbol{p}_{t-1}^{S}$	0.3229	0.1183	0.0068
$\Delta \boldsymbol{p}_{t-1}^{R}$	-0.3246	0.1961	0.0635
$\Delta \boldsymbol{p}_{t}^{R}$	0.3754	0.2014	0.0990
$\boldsymbol{p}_{t-1}^{S}$	-0.2838	0.0694	0.0001
$\boldsymbol{p}_{t-1}^{R}$	0.2469	0.0641	0.0002
Regime specific standard error	0.0659		

Source: Own illustration.

Regional Wheat Price Level and the Relevance of Harvest Shortfalls

Regional price effects of extreme weather events and wheat export controls in Russia and Ukraine, GÖTZ, L., I. DJURIC AND O. NIVIEVSKYI, *Journal of Agricultural Economics (forthcoming).*

REGIONAL PRICE EFFECTS OF EXTREME WEATHER EVENTS AND WHEAT EXPORT CONTROLS IN RUSSIA AND UKRAINE

Linde Götz[a], Ivan Djuric[a] and Oleg Nivievskyi[b 1]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany, [b] Institute for Economic Research and Policy Consulting (IER), Kiev, Ukraine.

Abstract

We build on the price transmission framework to identify domestic wheat price effects of wheat export controls. We explicitly take into account that a harvest failure causes domestic price effects. Moreover, the analysis at the regional level provides further evidence of the functioning of export controls in a large country. Results suggest a pronounced regional heterogeneity in the strength of domestic price effects of the 2010/11 export ban in Russia. The wheat price dampening effects amount to up to 67% and are strongest in the major wheat exporting region with direct access to the world market. This effect is transmitted to other regions by increased and reversed interregional trade flows. In contrast, we find that regional variation of export controls' domestic price effects in Ukraine is rather small.

Key words: export controls, international trade, agricultural trade policy, Russia, Ukraine, grain markets, food security, extreme weather events, climate change

JEL classification: C22, E30, Q11, Q13, Q17, Q18, Q54

1 Introduction

Grain production in Russia and Ukraine is characterised by extreme weather events. For example, Russia and Ukraine experienced droughts and wild fires in 2010/11 and 2012/13 with the hottest summer since the year 1500 measured in 2010 in Western Russia (Barriopedro et al. 2011). These weather extremes have dramatic consequences for agricultural production. In particular, grain production was in each case 30% below the average levels in Russia and 20%

[1] The authors would like to thank the Russian Grain Union for their valuable support for this study. Furthermore, we acknowledge financial support of the German Federal Ministry of Food and Agriculture through the Federal Office for Agriculture and Food within the project GERUKA "Global Food Security and the Grain Markets in Russia, Ukraine and Kazakhstan" (http://projects.iamo.de/geruka/) and the European Commission through the project AGRICISTRADE (www.agricistrade.eu). The authors are responsible for any errors.

below average levels in the Ukraine in 2010/11 and 2012/13. Grain production was more than 60% below average in some regions of Russia in 2010/11.

There is an intensive debate about the link between the Russian heatwave in 2010 and climate change. Coumou and Rahmstorf (2012) link the heatwaves in Russia with the effects of anthropogenic global warming, pointing out that climate change has increased the probability of such a weather event by a factor of three. In contrast, Dole et al. (2011) see the 2010 Russian drought as a more normal event, not related to anthropogenic climate change.

Russia and Ukraine have a history of restricting grain exports to the world market. Export controls are justified by domestic food security concerns and aim to dampen domestic agricultural prices and ultimately food price inflation. Russia and Ukraine have implemented export controls during the two recent commodity price booms in 2007/8 and 2010/11. Recently, Russia has again implemented a wheat export tax of 15% plus €7.5 on February 1, 2015 which was removed in May 2015 (Götz et al. 2015).

We investigate the effects of wheat export controls on the domestic wheat price to assess their effectiveness in dampening wheat prices in Russia and Ukraine. We follow a price transmission approach and supplement existing studies on export controls' domestic price effects in two respects. Firstly, we explicitly take into account the fact that export controls were implemented in the event of a domestic grain harvest shortfall, which causes additional domestic price effects. Building on the price transmission approach applied by Baylis et al. (2014), Djuric et al. (2015), Götz et al. (2016 and 2013) and Ihle et al. (2009) we modify the selection of the data base in our price transmission model framework accordingly. In particular, these existing studies identify and assess the domestic price effects of export controls by comparing the price transmission regime prevailing when the exports are restricted by export controls to the regime prevailing when trade is freely possible. In doing so, these authors ignore the domestic supply conditions. Instead, we take explicit account of these domestic supply conditions by our selection of the periods without trade restrictions, but with domestic supply shortfalls, as a more appropriate comparator for the actual effects of the trade restrictions. Secondly, we supplement existing studies on export controls in Russia and Ukraine (Fellmann 2014; Götz et al. 2016, 2013) at a national level by following a regional perspective, using region-specific price data to identify and to measure the size of domestic wheat price effects and the effectiveness of export controls in the different regions of Russia and Ukraine. This is supplemented by regional data on grain production and interregional trade flows to provide additional insights into the functioning and mechanism of export controls and to explain the regional pattern of the export controls' domestic price effects.

The remainder of this article is structured as follows. Section 2 provides a literature review. Section 3 offers an overview on export controls implemented in Russia and Ukraine and background information on regional wheat markets. Section 4 describes the theoretical framework for the analysis of domestic price effects in regional markets. Our econometric model, data base, the estimation approach and results are presented in sections 5 to 7, respectively. Results are discussed and conclusions are drawn in section 8.

2 Literature review

Regional effects of export controls have been investigated by Baylis et al. (2014), Baffes et al. (2015) and Ihle et al. (2009) following a regime-switching price transmission approach[2]. Baylis et al. (2014) and Baffes et al. (2015) adopt an approach in which the regime switches are determined exogenously by the knowledge of the time periods when exports were restricted. In contrast, Ihle et al. (2009) use a Markov-switching error correction model (MSECM) approach with an endogenous regime switch, similar to Götz et al. (2013) and Djuric et al. (2015). Götz et al. (2016) confirm that traders may change their pricing behaviour when export controls are expected, but not implemented, and that wheat storage may counteract the influence of export controls, implying that the regime changes may not be congruent with the dates of implementation and removal of export controls. Götz et al. (2016) also compare an endogenous switching smooth transition cointegration (STC) model with an MSECM and also with an exogenous regime-switching model. They find that the STC performs significantly better than the MSECM, but only slightly better than the model with regime-switches set according to exogenous information, i.e. the dates when export controls came into force or ended, respectively. Furthermore, although the STC proves to be the superior model among the models with endogenously determined regime-switch, regime classification in some periods remains a puzzle. This poses a particular challenge if modelling results for several regions are to be compared, and motivates us to follow Baylis et al. (2014) and Baffes et al. (2015), choosing a regime-switching price transmission approach with exogenous regime switch in our multi-region analysis.

[2] Please see the literature review provided by Götz et al. (2016) for the discussion of several papers mentioned in this section.

In the price transmission approaches followed by Djuric et al. (2015), Götz et al. (2013), Götz et al. (2016), Baylis et al. (2014), Porteus (2012) and Ihle et al. (2009), the price effects of export controls are identified and assessed by comparing the price transmission regime prevailing when exports are restricted to that which applies under free trade. However, export controls are often implemented because of a domestic harvest shortfall, which will also influence domestic price developments. A harvest shortfall may counteract the influence of an export control and thus disregarding its potentially confounding influence, particularly if the harvest shortfall is pronounced, may lead to erroneous results.

An exception among the existing studies is Baffes et al. (2015) who explicitly account for the influence of weather anomalies on price changes when investigating price dynamics caused by export bans on 18 maize markets in Tanzania, using an error correction panel model framework. They find that weather shocks have a strong short-run influence on domestic prices, which is less pronounced in markets engaged in regional or international trade. Their results suggest that an export ban has a larger influence on markets in the Northern zone compared to the Southern zone, in contrast to Ihle et al. (2009) who identify a larger influence of the export ban on maize markets in the Southern zone than in the Northern zone of Tanzania. Baffes et al. (2015: 13) conjecture that the disregarding of the influence of weather shocks and harvest cycles in Ihle et al. (2009) explains the difference in results.

Fellmann et al. (2014) also account for the impact of harvest failures when assessing the domestic price effects of export controls in Kazakhstan, Russia and Ukraine by simulations using the partial equilibrium model AGLINK-COSIMO. They find that strong export restrictions in the form of export bans in the event of harvest failure induce little price dampening effects on domestic producer prices in Russia, while those effects are large for Kazakhstan and the Ukraine. They explain the low strength of an export ban's domestic price effect in Russia by their assumption that Russia only exports 23% of its wheat production whereas they assume that Kazakhstan and Ukraine export almost 50% of their production in the respective scenarios.

Porteus (2012) investigates the domestic market effects of export bans for maize in 12 countries of East and Southern Africa (2002-2012) which are often implemented due to local production shortfalls. Assuming that export bans increase trade costs, price differences between markets in maize exporting countries and maize importing countries are investigated while also accounting for the influence, for instance of fuel costs, infrastructure projects, bribes and taxes. However, it is supposed that production shortfalls do not affect trade costs between markets. Results suggest that export bans do not alter price differences between markets. This is explained by referring to optimising behaviour by competitive traders in a rational expectations storage model.

We add to those studies which account for the domestic price effects of a harvest shortage when studying the influence of export controls. Furthermore, this is the first study which investigates the influence of export controls in Russia and Ukraine at the regional level.

3 Regional wheat markets, grain production development and export restrictions in Russia and Ukraine

We provide an overview of the major characteristics and differences of regional wheat markets in Russia and Ukraine. Particular attention is paid to the regional distribution of wheat production and regional grain production development. The different types of export controls implemented in the two countries are explained. We shed light on the export controls' regional trade effects to explain how the price effects of export controls are transmitted across the regions within each country.

Russia

Wheat production in Russia is split between several separate grain production regions (Figure 1). North Caucasus accounts for an average (base: 2005-2013) of 37%, West Siberia and Volga for 17%, respectively, Black Earth and Urals for about 12% and Central for 6% of Russian grain production (Rosstat, 2014).

Usually, Russian grain exports are supplied to the world market via ports in North Caucasus, which, with the Volga and Black Earth regions are the primary grain exporting regions. Under free trade, and with no harvest shortfall, grain flows from Volga and Black Earth towards the North Caucasus. Volga and Black Earth are also involved in intra-Russian wheat trade and primarily supply wheat to the Central region. West Siberia and the Urals are several thousands of kilometres away from the world market, and are rarely engaged in international trade, mainly supplying wheat to the domestic market, especially to the Central region.

Export restrictions were implemented by the Russian government during the 2007/8 and the 2010/11 international commodity price peaks. Wheat exports became limited in November 2007 due to an export tax of 10%. The export tax was increased to a prohibitive level of 40% in December 2007. Export taxes were removed in July 2008. It should be pointed out that the export tax system was implemented although domestic wheat production was 7% above the preceding three years' average level in the marketing year 2007/8 (Table 1). However, wheat exports were extraordinarily high (Figure 2) and the export tax aimed to reduce wheat exports induced by high world market prices, and hence dampen domestic wheat price increases. Nevertheless, in early 2008 domestic prices increased beyond the world market price level in all of the 6 regions (Figure 2).

Table 1: Wheat export restrictions, grain production and wheat exports in Russia and Ukraine

	2005/6	2006/7	2007/8	2008/9	09/10	10/11	11/12	12/13
					Russia			
Export control			tax			ban		
production (% of average)**	110	106	107	136	116	71	100	70
exports (% prod.)	22	24	25	29	30	10	38	30
					Ukraine			
Export control		quota	quota			quota	tax; MoU	indirect controls; MoU
production (% avg.)**	128	110	83	167	117	83	105	79
exports (% prod.)	35	24	9	50	45	26	24	46

** average of the respective 3 previous years;

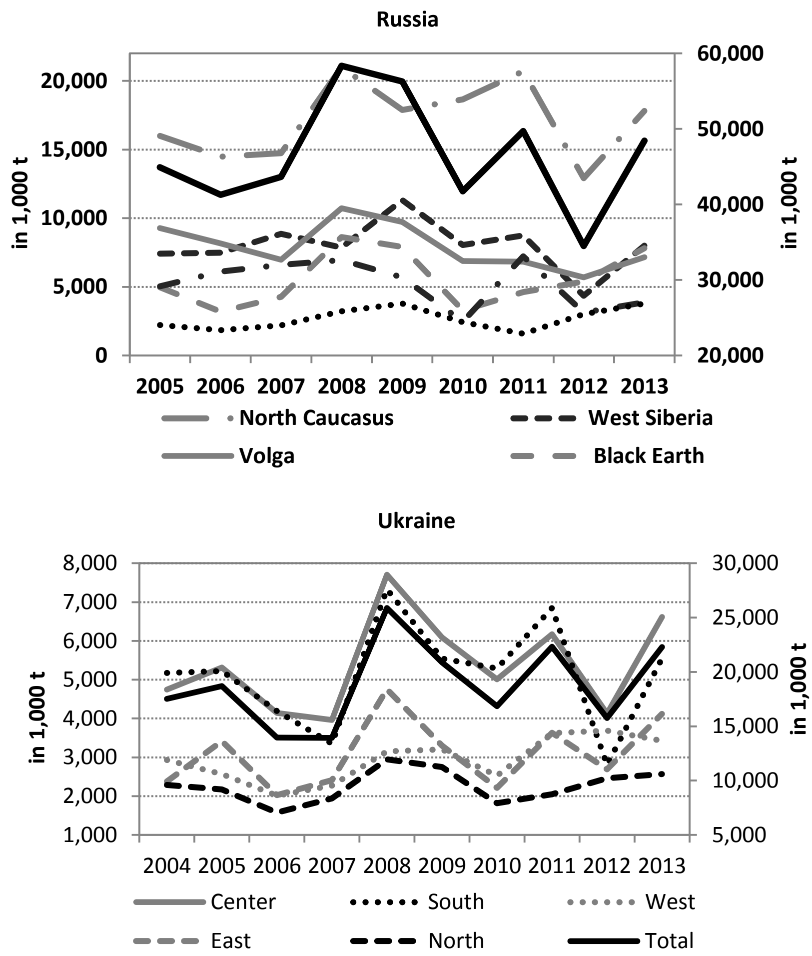
Sources: USDA (2015), Ukrstat.

Russia again restricted wheat exports during the 2010/11 commodity price peak. In August 2010 wheat exports were forbidden by an export ban, when total domestic wheat production was 29% below the preceding three years' average, with regional production shortfalls of up to over 60% (see Figure 1). The wheat export ban was cancelled in July 2011.

In contrast, exports remained freely possible during the 2012/13 marketing year, although total grain production was similar to 2010/11, about 30% below average. However, the pattern of the regional grain production shortfall was different. Production was almost average in Central and Black Earth regions, whereas West Siberia, Urals and North Caucasus were most severely hit with production levels that were 54%, 49% and 32% below average, respectively (Table 2). Similar to 2007/8 and 2010/11, wheat exports to the world market ceased in 2012/13, but without any export restrictions (Figure 2).

Favourable production conditions and thus relatively high yields can be observed in some regions but relatively low yields in other regions at the same time. For example, grain production was 4% above average in North Caucasus in the marketing year 2010/11, whereas the regions Volga, Urals and Black Earth were severely hit by the drought with grain production 66%, 62% and 54% below average, respectively (Table 2).

Figure 1: Regional grain production development Russia and Ukraine



Notice: "Total" refers to secondary axis

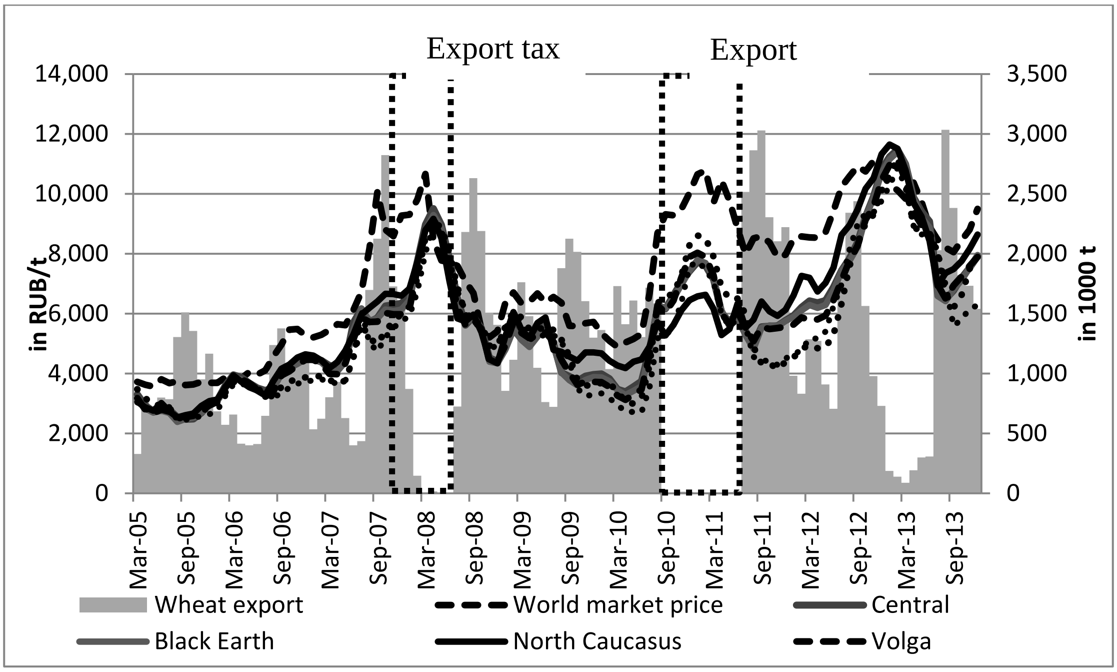
Sources: Agency of statistics of the Republic of Kazakhstan (2014), APK-Inform (2014), Rosstat (2014), Ukrstat (2014).

This explains why reversed trade flows were observed during the 2010/11 export ban. Figure 3 clearly demonstrates that large amounts of wheat were supplied by North Caucasus to the Volga region during the export ban 2010/11, whereas the Volga supplies wheat to North Caucasus if trade is freely possible and there is no harvest shortfall. Interregional grain trade flows by train are presented in Table 3 as an indication of grain trade within Russia during the export ban[3]. In

[3] It should be pointed out that in addition to rail transportation, grain is transported by truck particularly when the distances involved are short. Therefore, it can be assumed that the interregional grain export quantities were actually higher, especially between neighboring regions.

particular, North Caucasus exported large amounts of grain to Central, Black Earth, Volga and Ural, and West Siberia exported grain to the Urals, Volga and Central districts.

Figure 2: Development regional wheat prices and exports Russia



Sources: GTIS (2013), HGCA (2014), Russian Grain Union (2014).

Table 2: Regional wheat production developments Russia (2005-2013), as % of the average of the previous 3 years

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

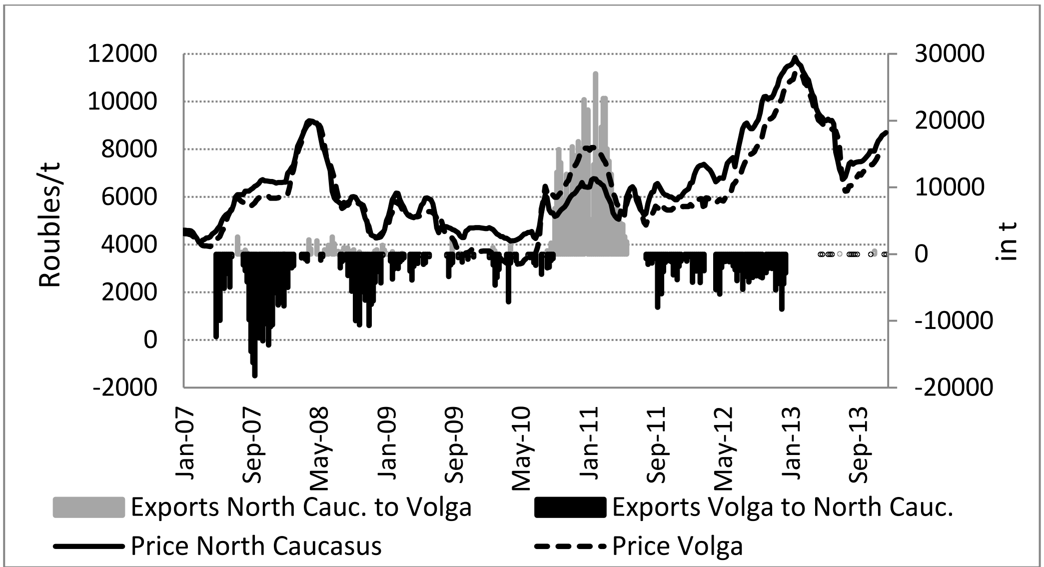
Source: Rosstat (2014).

Table 3: Interregional grain trade quantities (in t) by train, Russia, August 2010 - June 2011

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

Sources: Rosstat (2014). Notice: exports < 0; imports >0; in tons

Figure 3: Interregional train grain trade flows and wheat prices North-Caucasus-Volga, 2007-2013



Sources: Rosstat (2014)

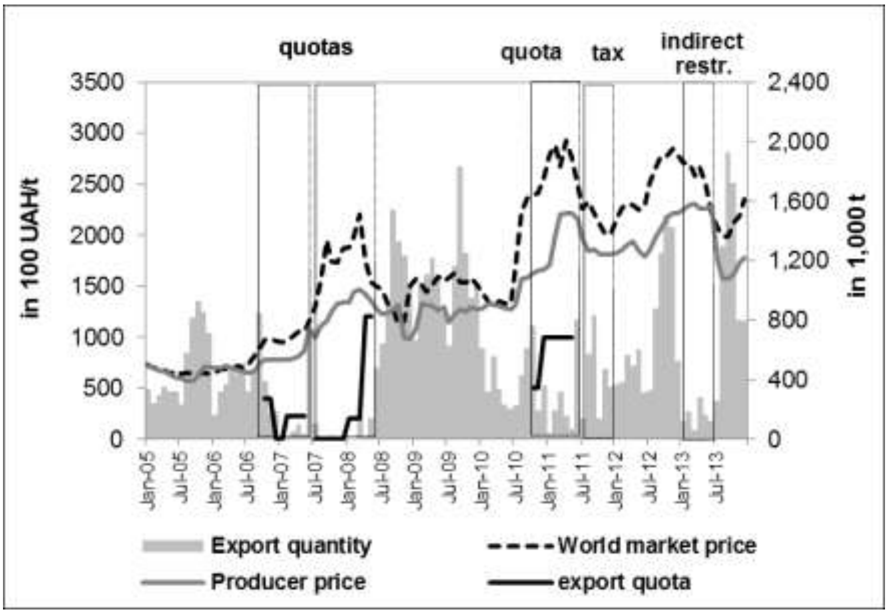
Ukraine

Similar to Russia, grain production is also divided between different regions in the Ukraine. The primary production regions are in the central and southern Ukraine, accounting for 29% and 27%, respectively (Figure 1). Grain production in western and eastern regions accounts for 16%, whereas the northern region accounts for 12% of Ukraine's total wheat production (Ukrstat, 2014).

Although grain production is distributed throughout the whole of Ukraine, the distance between the different production regions is small. Thus, as distinct to Russia, production regions are basically affected by similar climatic and weather conditions, with production shortages or surpluses occurring in all production regions simultaneously. Also, the difference in the distance of the grain production regions of Ukraine to the Black Sea ports is low compared to Russia. In particular, the grain producing regions are all within 700 km distance to the Black Sea ports. This explains the rather small difference in regional wheat prices as shown in Figure 5. However, the development of wheat prices in

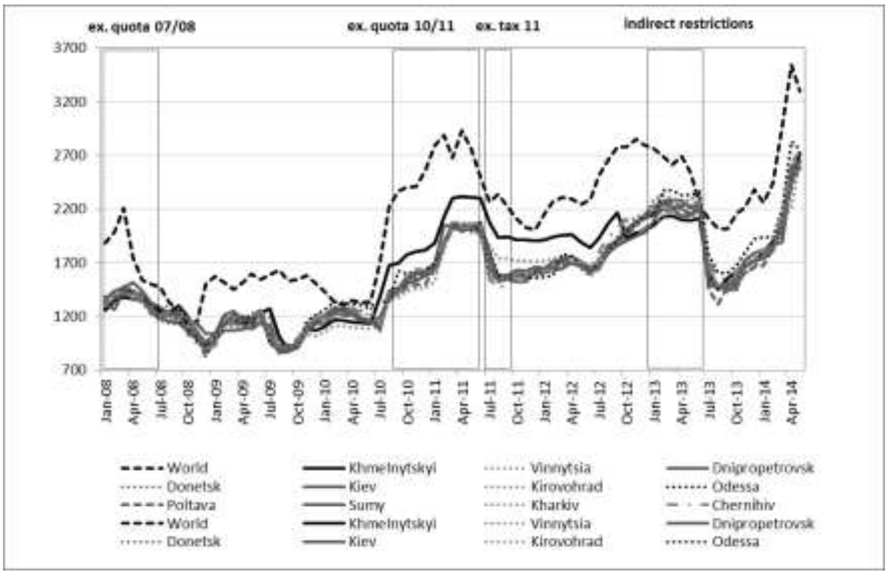
Khmelnytskyi region is an exception. During the 2010/11 export quota, the 2011 export tax and post-harvest 2012, prices in the Khmelnytskyi region were significantly higher than in other regions[4].

Figure 4: Development of wheat prices and exports Ukraine



Sources: APK-Inform (2014b), GTIS (2013), HGCA (2014), Rosstat (2014).

Figure 5: Development of regional milling wheat prices in Ukraine



Notice: Prices are averages of milling and bread wheat prices

[4] The higher bread wheat prices in the Khmelnytskyi region in 2010 through 2012 were driven by 2 key factors: 1) the Khmelnytskyi region is a key supplier of high quality bread wheat for the western regions of Ukraine. In 2010 the wheat production shortfall in Khmelnytskyi region was even more pronounced than in Ukraine overall. 2) In addition, during the 2011/12 marketing year, bread wheat supply in the Central regions was particularly low due to problems with corn-bugs, which harm the gluten in the wheat kernel such that the wheat cannot be used for baking. The resulting shortages of suitable bread making wheat drove prices up.

Source: APK-Inform (2014b).

An export quota system (government licence) was implemented in the Ukraine during both world market price peaks. Export quotas varying between 3,000 tons and 1.2 million tons were in force from October 2006 to April 2007, from June 2007 until May 2008, and from October 2010 until May 2011 (Figure 4). The size of the quota was changed repeatedly and the quota system was extended multiple times (APK-Inform, 2014a).

In addition, Ukraine implemented a wheat export tax of 9% in July 2011, which was removed in October 2011. Following this, the Ukrainian government regularly signed a Memorandum of Understanding (MoU) with the grain exporting companies on the procedures for monitoring grain availability and export practices. Also, it specified the maximum grain exports for which trade remained open. If actual exports exceeded this maximum, trade was restricted. During the 2012/13 marketing year wheat exports became indirectly restricted by making it more difficult to get access to train wagons required to transport grain to the harbour and to obtain phytosanitary certificates, which are a mandatory requirement for exports.

Wheat production in Ukraine was 10% above average in 2006/7 and 17% below average in 2007/8, respectively (Table 1). Grain production was 17% below average size in the 2010/11 marketing year but was 5% higher in 2011/12. Nonetheless, exports were restricted in the 2010/11 and 2011/12 marketing year.

4 Economics of domestic regional price effects of export controls

Export restrictions are introduced either to prevent rapid or dramatic increases in world prices from being transmitted to domestic markets, or to retain domestic supplies for the home market in the face of domestic harvest shortfalls, and thus to keep domestic prices below world prices. Such domestic price dampening effects can be understood as the result of two partial effects, a domestic supply effect and a price insulating effect. By decreasing the size of exports and increasing the supply on the domestic market, export controls reduce the domestic market price compared to the price that would prevail if trade was possible.

As the second effect, export controls separate domestic prices from world market price developments and prevent high prices prevailing on the world market from being transmitted to the domestic market. In particular, if arbitrage activities become restricted or even prohibited, domestic prices become to some degree insulated from price developments on the world market, and the importance of domestic factors for domestic price determination increases, whereas the influence of the international prices decreases. Since export controls are usually implemented when world market prices are increasing, price insulation contributes to the dampening of the domestic price relative to the world market price (compare Götz et al. 2016).

The price dampening effect is relevant to the region with direct access to the world market and normally exports to the world market. In general, any export control (export quota, export tax or an export ban) can be depicted as an export tax (Alston and James 2002), with an export ban considered as a prohibitive export tax, reducing the fob price.

The change in the fob price is transmitted to the producer price in the exporting region and further to the other regions according to the degree of integration of the regional markets. Markets become integrated by spatial arbitrage, either directly by trade between the regions themselves or indirectly through the network via the trading linkages that connect the regions (Fackler and Goodwin 2001: 979). According to the Law of One Price, regional prices differ at most by the size of transaction costs if markets are efficient, resulting in an optimal resource allocation.

However, export restrictions are often implemented in the situation of a production shortfall which might be regionally specific. A harvest shortage decreases domestic supply regionally, inducing price increasing effects, which may raise domestic regional prices beyond world market prices. Export controls counteract the price increasing effects of regional harvest shortfalls by reinforcing incentives for trade flows from regions with supply surplus to regions experiencing a harvest shortfall.

5 Model framework

To measure the price effects of export controls in the different regions, we utilise a price transmission approach similar to Baylis et al. (2014), Götz et al. (2016), Götz et al. (2013), and Ihle et al. (2009).

The influence of the export controls is captured by a regime-switching long-run price transmission model, which can be represented as follows:

$$\ln\left(p_t^d\right) = \alpha + \gamma_\alpha * D_t + \beta * \ln(p_t^{wm}) + \gamma_\beta * D_t * \ln(p_t^{wm}) + u_t; \qquad t = 1, \dots, \dots n \qquad (1)$$

where p^d is the domestic price and p^{wm} is the relevant world price, with α and $(\alpha + \gamma_\alpha)$ the intercept parameter of the "free trade" and the "restricted trade" regime, β and $(\beta + \gamma_\beta)$ the slope parameter of the "free trade" and the "restricted trade" regime, respectively. D_t denotes a dummy variable with $D_t = 1$ if export restrictions apply ("restricted trade regime") and $D_t = 0$ otherwise, i.e. if trade is freely possible ("free trade regime").

The parameters of the "free trade" regime are estimated based on prices observed when trade is freely possible whereas the parameters of the "restricted trade" regime are evaluated based on price observations when trade is restricted by export controls. The intercept parameter represents the trade costs including transaction costs and the slope parameter can be interpreted as the long-run price transmission elasticity, indicating the degree to which changes in the world market price are transmitted to the domestic price. In particular, if the world market price increases by 1%, then the domestic price increases by β or $(\beta + \gamma_\beta)$ per cent.

Previous studies have demonstrated that the long-run price equilibrium under export controls is characterised by a larger value of the intercept parameter, and a smaller value of the slope parameter compared to when trade is freely possible. Similar to Götz et al. (2016) we assume that the difference in the intercept parameter γ_α corresponds to the domestic supply effect, and the difference in the slope parameter γ_β reflects the price insulating effect (compare section 4) in our model framework as given by (1). Thus, we expect $\gamma_\alpha > 0$ and $\gamma_\beta < 0$.

We recognise that the export ban in Russia 2010/11 was implemented in a situation of marked domestic harvest failures by modifying the selection of the data base to estimate the price transmission model (1). To identify the effect of the export ban during this shortage period, we limit our database in a separate analysis to those prices which were observed when a production shortfall prevailed. Accordingly, we compare prices observed when the export ban 2010/11 was implemented in the situation of a strong harvest shortfall, with prices observed when trade was freely possible during a harvest shortfall as in 2012/13. Thus, α and β are the model parameters characterising a regime which we term "free trade under production shortage" and $(\alpha + \gamma_\alpha)$ and $(\beta + \gamma_\beta)$ distinguish the regime "restricted trade under production shortage".

For Ukraine, the production shortfall was less pronounced compared to Russia. Therefore, we compare prices observed when export controls were implemented and compare it to prices when trade was freely possible in the case of Ukraine.

A significant drop in production in one region decreases regional supply and increases the regional domestic price which could even rise beyond world market prices. Therefore, we expect that a long-run price equilibrium between the regional and the world market price under circumstances of production shortage is characterised by the decrease in the intercept parameter (relative to non-shortage periods), corresponding to a decrease in levels of regional supply.

As illustrated above, the dampening effect of the domestic price is the result of the domestic supply effect and the price insulating effect. Basically, the price dampening effect of the export controls is calculated as the average change in the difference between the world market and the domestic market price in the "restricted trade" regime ($D_t = 1$) when compared to the "free trade" regime ($D_t = 0$). This indicator informs us of the percentage by which the domestic price was decreased by the export controls relatively to the world market price. To calculate the domestic price dampening effect we make use of the parameters estimated by the model as given by (1) and simulate the domestic wheat prices p^d:

$$\text{price dampening effect} = \left(\sum_{t=1}^{n} \frac{(p_t^{wm} - e^{(\alpha+\beta*\ln(p_t^{wm}))})}{e^{(\alpha+\beta*\ln(p_t^{wm}))}} * D_t;\ D_t=0\right) - \left(\sum_{t=1}^{n} \frac{(p_t^{wm} - e^{((\alpha+\gamma_\alpha)+(\beta+\gamma_\beta)*\ln(p_t^{wm}))})}{e^{((\alpha+\gamma_\alpha)+(\beta+\gamma_\beta)*\ln(p_t^{wm}))}} * D_t;\ D_t=1\right) \quad (2)$$

where $p_t^d = e^{(\alpha+\beta*\ln(p_t^{wm}))} * D_t$ with (D_t=0) is the simulated domestic price if trade is freely possible

and $\overline{p_t^d} = e^{((\alpha+\gamma_\alpha)+(\beta+\gamma_\beta)*\ln(p_t^{wm}))} * D_t$ with (D_t=1) is the simulated domestic price if export controls are implemented

which provides the % change in the difference between the world market price and the domestic price relatively to the domestic price when exports become restricted to when exports are freely possible.

We also calculate the price insulating effect which is provided by the % change in the long-run price transmission elasticity in the regime "restricted trade" compared to the "free trade" regime as follows:

$$\text{Price insulating effect} = -\frac{\gamma_\beta}{\beta}*100 \quad (3)$$

assuming that the change in the long-run price transmission elasticity results from export controls.

If a domestic supply effect is observed, then $\gamma_\alpha > 0$. However, a quantitative assessment of the domestic supply effect is not possible within this framework.

6 Data

We study the regional domestic price effects of the export ban (2010/11) in Russia, the export quota regimes (2006/7, 2007/8, 2010/11) and the export tax (2011) in Ukraine to assess the export controls' effectiveness in dampening regional wheat prices. In our analysis of the export ban 2010/11 in Russia, we account for the influence of the pronounced grain harvest failure on domestic prices.

For Russia we use weekly wheat ex warehouse region-specific price series (2005-2013) of Class III milling wheat (Russian Grain Union, 2014) for the regions North Caucasus, Black Earth, Central, Volga, West Siberia and Urals (Figure 2).

The regime-switching long-run price transmission model given by (1) is estimated for each region individually. Our data set comprises 26 region-specific price observations (January - June 2013) observed in times of domestic production shortage, but when trade remained open, and 47 region-specific price observations during the export ban 2010/11 against the backdrop of a production shortfall (August 2010 - June 2011). From this regime-switching model we retrieve the parameters of the regime "free trade under production shortage" and the "restricted trade under production shortage" regime[5]. In addition, we estimate a linear long-run price transmission model based on 360 observations when production levels were about average to retrieve the parameters of the "free trade" regime.

We also follow a regional perspective to capture the domestic price effects of export restrictions in the Ukraine. We use monthly wheat ex warehouse price series (January 2008 - May 2014) for class III milling wheat (APK-Inform, 2014b) for 11 Ukraine regions (Figure 5). We use the FOB price of wheat (French soft wheat, class 1) in Rouen, France (HCGA, 2014) as the world market price[6] for each of the regions and countries. Since Ukrainian and Russian class III wheat is usually used for bread production, we use a French bread wheat type, which is heavily traded internationally, as the counterpart[7].

Grain production in the Ukraine was about 20% below 2005-2013 average levels in 2007, 2010 and 2012 and thus the production shortfall was less pronounced compared to Russia with a production shortfall of 30% in 2010 and 2012. However, we have no data on a period of

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5 We use a very general definition of a production shortage period. A period represents a shortage period if production is significantly below the average of the production levels of the last 3 years, and exports to the world market are not detected or very small. Table 1 indicates that a shortage period or a grain marketing year of a shortage has been detected in Russia in 2010/11 and 2012/13 with a production shortfall of about 30% on average. Regionally, production shortfalls vary up to between 50% and 65% in those two marketing years. We choose wheat price observations of 2012/13 as the shortage data base for which wheat exports to the world market are almost not detected, although trade was freely possible (January to June 2013).

6 We would prefer a FOB wheat price at one of the Black Sea ports as the world market price in the time period underlying our analysis. However, a continuous price series is not available due to export controls in Russia and Ukraine 2007/8 and 2010/11. Therefore, we use a French FOB price at the port of Rouen which is governed by the price developments of the MATIF (commodity futures market). According to grain traders' information, MATIF prices are increasingly relevant for wheat trade in the Black Sea region. The MATIF dominates spot market prices at the port of Rouen, the primary harbour through which wheat is exported from France to the international markets.

7 For the influence of the different qualities of wheat on price transmission in the world wheat market please see Ghoshray (2002).

domestic shortage and open trade for the Ukraine, so we cannot account for the influence of the wheat harvest shortage in the estimates for the Ukraine. Therefore, the parameters of the regime "restricted trade" are estimated based on 17 prices observed during the export quota in 2008, the export quota 2010/11 and the export tax in 2011.[8] The corresponding regime "free trade" is estimated based on 60 price observations during 2008-2014, when wheat trade was not restricted by official export controls.

Due to the low frequency (monthly) of the regional prices of Ukraine, we additionally calculate our indicators based on national averages for weekly wheat ex warehouse prices of class III milling wheat 2005-2012 to identify the effects of the different export control regimes (export quota: 10/2006-05/2007; 06/2007-05/2008; 10/2010-05/2011; export tax: 07-10/2011) for Ukraine individually, (Figure 4). Table 6 demonstrates that 30, 53, 38, 17 and 279 price observations were used to estimate the parameters for each of the four "export control" regimes ("quota 2006/7", "quota 2007/8", "quota 2010/11" and "tax 2011") and the "free trade" regime, respectively.

We find our data series integrated of order 1 based on the ADF-test and the KPSS test results (on-line Appendix, Table S1) and all price pairs cointegrated with the world market price according to the results of Johansen trace test (on-line Appendix, Table S2).

7 Estimation approach and results

Results of the Granger-causality test (Toda and Yamamoto (1995) procedure) suggest that the world market price Granger-causes the regional price for all price pairs for Russia and Ukraine at the 5% significance level (Appendix, Table S3). These results also imply that the regional price does not Granger-cause the world market price for all regions except the Black Earth region of Russia[9]. As a consequence, w assume that the world market price is exogenous for all price pairs and estimate the long-run price equilibrium regression with ordinary least squares (OLS) in line with Engle and Granger (1987) for all price pairs[10]. OLS provides economically

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8 However, the MoU was in place and traders reported indirect restrictions on exports, e.g. by limiting the available number of wagons to transport grain to the harbour, which increased export risk and trade costs (APK-Inform, 2014a).

9 The result for the Black Earth region is questionable against the backdrop that the hypothesis is rejected for North Caucasus, the primary grain export region with direct world market access. Since Black Earth is exporting through North Caucasus region, we would rather expect that the hypothesis is rejected for North Caucasus than for Black Earth according to economic theory.

10 Assuming the domestic and the world market prices are cointegrated, the OLS regression yields consistent and efficient estimates of the long-run equilibrium parameters (Stock, 1987). For comparisons of estimators please for instance refer to Abeysinghe and Boon (1999) and Wickens and Breusch (1988).

interpretable parameters for almost all price pairs for Russia and Ukraine. Exceptions are the models for West Siberia and Urals, which are estimated with fully modified ordinary least squares (FMOLS; Phillips and Hansen, 1990). Whenever test results indicate heteroscedasticity (White test) and/or autocorrelation (Breusch-Godfrey test), the covariance is corrected with FMOLS or the heteroscedasticity and autocorrelation consistent (HAC) covariance estimator (Newey and West, 1987). We use the Wald-test to test whether the slope coefficient of each regime is equal to one, and whether the slope coefficients of the different regimes are equal.

In general, parameter estimates for the "free trade" regime for the regions of Russia suggest that the pattern of world market integration of the different regions is strongly influenced by distance (and thus transaction costs) of grain transportation from each region to the world market (Table 4). For example, in the case of the North Caucasus region, which has direct access to the ports at the Black Sea, has the lowest intercept parameter compared to the other regions, and even not statistically significantly different from zero. Further, the long-run price transmission elasticity (represented by the slope parameter) is highest, effectively equal to 1. By contrast, the intercept parameter is highest and the long-run price transmission parameter is the lowest for West Siberia and Urals, the grain production regions which are the most distant to the world market (Table 4).

The results also confirm the expected price effect of a harvest failure. In particular, for all 6 regional price pairs the intercept parameter of the long-run equilibrium regression decreases between the "free trade" and the "free trade under production shortage" regimes.

Regarding the export ban 2010/11 in Russia, we compare parameter estimates of the "free trade under production shortage" regime with the "restricted trade under production shortage" regime. A price insulating effect as given by equation (3) is identified for 4 regions and a price dampening effect as given by equation (2) is detected in all 6 regions (Table 4).

The price insulating effect is markedly heterogeneous among the regions. It is most marked in the Northern Caucasus, the region with direct access to the world market, amounting to 76%. This means that the export ban 2010/11 has dampened the domestic wheat price in North Caucasus by 76% compared to when trade was freely possible. Significant price dampening effects are also identified for Central (44%) and Black Earth (46%), two regions with strong trade relations with North Caucasus. The price insulating effect is lowest for Volga (31%), Urals (35%) and West Siberia (2%), which are further away from the world market access harbours in North Caucasus. In addition, West Siberia and Urals both usually don't export to the world market, but rather to other regions within Russia. This explains why the interruption of exports to the world market has a smaller effect on world market price transmission to those regions and is corroborated by the results of the Wald-test, which cannot reject the hypothesis regarding Volga and Urals that the long-run price transmission is equal in both regimes.

The domestic supply effect is also corroborated for all regional price pairs except West Siberia, which is reflected by an increase in the intercept parameter in the “restricted trade under production shortage” regime compared to the “free trade under production shortage” regime. West Siberia, with North Caucasus, are the only regions exporting grains interregional during the export ban. Differing to North Caucasus, a domestic supply effect is not observed in West Siberia. This may be explained by the large grain stocks which were built up during the export ban in North Caucasus, which disposes over substantial grain storage facilities, but not in West Siberia, whereas storage capacities are deficient.

A price dampening effect, which results from the price insulating and the domestic supply effect, is also identified in all regions. It is strongest in North Caucasus and West Siberia amounting to 67% and 55%, respectively, and is lowest in the regions Volga and Urals, which were most severely hit by the drought, amounting to 45% and 35%, respectively.

For comparison, Table 4 also presents the estimates for the regional price insulating and the price dampening effect without accounting for the influence of a harvest failure in the estimation. In this case we compare the parameters of the “restricted trade under production shortage” regime to the “free trade” (and not “free trade under production shortage”) regime. In this case, a price insulating effect is not identified for West Siberia and Urals and a price dampening effect is not identified for Urals. The results for West Siberia and Urals contradict economic theory. These results confirm our argument that accounting for domestic supply effects is necessary to correctly identify the domestic price effects of export controls.

World wheat market integration of the regions of Ukraine is also rather strong when trade is freely possible, varying slightly between 0.75 in Sumy and 0.89 in Kirovohrad (Table 5). Also, results of the Wald-test do not allow to reject the hypothesis that the long-run price transmission elasticity is equal to one for each region.

The price insulating effect varies between 32% in Kirovohrad and 13% in Kharkiv suggesting that due to the export restrictions implemented 2008-2011, the domestic wheat price was dampened strongest in Kirovohrad by 32% and least in Kharkiv by 13% compared to when trade was freely possible. No price insulating effect is observed in Khmelnytskyi region (compare footnote 3). A price dampening effect is observed in all regions, varying between 1% and 12%. Thus, regional variation in the domestic price effects is rather small.

As illustrated above, as a result of the limitations of our regional price data set, we identify the effects of the export quota 2008, export quota 2010-11 and export tax 2011 jointly. Comparing the parameters of the “restricted trade” regime with the “free trade” regime, we find the intercept increasing (domestic supply effect) and the slope coefficient decreasing (price insulating effect) according to theoretical expectations for 10 out of 11 regional price pairs. An exception is the Khmelnytskyi region (see footnote 5, section 3).

The analysis based on the national average price data for the Ukraine allows us to assess the domestic price effects of the export restrictions individually (Table 6). As expected, we find that the intercept parameter of the long-run equilibrium regression increases in the “restricted trade” regime when compared to the “free trade” regime for all phases of export controls. Also, the slope parameter decreases in all cases except the export tax system 2011. We identify a price insulating effect during the three export quota systems, amounting to 40%, 35% and 4% during the 2006/7, 2007/8 and 2010/11 export quota system.

The estimate for the price insulating effect during the export tax amounting to 9% in 2011 is slightly puzzling, and appears too high compared to the other cases. In contrast, the estimated price damping effect of 10% of the export tax system 2011 is the lowest compared to the other cases of export controls. The price dampening effect is highest during the export quota 2010/11 amounting to 26%, followed by 23% for the export quota 2007/8 and 12% for the export quota 2006/7.

Table 4: Region-specific parameter estimates and indicators for Russia

Region	North Caucasus	Central	Black Earth	Volga	West S.	Urals
regime "free trade" - 360 observations						
Intercept	-0.037	0.578***	0.479***	0.664***	0.901***	1.701***
Slope	0.982***	0.905***	0.914***	0.892***	0.857***	0.769***
Wald test (p-val.), H_0: slope=1	0.256	0.000	0.000	0.000	0.000	0.000
White test (Prob. Chi-Square)	0.001	0.003	0.002	0.000	0.000	0.000
Breusch-Godfrey LM test (Prob. Chi-Square)	0.000	0.000	0.000	0.000	0.000	0.000
regime "restricted trade under production shortage" - 47 observations (export ban 2010/11)						
Intercept	5.090***	3.603**	3.169*	2.357	-2.453	-0.039
Slope	0.392**	0.567***	0.614***	0.703***	1.219***	0.972***
Wald test (p-val.), H_0: slope=1	0.001	0.026	0.059	0.199	0.344	0.877
White test (Prob. Chi-Square)	0.111	0.020	0.041	0.013	0.529	0.064
Breusch-Godfrey LM test (Prob. Chi-Square)	0.000	0.000	0.000	0.000	0.000	0.000
regime "free trade under production shortage" - 26 observations (January-June 2013)						
Intercept	-5.516*	-0.049	-1.142	-0.171	-2.202	-4.585
Slope	1.603***	1.010***	1.128***	1.019***	1.239**	1.499**
Wald test (p-val.), H_0: slope=1	0.060	0.970	0.648	0.948	0.721	0.503
White test (Prob. Chi-Square)	0.033	0.116	0.217	0.026		
Breusch-Godfrey LM test (Prob. Chi-Square)	0.000	0.000	0.000	0.000		
Wald test (p-val.) H_0: slope "restr. trade under prd. shortage" = regime "free trade under prd. shortage"	0.000	0.023	0.013	0.173	0.027	0.598
indicators domestic price effect, harvest shortfall is accounted for						
Price insulating effect	76%	44%	46%	31%	2%	35%
Price dampening effect	67%	50%	50%	45%	55%	35%
indicators domestic price effect, harvest shortfall not accounted for						
Price insulating effect	61%	37%	30%	21%	-20%	-11%
Price dampening effect	43%	17%	15%	13%	14%	-2%

Source: own calculations.

Table 5: Region-specific parameter estimates and indicators for Ukraine

Region	Vinnytsia	Dnipropetrovsk	Donetsk	Kiev	Kirovohrad	Odessa	Poltava	Sumy	Kharkiv	Khmelnytskyi	Cherni
					regime “free trade” - 60 observations						
intercept	**1.377*** **	**1.135 *** **	**1.323*** **	**0.980*** **	**0.521**	**0.997*** **	**1.015*** **	**1.574*** **	**1.275*** **	**0.598**	**1.106** **
slope	**0.779*** **	**0.811*** **	**0.787*** **	**0.831*** **	**0.891*** **	**0.833*** **	**0.825*** **	**0.752*** **	**0.792*** **	**0.888*** **	**0.817*** **
Wald test (p-val.), H_0: slope=1	0.001	0.001	0.001	0.005	0.070	0.010	0.005	0.000	0.000	0.056	0.004
					regime “restricted trade” - 17 observations (export quota 2008, export quota 2010-11, export tax 2011)						
intercept	**2.411** **	**2.337** **	**2.931*** **	**1.974** **	**2.725*** **	**2.220** **	**2.404*** **	**3.199*** **	**2.031** **	**0.328**	**2.202*** **
slope	**0.642*** **	**0.651*** **	**0.576*** **	**0.700*** **	**0.602*** **	**0.669*** **	**0.641*** **	**0.542*** **	**0.691*** **	**0.925*** **	**0.669*** **
Wald test (p-val.), H_0: slope=1	0.039	0.027	0.012	0.074	0.017	0.063	0.036	0.009	0.061	0.654	0.052
White test (Prob. Chi-Square)	0.007	0.055	0.159	0.013	0.218	0.031	0.042	0.108	0.003	0.044	0.025
Breusch-Godfrey LM test (Prob. Chi-Square)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Price insulating effect	18%	20%	27%	16%	32%	20%	22%	28%	13%	-4%	18%
Price dampening effect	10%	10%	9%	7%	8%	11%	10%	7%	9%	1%	12%

[1] Based on parameters of the “free trade” regime they are estimated based on prices observed when trade is freely possible, whereas the parameters of the “restricted trade” regime are evaluated based on prices observed when exports are restricted.

*** <1%, **, 5%, *10% significance level;

Source: Own calculations.

Table 6: Parameter estimates and indicators for Ukraine based on national average prices

	regimes "restricted trade"				regime "free trade"
	quota 2006/7	**quota 2007/8**	**quota 2010/11**	**tax 2011**	
nb. of obv.	30	53	38	17	279
intercept	3.55***	3.45***	1.74	6.53***	1.19***
slope	0.46***	0.5***	0.74***	0.13**	0.82***
Wald test (p-val), H_0: slope=1	0.000	0.000	0.330	0.000	
White test (Prob. Chi-Square)	0.002				
Breusch-Godfrey LM test (Prob. Chi-Square)	0.000				
	indicators of domestic price effects[1]				
Price insulating effect	40%	35%	4%	83%	
Price dampening effect	12%	23%	26%	10%	

[1]compared to free trade regime;

*** <1%, **, 5%, *10% significance level;

Source: Own calculations.

8 Conclusions

We investigate the domestic wheat price effects of export controls to assess their effectiveness at the regional level in Russia and Ukraine. In contrast to existing estimation frameworks, we explicitly account for the effects of a domestic production shortage on domestic wheat price effects. To do so, we modify the database for the analysis of the export ban 2010/11 in Russia, when a harvest shortfall of 30% on average and up to 60% at the regional level was observed.

Our results confirm a domestic wheat price effect of a harvest failure for all regional price pairs of Russia. This is in line with Baffes et al. (2015) who also show that weather shocks have a strong short-run influence on local prices. The identified regional wheat price effects of the export ban implemented in Russia in 2010/11 demonstrate a pronounced variation. In particular, the price insulating effect varies between 76% and 2%. For the regions Volga and Urals, the Wald-test does not support a price insulating effect, which we interpret as evidence for the low influence of the world market price and thus the export ban on price formation in those regions. The price dampening effect varies between 67% and 35% in the 6 regions. The price dampening effect is by far the strongest in North Caucasus (67%), the region which has direct access to the world market and through which the vast majority of wheat exports of Russia at large are operated. Our modified estimation approach applied to the export ban in Russia 2010/11 is shown to be superior to the conventional approach in existing studies. Comparing results of the two estimation approaches makes it clear that domestic price effects of export restrictions cannot be properly identified without accounting for domestic supply effects caused by a harvest shortfall.

Data on interregional grain trade flows by train show that Russian interregional grain trade increased and was reversed during the export ban. This suggests that the price dampening effect of the export ban observed in North Caucasus was transmitted to the regions Black Earth, Central and Volga through grain exports from North Caucasus to these regions. In particular, grain production in North Caucasus was even slightly above average, whereas Volga and Urals were affected by a grain production shortfall of over 60% when the export ban was implemented in 2010. Although substantial amounts of grain were imported by the Urals from West Siberia and North Caucasus, it seems that the below average grain supply levels in the Urals had a marked increasing effect on the regional grain price, which explains why the price dampening effect was substantially lower in the Urals (35%).

If trade is freely possible, wheat price formation in North Caucasus, the primary export region, is strongly influenced by world market price developments. If trade becomes prohibited, the influence of the world market on the price in North Caucasus decreases, whereas the importance of domestic factors increases. In contrast, West Siberia, the grain-producing region which is most distant from the world market, primarily supplies its surplus supply to deficit regions within Russia, regardless of whether international trade (usually via North Caucasus) is open or restricted. This is in line with our findings that the strongest price insulating effect of the export ban is observed in North Caucasus (76%) whereas it is by far the lowest in West Siberia (2%). However, more comprehensive analysis on regional wheat market integration in Russia during the export ban 2010 is required to substantiate this evidence, which is beyond the scope of this paper (cf. Serebrennikov et al., 2014).

In contrast, the regional variation of the export controls' domestic price effects in Ukraine is small. The price insulating effect varies between 13% and 32%, whereas the price dampening effect varies between 1% and 12%. Compared to Russia, distance between the different regions of Ukraine and between the even peripheral grain production regions and access to the world market is rather small. Also, grain producing regions are affected by essentially the same weather conditions implying that regional grain production development is rather similar. Regarding the price effects of the export quota 2006/7, 2007/8 and 2010/11 we do not find unambiguous differences in the domestic price effects. Due to the frequent and unexpected changes in the export controls, the distinction of additional regimes might be required to identify the price effects more clearly. Compared to Götz et al. (2016), the identified price dampening effect is of the same size in 2010/11 and a bit lower in the other periods of export controls. Thus, all results suggest a significantly weaker price dampening effect for Ukraine, when exports remained possible up to a certain degree, compared to the export ban 2010/11 in Russia when exports became completely forbidden.

This study has implications for modelling agricultural trade policies in the case of Russia, where agricultural production is located in several distant production regions, by demonstrating the importance of a regional modelling approach. In particular, our results for the wheat export ban in Russia differ from the scenario results produced by Fellmann et al. (2014). Based on a partial equilibrium model they find that given a 30% production shortfall, a wheat export ban leads to a 6% decrease of the Russian producer price compared to free trade. They explain this low value by their assumption that only 23% of total wheat production at a national level is exported by Russia. This assumption seems to be realistic against the backdrop of the size of exports observed (Table 1).

In contrast, we find that the export ban in Russia 2010/11, when harvest levels were (similarly to the scenario assumptions) about 30% below average, induced price dampening effects varying regionally between 67% and 35%. According to our results, the strongest price dampening effect was observed in North Caucasus, the region with direct world market access and with by far the highest share of exports, more than 60% of its production (Rosstat, 2014). The share of production exported to the world market varies strongly between the regions. For example, West Siberia, although it is second largest wheat producing region, only exports regionally within Russia, and never exports to the world market due to its large distance to the ports. Our analysis at a regional level has provided further evidence on the functioning of export controls in a large country. Results suggest that the strong price dampening effects observed in North Caucasus were transmitted to the other regions by interregional trade flows.

Even if substantial regional price dampening effects of up to almost 70% of export controls are identified in Russia, the assessment of the effectiveness of export controls to dampen domestic wheat prices has to be put into perspective. Comparing price developments during the export ban 2010/11 and 2012/13 (Figure 2), when trade remained freely possible, two periods characterised by a production shortfall of about 30% below the average, it becomes evident that in 2012/13 regional prices exceeded the world market price for a period of only 3 months. However, export controls increase grain production costs, decrease the grain export price, and reduce incentives for investments in the grain sector, with negative implications for domestic and global food security. Thus, the economic costs of export controls are high (Götz et al., 2015, Magrini et al., 2014, Jayne and Tschirley, 2010). From the perspective of the whole economy, it can be expected that the welfare economic costs of more consumer-oriented measures as direct income transfers, food vouchers etc. are substantially lower compared to the trade-oriented measures as export controls. However, export controls remain an attractive measure for policy makers since they do not cause any budgetary costs, and instead even generate budgetary income in the case of an export tax. The short-run costs of this policy have to be borne by farmers and traders.

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Annex

Table S1: Unit root test results

series	ADF test[1]			KPSS2 test[2]		
	test statistic	specification	5 % critical value	test statistic	specification	5 % critical value
Russia						
North Caucasus	0.647	1 lag	-1.942	0.199	17 lags, constant & trend	0.146
Δ North Caucasus	-10.873	0 lags	-1.942	0.051	10 lags, constant	0.463
Central	-2.665	1 lag, constant & trend	-3.419	0.160	17 lags, constant & trend	0.146
Δ Central	-9.924	0 lags	-1.942	0.047	12 lags, constant	0.463
Black Earth	-2.895	1 lag, constant & trend	-3.419	0.158	17 lags, constant & trend	0.146
Δ Black Earth	-8.992	0 lags	-1.942	0.046	12 lags, constant	0.463
Volga	-3.031	1 lag, constant & trend	-3.419	0.152	17 lags, constant & trend	0.146
Δ Volga	-7.773	1 lag	-1.942	0.045	13 lags, constant	0.463
West Siberia	-2.227	2 lags, constant	-2.876	0.143	17 lags, constant & trend	0.146
Δ West Siberia	-7.727	1 lag	-1.942	0.049	13 lags, constant	0.463
Urals	-2.836	2 lags, constant & trend	-3.419	0.127	17 lags, constant & trend	0.146
Δ Urals	-7.729	1 lag	-1.942	0.045	14 lags, constant	0.463
Ukraine						
Vinnysia	-2.983	1 lag, constant & trend	-3.471	0.089	6 lags, constant & trend	0.146
Δ Vinnysia	-6.186	0 lags	-1.945	0.101	1 lag, constant	0.463
Dnipropetrovsk	-2.831	1 lag, constant & trend	-3.471	0.085	6 lags, constant & trend	0.146
Δ Dnipropetrovsk	-7.078	0 lags	-1.945	0.108	2 lags, constant	0.463
Donetsk	-2.597	0 lags, constant & trend	-3.470	0.085	6 lags, constant & trend	0.146
Δ Donetsk	-7.763	0 lags	-1.945	0.112	0 lags, constant	0.463
Kiev	-2.205	0 lags, constant & trend	-3.470	0.094	6 lags, constant & trend	0.146
Δ Kiev	-7.222	0 lags	-1.945	0.125	0 lags, constant	0.463
Kirovohrad	-3.090	1 lag, constant & trend	-3.470	0.105	6 lags, constant & trend	0.146
Δ Kirovohrad	-6.099	0 lags	-1.945	0.156	0 lags, constant	0.463
Odessa	-3.091	1 lag, constant & trend	-3.470	0.076	6 lags, constant & trend	0.146
Δ Odessa	-6.850	0 lags	-1.945	0.092	2 lags, constant	0.463
Poltava	-3.182	1 lag, constant & trend	-3.470	0.088	6 lags, constant & trend	0.146
Δ Poltava	-7.339	0 lags	-1.945	0.091	1 lag, constant	0.463
Sumy	-2.982	1 lag, constant & trend	-3.470	0.091	6 lags, constant & trend	0.146
Δ Sumy	-6.716	0 lags	-1.945	0.105	2 lags, constant	0.463
Kharkiv	-3.319	1 lag, constant & trend	-3.470	0.086	6 lags, constant & trend	0.146
Δ Kharkiv	-5.957	0 lags	-1.945	0.112	1 lag, constant	0.463
Khmelnytskyi	-2.732	1 lag, constant & trend	-3.470	0.127	6 lags, constant & trend	0.146
Δ Khmelnytskyi	-6.337	1 lag	-1.945	0.092	2 lags, constant	0.463
Cherni	-3.415	1 lag, constant & trend	-3.470	0.087	6 lags, constant & trend	0.146
Δ CHerni	-6.356	0 lags	-1.945	0.107	3 lags, constant	0.463

Note: [1]Augmented Dickey-Fuller test; [2]Kwiatkowski-Philips-Schmidt-Shin test; *** significance at 1 %, ** 5 %, * 10%; Lag length is defined based on Schwarz information criterion.

Source: Own calculation and illustration.

Table S2: Johansen's trace test results

region	specification	rank test	p-value	5 % crit. val.
		Russia		
North Caucasus	2 lags, constant	19.07	0.0714	17.98*
Central	2 lags, constant	19.90	0.0546	17.98*
Black Earth	2 lags, constant	20.72	0.0415	15.495
Volga	3 lags, constant	20.85	0.0397	15.495
West Siberia	3 lags, constant	20.16	0.0500	17.98*
Urals	3 lags, constant	19.99	0.0530	17.98*
		Ukraine		
Vinnysia	1 lag, no constant	16.619	0.009	12.321
Dnipropetrovsk	1 lag, no constant	15.758	0.013	12.321
Donetsk	1 lag, no constant	17.569	0.006	12.321
Kiev	1 lag, no constant	16.413	0.010	12.321
Kirovohrad	1 lag, no constant	16.872	0.009	12.321
Odessa	1 lag, no constant	12.935	0.040	12.321
Poltava	1 lag, no constant	16.621	0.009	12.321
Sumy	1 lag, no constant	15.260	0.016	12.321
Kharkiv	2 lags, no constant	12.990	0.039	12.321
Khmelnytskyi	1 lag, constant	22.635	0.004	15.495
Cherni	1 lag, constant	20.123	0.010	15.495

Table S3: Results Granger Causality test (Toda and Yomamoto procedure)

Region	Lags	H_0: world price does not GC regional price			H_0: regional price does not GC world price		
		Chi-sq	**df**	**Prob**	**Chi-sq**	**df**	**Prob**
			Russia				
North Caucasus	4	9.761	3	0.021	2.560	3	0.466
Central	2	6.232	2	0.044	5.561	2	0.062
Black Earth	2	11.700	2	0.003	9.942	2	0.007
Volga	3	10.954	3	0.012	5.713	3	0.126
West Siberia	3	12.953	3	0.005	3.880	3	0.275
Ural	5	20.465	5	0.001	7.081	5	0.215
			Ukraine				
Vinnytsia	2	46.639	2	0.000	0.185	2	0.912
Dnipropetrovsk	2	44.311	2	0.000	1.316	2	0.518
Donetsk	2	49.219	2	0.000	0.310	2	0.856
Kiev	2	54.449	2	0.000	1.370	2	0.504
Kirovohrad	2	31.798	2	0.000	0.351	2	0.839
Odessa	2	32.502	2	0.000	0.308	2	0.858
Poltava	2	28.552	2	0.000	0.411	2	0.814
Sumy	2	35.155	2	0.000	0.239	2	0.887
Kharkiv	2	46.072	2	0.000	0.188	2	0.910
Khmelnytskyi	4	36.955	4	0.000	0.763	4	0.943
Cherni	2	32.623	2	0.000	0.271	2	0.874

Sources: Own calculations.

The Rouble Crisis and Russian Wheat Export Controls, GÖTZ. L., U. KOESTER, T. GLAUBEN AND R. BULAVIN, *Intereconomics - Review of European Economic Policy, 2015, Vol. 50(4): 227-233.*

THE ROUBLE CRISIS AND RUSSIAN WHEAT EXPORT CONTROL[1][2][3]

L. Götz[a], U. Koester[b,a], T. Glauben[a] and R. Bulavin[c]

[a] Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany, [b] University of Kiel, Germany, [c] Russian Grain Union, Moscow, Russia.

Abstract

The Russian government implemented a wheat export tax in February 2015 to damp food inflationary pressures resulting from the rouble's dramatic devaluation. This article discusses the causes of the instability and volatility of the rouble, and the effects of the export controls on domestic wheat and bread prices. Although appealing to governments due to its low financial costs, we show that the economic costs of such export taxes are substantial in the long-run. We suggest desisting from such trade-oriented measures and rather helping needy consumers to adapt to high food prices.

1 Introduction

Russia is suffering from a significant rouble crisis and its accompanying consequences. The exchange rate of the rouble has been very unstable over the last months; the price of the US dollar was 34 roubles on average in January 2014, rose to 70 roubles/US$ in February 2015, and declined again to about 50 roubles/US$ in May 2015 (see Figure 1).

In spite of the recovery of its value, an accurate projection of the future development of the rouble seems impossible. Indeed, a projection is beyond this exercise. Instead, we prefer to assess the causes of the instability, its repercussions for the Russian food and agricultural markets, and also to assess the export tax implemented on the Russian wheat market that was agreed upon in Dec. 2014 and set in place February 1, 2015. In the first section of the article we analyse the causes of the rouble's instability and its repercussions on the food markets.

1 The article is a significant extension of Glauben, T., L. Götz and U. Koester, 2015. The rouble crisis and the Russian grain export controls. IAMO. Policy Brief. Nr. 22.

2 The article benefited greatly from comments on an earlier draft by R.A. E. Müller, CAU Kiel.

3 This study is part of the projects GERUKA (www.iamo.de/geruka), MATRACC (www.iamo.de/matracc) and AGRICISTRADE (www.agricistrade.eu). Financial support for this study was provided by the German Federal Ministry of Food and Agriculture (BMEL), the German Federal Office for Agriculture and Food (BLE), the Volkswagen-Stiftung and the European Commission.

Thereafter, we assess the wheat export controls that were introduced to mitigate the effects of the devaluation of the rouble and its effects on agricultural and food markets.

Figure 1: Development of the rouble exchange rate (in rouble/US$)

Source: Quandl, 2015.

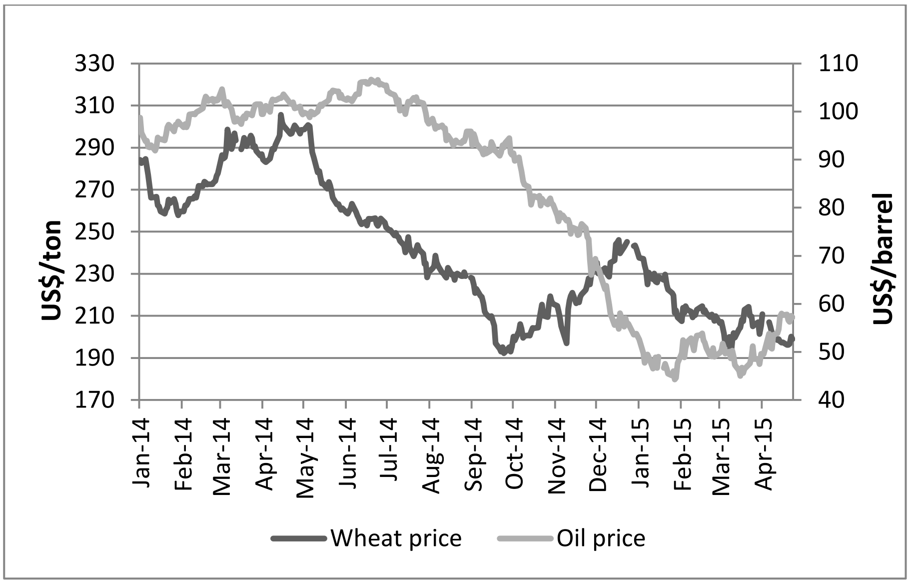
2 Causes of the rouble's instability

The rouble's instability is a result of international economic causes, but is also augmented by the economic impact of internal Russian policies (economic and non-economic). The main economic effect is based on the decline of international oil and gas prices (Liefert and Liefert, 2015) (see Figure 2). Since about 70% of Russia's exports in value terms are oil and natural gas, the oil price plunge strongly decreased the demand for the rouble. Hence, the drop in average oil prices from about 108 US$ per barrel to about 44 US$ per barrel (or 59 percent) did reduce earnings of foreign exchange drastically. At the same time, the demand for foreign exchange increased as the devaluation of the currency spurred the outflow of capital. The increase in the value of the US$ contributed further to Russia's increase in demand for foreign exchange, and to a devaluation of the rouble.

The Russian Central Bank tried to reduce the devaluation of the rouble through heavy intervention in the market for foreign exchange. The amount of foreign exchange dropped significantly from October 2014 to April 2015 (see Figure 3). It is worthwhile to note that this policy has most likely stabilised the value of the rouble, but it was highly expensive; Russia sold roubles at a high price but roubles have received a much lower price since April 2015.

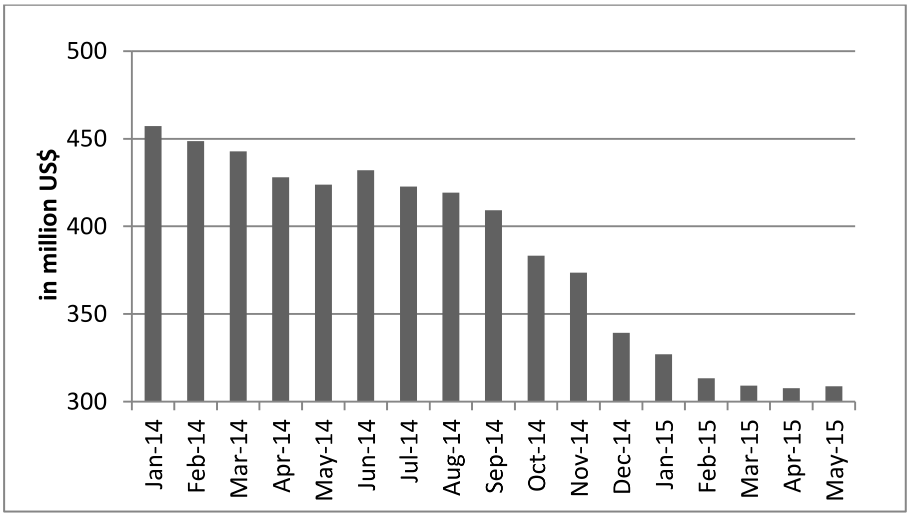
These purely economic determinants of the rouble crisis were reinforced by political determinants. Sanctions by the EU and by the US have affected Russian capital markets, leading to an increase in foreign exchange and a further devaluation of the rouble. In addition, Russia implemented import restrictions for food products, which has also increased demand for roubles. It can be assumed that Russia imported food from the cheapest supplier on the world market before the crisis, but had to change the origin of its imports from low cost to high cost suppliers due to the import sanctions. Thus, import expenditures in roubles increased, leading to a further shift of demand for foreign exchange. This effect was of importance as Russia is highly dependent on food imports (see Figure 4).

Figure 2: Wheat and oil price development 2014-2015



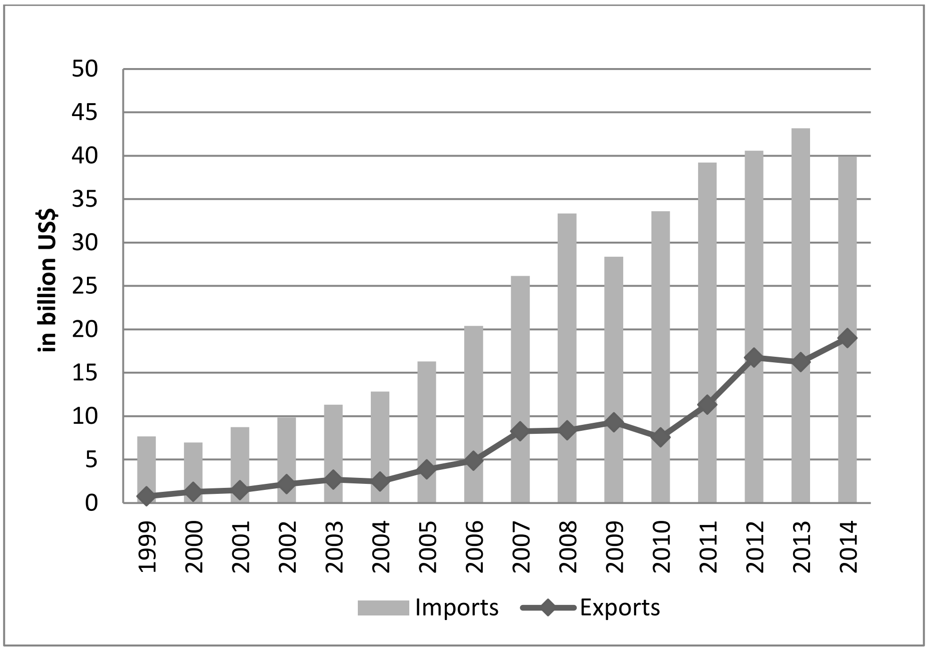
Source: finanzen.net, 2015.

Figure 3: Foreign exchange reserves



Source: Central Bank Russia, 2015.

Figure 4: Development of Food Imports and Exports in Russia (1999-2014)



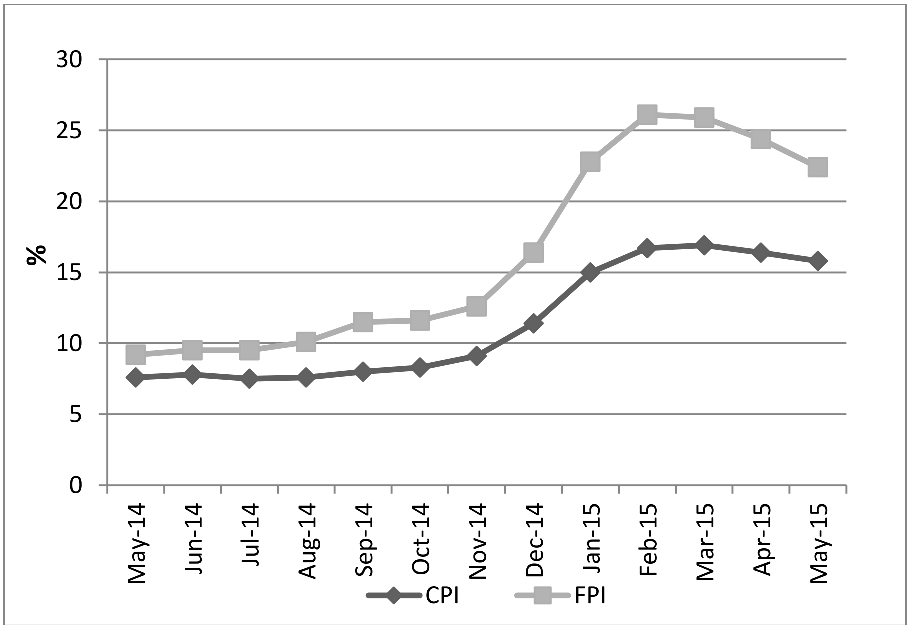
Source: GTI, 2015.

3 Impact of the rouble crisis

3.1 Rise in Inflation

The devaluation contributed to an increase in the rate of inflation from 6.5 percent in 2013 to 11.4 percent in 2014, and to 16.7 percent in February 2015 (see Figure 5).

Figure 5: Development of consumer price index (CPI) and food price index (FPI)



Source: Tradingeconomics, 2015.

The price index for the consumer basket of goods increased somewhat less than the index for food products. This might be partly due to the non-uniform effect of the devaluation of the rouble on domestic prices: a devaluation leads to a change in relative prices. In particular, prices of tradeables increase strongly as a direct effect of a devaluation, whereas prices of non-tradeables increase to a lesser extent as a consequential adjustment in market prices. Thus, prices of food imports in Russia were strongly affected by the devaluation of the exchange rate and increased substantially.

Most agricultural products are not only tradeables, but also suitable for storage. Thus, if prices are expected to increase, producers and traders may prefer not to sell and instead to build up stocks. Consumers may prefer to buy more than they would without inflation expectations and thereby increase the quantity of stored products. It is certainly true that the individual consumer may have little storage capacity. However, the large number of households counts.

The Russian embargo also affected food price inflation. Food availability declined, which thus increased food prices. Also, the effect on food price inflation was more pronounced than for the consumer price index since the price elasticity of demand for food products is - in absolute terms - smaller than for other consumer goods.

Prices for food products in Russia are also determined by active intervention by the government on food markets. Unfortunately, there is no detailed information available on the specifics of intervention on food markets. It has been reported that retail shops have been asked not to increase food prices, particularly of those food items, which are produced in Russia. It is not known how the Russian government has enforced this request. However, it is known that the communities have the means to control retailers.

Hence, it should not be a surprise that the price index for food products increased more than the price index for consumer goods since February 2015.

3.2 Increase in volatility

A primary cause of increased volatility from day to day is the increase in uncertainty. The change in the fundamentals of price formation may affect the level of prices at that point in time when new information is available. New changes on fundamentals do not normally come up on a daily basis; hence, significant fluctuations of daily prices (see Figure 6) point to man-made uncertainty and the lack of instruments to cope with this uncertainty.

Figure 6 highlights the increase in volatility of wheat and oil prices since January 2014. The volatility of these prices has increased significantly since December 2014, when the possible introduction of measures was discussed. It should be noted that in December 2014 wheat and oil price changes started to increase strongly (see Figure 2), which may have led to political concern.

3.3 Measures introduced

There is no official document declaring the objective of the government's intervention on the wheat market. However, some statements made by public administrators do refer to the aim of the measures: For example, Prime Minister Dimitry Medvedev pointed out on December 22, 2015 that wheat export duties were introduced "temporarily, but flexibly enough to enable us to regulate the grain market situation and to provide the people with bread and baked products (Interfax, 2015)".

This measure was designed to stop the increase in bread prices in order to contribute to the food security objective. The selected measures may have been influenced by the preferences of the population. According to a poll, fifty-five percent of respondents said that a country's economic system should be based on "government planning and allocation" (The Moscow Times, 2015).

Russian authorities explain the measures with the need to reduce the recent high wheat exports and to ensure adequate grain supplies for the domestic population; the official, declared rationale is to put a stop to the domestic price increases for grain-based consumer products.

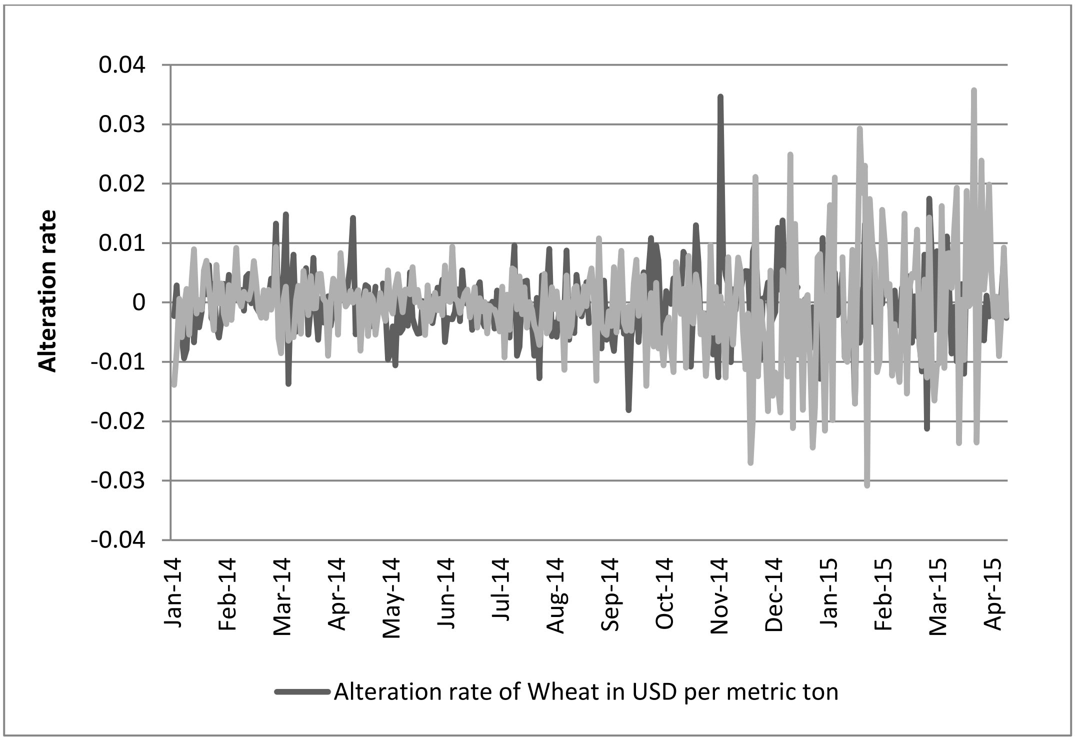
In the following we analyse the effects of the introduced measures with respect to the stated objectives. Moreover, we explore whether there could have been alternative measures that could have been more targeted and less costly. Furthermore, we develop some hypotheses on how the introduced measures will affect world markets of wheat. The introduction of measures such as an export ban to limit grain exports has been discussed since September 2014. However, on December 16, the Agricultural Minister of Russia, Nikolai Fyodorov, stated: "We do not plan to do anything apart from invading this market with government intervention in the form of grain procurement for the government fund (Interfax 2015)". However, on December 22, 2014, the Deputy Russian Prime Minister, Arkady Dvorkovich, announced the introduction of a wheat export tax: "We'll draft a resolution on grain export duties, this will be done in 24 hours (Interfax, 2015)."

A decree introducing an export duty on wheat was announced late in December 2014, to become effective February 1, 2015. The levied tax is 15 per cent of the export price per ton, but at least

35 euros per ton. In addition, 7.5 euros per ton have to be paid. The tax is not levied on exports into countries of the Eurasian Economic Union.

Initially, the regulation was announced to end in June 2015, but may be prolonged in the same form or in any other. Starting in early December 2014, the authorities have also used administrative barriers to hinder grain exports. Procedures to issue phytosanitary certificates required for exporting and trans-shipping grain via ports were tightened. The export duty was cancelled on May 15, 2015, and on May 28 the introduction of a modified export duty on July 1, 2015 was announced. According to the new formula, a 50% rate of the duty applies to a wheat price less than 5,500 roubles per ton, with a minimum amount of 50 roubles per ton.

Figure 6: Daily wheat and oil price changes, 2014-2015



Source: Finanzen.net, 2015.

One may wonder why the Russian government only focuses on wheat exports. Wheat-based consumer goods may seem to be of little importance for the general consumer, but these goods are very important for some poor households. Moreover, the bread price is a politically important price in many countries, and the focus on wheat might have been determined by this notion. Hence, the political signal to do something against the pressure of food price inflation may have seemed more important than the economic consequences. Nevertheless, the economic effects are important for the well-being of the population in Russia, as well as for international trade.

3.4 Effects on the domestic prices of wheat

The domestic price of wheat in an open economy is directly related to the world market price of wheat. Wheat is traded in US$, hence, the Russian export price in roubles is given by the wheat price in US$ achieved on the world market times the US$-rouble exchange rate ($P^{R} = r^{R}_{\$} * P^{US\$}$), if the export tax does not apply. Thus, the change of the Russian wheat price in roubles can be caused by a change in the exchange rate, a change in the world market price in US$ or a change in the difference between the world market price and the domestic price, i.e. trade costs. At the time of deciding on the decree, it was not known and beyond any rational expectations that the Russian rouble would appreciate significantly in the near future, and that the world market prices for wheat would continue to decrease substantially. Actually, the Russian exchange rate dropped by 38 percent and the world market price for wheat declined by 29 percent from December 16, 2014 to April 2, 2015.

Figure 7 shows the development of regional wheat prices in Russia. The wheat price started to decrease in February 2015 in all regions. This price development can be explained by the following factors:

1) The price of wheat has certainly gone up less after February 1, 2015 due to the revaluation of the rouble, and also because of the further decrease of wheat's world market price in US$.

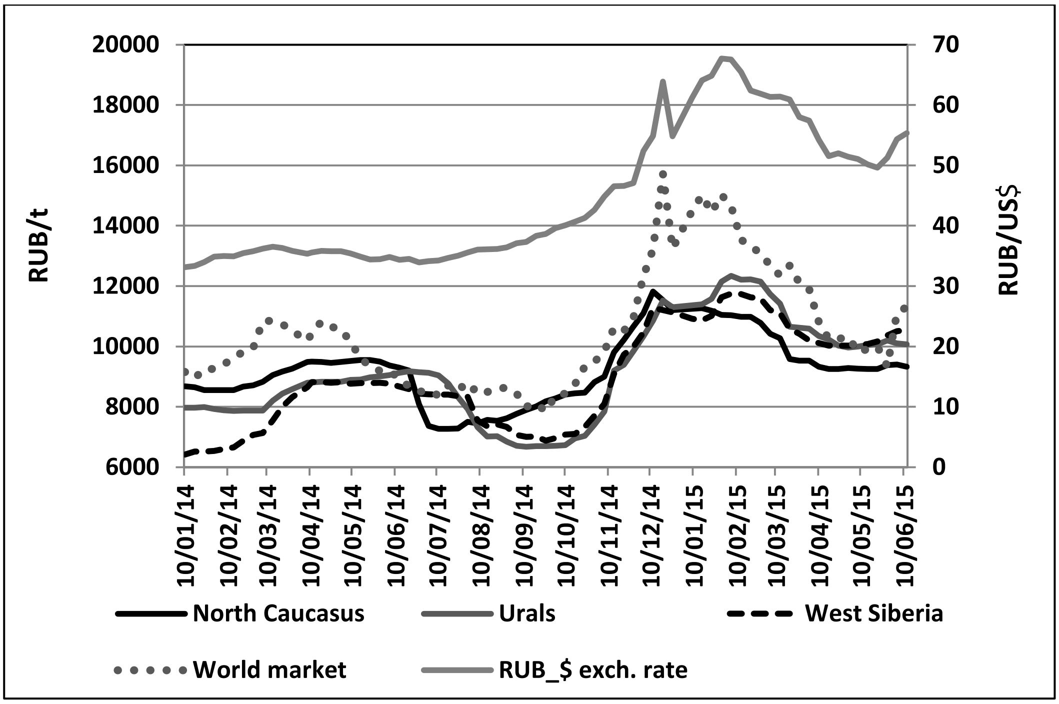
2) It might be argued that the decline of Russian wheat exports have contributed to damping price increases. Indeed, Russian exports of wheat did decline significantly after the export tax became effective in February 2015 (See Figure 7).

3) However, the decline in export quantities does not necessarily imply an increase in market supply in the country. Rather, wheat for export could be held on stocks. Basically, stock-keepers had two alternatives:

a) keeping stocks until the export tax was removed, or

b) supplying the quantities that had been planned for export to the domestic market.

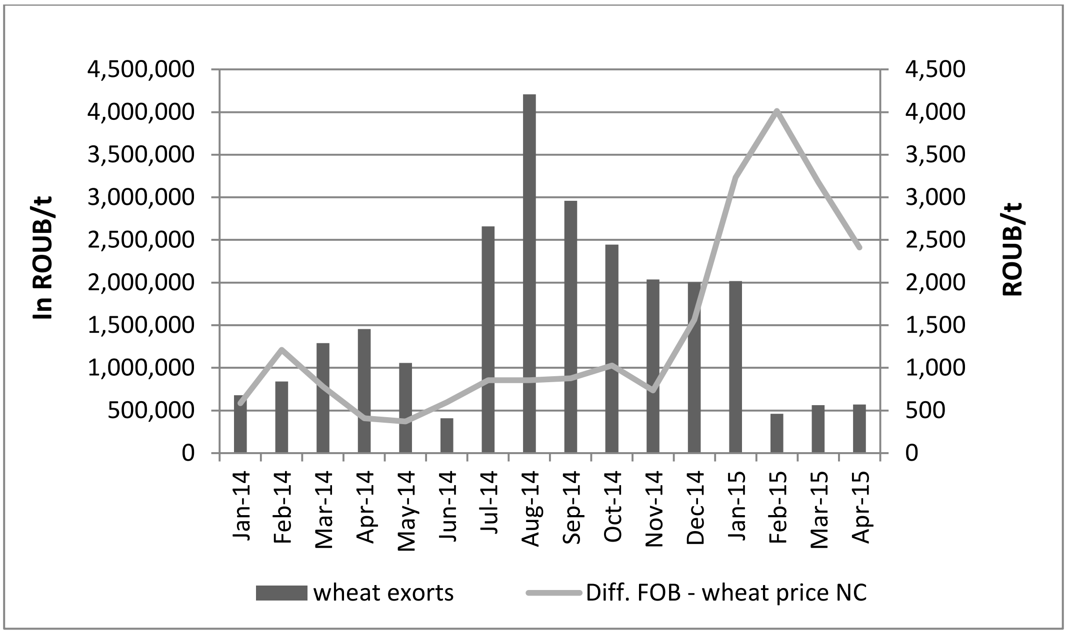
Figure 7: Development of selected regional wheat prices of Russia, world market price and rouble-$ exchange rate



Source: Grain Union of Russia (2015); the world market price refers to a Rouen (France) FOB price (AHDB, 2015).

Wheat traders did not prefer to sell wheat on the world market under the export tax system for two main reasons; the wheat price obtained by the producer was reduced by high transaction costs, and the export tax. This is also reflected in Figure 8, which shows the difference between the development of the FOB wheat price and the producer price in North Caucasus, the primary wheat-exporting region. Transaction costs increased because the Russian government had introduced non-market instruments to lower the export volume. Therefore, it became more cumbersome to book freight trains and obtain the phytosanitary certificates required for export. These administrative interventions not only led to higher direct costs for traders, but also to an increase in uncertainty. Trade in wheat - particularly international trade - is conducted in contracts that not only specify quantity and quality of the wheat that is contracted, but also the exact time of delivery. If traders are not able to guarantee the exact time of delivery, they suffer from a competitive disadvantage in comparison to non-Russian traders. This is reflected by the following insights provided by the Russian Grain Union: “Traders are trying to fulfill previously signed contracts but are not agreeing any new deals. The risks are so unpredictable now that exporters are afraid to sign contracts…when you sign a contract now you cannot guarantee that you will be allowed to ship this volume out of the country...”(Reuters, 2015b).

Figure 8: Difference between the FOB and the regional wheat price in North Caucasus and wheat exports of Russia



Source: GTI, 2015.

Figure 7 illustrates that the observed wheat price decrease is relatively strong in the North Caucasus region, whereas it is significantly lower in the Urals and West Siberia. This can be explained by the following factors:

1) North Caucasus is a wheat-producing region with direct access to the world market via its ports at the Black Sea. North Caucasus exclusively supplies its wheat surplus to the world market and usually does not supply wheat to internal markets within Russia. Thus, price determination in North Caucasus is strongly influenced by the world market price.

2) In contrast, West Siberia and the Urals are two regions with a distance of about 4,500 km and 3,000 km, respectively, to the Black Sea harbors, and thus world market access. Due to large trade costs, producers rarely supply wheat to the world market and rather supply their wheat surplus to deficit regions within Russia, particularly the Central region.

3) The introduction of an export tax is equivalent to a change in the FOB price from the perspective of a grain trader in North Caucasus, assuming that trade costs, i.e. transaction[4] and transport costs, remain constant. In particular, the change of the FOB price is equal to the size of the export tax, thus damping regional wheat prices. Introducing the export tax has no direct effect on wheat prices in the Urals and West Siberia since neither region supplies wheat to the world market. However, the price damping effects of the export tax are transmitted indirectly

[4] Transaction costs comprise all costs beyond trade costs as e.g. costs resulting from market uncertainty.

from North Caucasus via third markets to the Urals and West Siberia. The price damping effects in the Urals and West Siberia are lower compared to North Caucasus since both regions are characterized by high transaction costs of exports to the world market.

Furthermore, the increase in traders' uncertainty is due to the specifics of their decision making. Two aspects are of interest: First, the change in the regulation of wheat exports was not introduced by a general law, but rather by a decree. A decree can be introduced faster than a change in law and a decree is generally not discussed at length before the decision. Hence, the likelihood that a decree may be ordered is higher than the decision on a new law or a change of it. Thus, the government's preference for decrees creates more uncertainty and a less favourable environment for exporters than a law does. Second, the decree introduced changes to be effective with a high probability for wheat exporters from February 1 to June 30; however, at the time of the announcement it was not known with certainty what the situation might be after June 30. Indeed, as explained above, the export tax was removed before its expiration, but a modification and extension of the export duty after July 1 was announced as well (Interfax, 2015). If traders had expected the decree to be terminated on June 30, they could have stocked up wheat in the expectation of higher export prices after June 30. If traders have stocked wheat they have directly interfered with the intention of the decree: wheat prices in Russia would not have decreased as much as expected by the government, but instead may have risen.

Unfortunately, there is no official information on wheat storage in Russia. Actually, there is likely no country that has reliable statistics on wheat storage. Stock keepers are not only governmental organisations, but also private traders, farmers, retailers and even consumers; not all of them reveal information on stock levels and if they do, the information may not be realistic.

4 Effects on the domestic prices of bread

Consumers will quite likely not experience any price reductions. For wheat export restrictions to have an effect on bread prices, any decrease in wheat prices must be passed on to the consumer along all stages in the wheat-to-bread value chain. The 2007/2008 as well as the 2010/2011 export restrictions did not result in any notable price damping effects for consumers. In the spring of 2008, Russia imposed an export tax. Yet the reduced wheat prices did not lead to a corresponding decrease in flour prices. Instead, the decrease in wheat price increased the difference between wheat and flour prices. While the mills increased their profits, consumers were still confronted with rising bread prices.[5] It must be pointed out that food prices in Russia are currently subject to strict government control (Interfax, 2015; Agra-Europe, 2015).[6] To what extent the grain processing industry can actually be pushed into passing price decreases on to the consumer is anybody's guess.

Even if the consumer price increases were slightly less, this would only marginally improve the security of the food supply. Food security is mostly a problem of poor households rather than an issue of food items' general availability. Assuming that these households spend a major part of their income on grain and grain products, the small reduction in grain prices will scarcely improve their nutritional situation. As is generally known, grain prices constitute only a small percentage of baked goods' prices. Research indicates that a 50 percent reduction in wheat prices in the Central region/district of Russia only leads to a 5 percent bread price reduction in Moscow (Götz et al., 2015).

4.1 Economic costs of Russian export restrictions for wheat

Aside from examining whether levelling the export tax will prevent bread price increases, the economic costs of the tax needs to be taken into account. It is also worthwhile to contemplate whether the measure is economically sensible.

It should be noted that economic costs are not identical or even related to financial costs. Governments are often particularly concerned about short-run financial costs because these costs are visible and may impair the financial capacity of the government. Hence, export taxes may be assessed positively as they contribute to revenue, ease financial constraints, and contribute - at least somewhat - to the food security objective. Thus, a tool that has no financial costs but still creates budget revenues makes export taxes so appealing for governments, although export controls incur high economic costs to the whole economy in the long-run for several reasons. First, in the short term, producers and grain traders would experience loss in profit and income as a result of the dampened wheat price level, while consumers would hardly notice any price relief. However, low grain prices are beneficial for keeping farm animals.[7]

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5 Bread prices increased as a result of higher energy and labour costs. The price-lowering effects of the export restrictions were so small that they could not prevent increases in bread prices.

6 Due to the drastic devaluation of the rouble and the Russian sanctions against the import of agricultural goods, the prices of largely imported food items will increase. This will especially affect the fruit and vegetable supply (Agra-Europe, 2015).

7 A close relationship exists between wheat and feed wheat because the products are interchangeable. High wheat prices are usually accompanied by high feed wheat prices.

Secondly, experience from the past decade indicates that volatility on international markets - including those for foreign exchange, oil and agricultural commodities - has increased and may continue to do so for some time. Hence, it is interesting to consider the possible effects of specific measures on volatility and the ability of market participants to cope with future volatility. The selected measure has some negative effects on the resilience of market participants. Unforeseeable government interventions in the grain market create uncertainty and create higher risk for market participants. Thus, the domestic market will function less efficiently as it will become more costly to use forward markets for risk reduction. Even more importantly, the selected measure will make it impossible for Russian grain producers and traders to hedge against price fluctuations in international futures markets. With increasing risk for grain producers and storage facilities, the costs of producing and storing grain will increase. As a consequence, growers will receive lower prices for wheat sold to traders, and the profitability of the wheat production decreases.

Thirdly, even if the government interferes with the wheat markets for a limited time only, the integration of the Russian grain market into the global market will be diminished for quite a while. Consequently, Russia will become a less reliable and therefore less important grain-supplying country. Grain import contracts for delivery after 30 June 2015 will be deemed uncertain. Since the current government restrictions may continue or even be tightened, Russian grain traders are unsure of their ability to export grain at predictable prices. Foreign importers will only be ready to assume the default risk of Russian grain contracts if the price of Russian grain is lower than the price of grain from other countries. This will lead to lower domestic prices, and Russian grain export prices will sink below the price of comparable grain from other countries. As a result, the Russian grain industry will be negatively impacted for the long term.

Fourthly, in the medium- and long term, Russian grain producers will produce less grain due to lower prices and higher price risks. This will decrease Russian grain exports and disconnect the Russian grain sector from international grain markets. Furthermore, investments in the development of the grain sector will likely diminish. Russia has a considerable growth potential in the grain sector with additional business opportunities. To realise this potential, comprehensive investments, especially private sector investments in modern technologies, are required (Glauben et al., 2014). Export restrictions decrease private investments in the grain sector. Especially in times of recession, these investments could result in significant and welcome income opportunities.

Overall, the government measures lead to the separation of the Russian grain sector from international markets. Grain producers and traders will suffer income losses while consumers profit little or not at all. In the long-term, necessary investments in the strategically important grain sector will diminish. This works against a more secure Russian food supply and consumer price moderation.

4.2 Alternative measures

One may wonder whether the Russian government could have chosen alternative measures that could have undermined the functioning of markets less, but may have contributed to the stated objectives in a more targeted and less costly manner.

The government should desist from market interventions by trade-oriented measures and should rather focus on consumer-oriented measures. In particular, instead of trying to damp domestic food prices, it would be a more effective and cost-efficient response of the government to let domestic food prices increase and help the needy population to adapt to high consumer prices. For example, direct income transfers targeted on the household income of poor people would have been better from an economic point of view. It may be that identifying poor households was not possible in such a short period of time, but information is available on pensioners with low pensions. Not all of them are poor, as some of them have alternative income or property, but nevertheless, a transfer focused on pensioners with low pensions would have been better targeted than a reduction of bread prices. The Russian Grain Union suggests providing food vouchers (Reuters, 2015a).

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Regional Wheat Price Relationships

How well is the Russian wheat market functioning? A comparison with the corn market in the USA, G*ÖTZ*, *L., D.* S*EREBRENNIKOV AND M.* S*VANIDZE, mimeo, 2016. Revised version of* S*EREBRENNIKOV, D. AND L.* G*ÖTZ (2015): Bayesian threshold adjustment in spatially integrated wheat markets in Russia, Selected Paper, Agricultural & Applied Economics Association's 2015 AAEA & WAEA Joint Annual Meeting, July 26-28, San Francisco, USA.*

How well is the Russian wheat market functioning? A comparison with the corn market in the USA

Linde Götz, Dmytro Serebrennikov and Miranda Svanidze

Abstract

We use a threshold vector error correction model to account for the influence of trade costs on price relationships in the grain markets of Russia. We find a strong influence of distance. In particular, the band of inaction and the upper and the lower threshold increase with distance between the regions of the price pairs, whereas the long-run price transmission elasticity, the speed of adjustment parameter and the total adjustment decrease. Results suggest that the integration of the regional wheat markets strengthened during the wheat export ban in 2010/11, which can be explained by the increase in interregional trade flows. The comparison with the preliminary results for the corn market of the USA makes evident that the influence of distance is substantially stronger in the Russian market compared to the USA.

Key words: regional market integration, threshold vector error correction model, regularized Bayesian technique, grain markets, Russia, USA, export ban

1 Introduction

In recent years Russia has advanced from a grain importing country to one of the primary grain exporting countries. Even, it is forecasted that Russia will become the largest grain exporter in the world in the marketing year 2016/17 (Interfax 2016). Russia could further boost its grain production by increasing production efficiency and to a limited extend by re-cultivating formerly abandoned agricultural land. Therefore, Russia could play a large role for future global food security (Lioubimtseva and Henebry, 2012).

This study aims to address the research question how well the Russian grain market is functioning, a question which has not been addressed in the literature before. Following a price transmission approach we are focusing on the primary grain producing regions and investigate the integration and efficiency of the regional grain markets. To what degree and how fast are price shocks in one region transmitted to the other regions? Do prices reflect trade costs and demand and supply conditions? Strong market integration and high efficiency are particularly relevant to the Russian wheat market, given that the Russian grain market is characterized strong production volatility resulting from extreme weather events which are expected to increase with climate change. Favourable production conditions and thus relatively high yields can be observed in some regions but relatively low yields in other regions at the same time. Therefore, interregional grain trade is of high importance to equilibrate grain supply and demand within Russia. Nonetheless, grain market transport and storage infrastructure is deficient in several regions and price peaks are repeatedly observed on regional markets, exceeding even the world market price. A well-functioning market could contribute to cushioning price increasing effects of regional harvest shortfalls and prevent that prices increase beyond the world market price.

However, Russia has a history of restricting the exports of wheat to the world market when domestic wheat prices peak. In particular, wheat exports were controlled by an export tax 2007/8, an export ban in 2010/11 and are at present controlled by an export tax which is in place since February 2015. Export controls have strong negative effects on grain production and hamper to further development of the grain sector (Götz et al. 2016b). As our second question, we investigate the effects of the wheat export ban 2010/11 on regional price relationships to shed further light on the domestic price effects of export controls. This is an addition to Götz et al. 2013, 2016b which focus on the export controls' effects on the integration in the world wheat market.

Generally, a unique concept of market integration and efficiency does not exist (Fackler and Goodwin 2001). In this paper we assume that a well-functioning market is a spatially efficient market which is characterized by strong market integration. Thus, price shocks in one region are quickly transmitted to the other regions inducing interregional trade flows when price differences exceed trade costs (Fackler and Goodwin 2001). Also, regional prices differ at most by the costs of trade between those regions (Law of One Price) and profitable opportunities for trade arbitrage do not persist. Further, an efficient market is characterized by adequate trade costs, which are determined by many factors, e.g. distance to other markets, quality and quantity of transport and communication infrastructure, corruption, market risk and legal barriers as phytosanitary license and inspection requirements (Tomek and Robinson 2003).

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

The Russian wheat market is characterized by extremely large distances between regional markets of up to 4000 km. To assess how well the Russian market is functioning we conduct a comparative price transmission analysis for the corn market of the USA which is also characterized by large distances, strong variation in regional production and high interregional trade flows. We assume that the corn market of the USA is one of the most efficient grain markets in the world characterized by well-developed transport and storage infrastructure and high market transparency, serving as a benchmark for the Russian wheat market in this study.

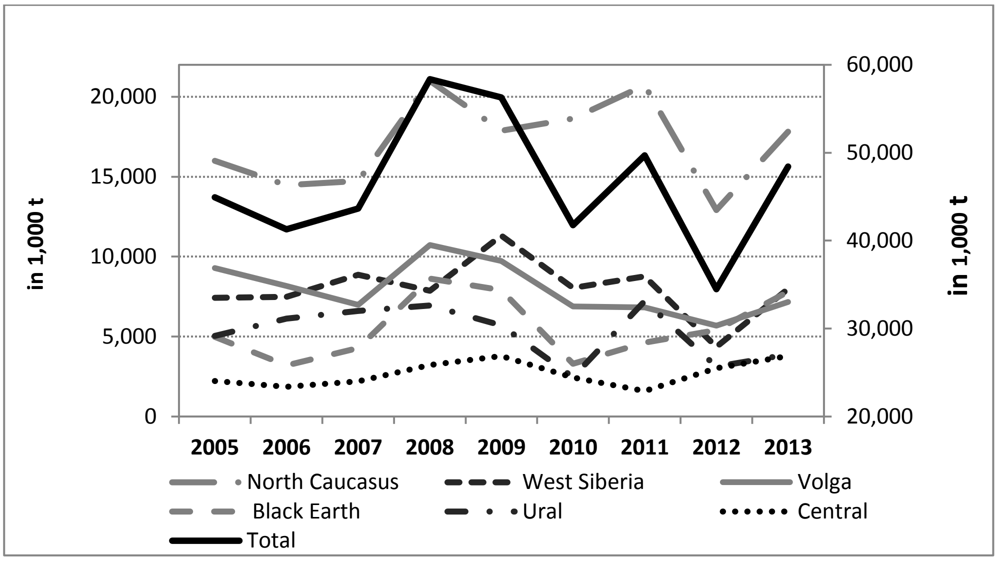
The remainder of this paper is organized as follows. In the next section, we discuss market conditions and the consequences of the export ban 2010/11 for wheat trade in Russia. This is followed by the review of major literature sources. The detailed presentation of econometric model is given in the section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

2 Characteristics of the Russian wheat market and the export ban 2010/11

2.1 Regional wheat production and harvest shortfall

Wheat production in Russia is concentrated on a limited, yet spatially protracted area. The Southern and Central areas (North Caucasus, Black Earth, Central and Volga) have direct access to sea port facilities and thus world markets and have a developed network of railway tracks and highways. They are highly active in international grain trade and in delivering grain to consumption regions in Russia with deficit stocks. The major grain cultivated in this region is winter wheat. In contrast, Urals and West Siberia are far away from the world market (distance to Black Sea ports is up to 4000 km) and the major consumption areas (distance to Moscow is 2000-3000 km). Due to outdated and insufficient transport infrastructure, both regions are not well connected either with the world market or the consumption areas. The primary grain produced in those regions is spring wheat which is generally characterized by lower yields comparably to winter wheat.

Figure 1: Regional wheat production development in Russia



Source: Götz et al. 2016b

Biggest crops are traditionally grown in the south of European part (North Caucasus, Black Earth and Volga), Urals and West Siberia. Two large regional production clusters emerge depending on both the type of culture and the area of cultivation. The winter wheat cluster covers Southwest Russia between Black Sea and Volga. Yields in this area amount to 3 tons per hectare on average (2006-2010). The spring wheat cluster spans over Urals and West Siberia. In contrast to winter wheat, spring wheat is much less productive with yields amounting to 1.7 tons per hectare on average (2006-2010).

The size of wheat production in the major grain production regions differs strongly. As can be seen from Figure 1, wheat production is highest in North Caucasus, with an annual production varying between 12 and 22 million tons in the period 2005-2013. This is followed by Volga and West Siberia with wheat production varying between 4 to 11 million tons in each region), Black Earth (between 3 to 9 million tons)), Urals (between 2 to7 million tons) and Central (2-4 million).

In addition, the variation of wheat production within a region is also extremely high. Table 1 gives regional wheat production as the average of wheat production in the previous three years. It becomes evident that for example in the Volga region, wheat production varied between 34 and 143% in the marketing years 2005/6 to 2012/13. Weather conditions are a key determinant of the quantity of wheat production. Due to large distances, the production regions are affected by different climatic and weather conditions. This implies that favorable production conditions and thus relatively high yields might be observed in some regions but relatively low yields in other regions at the same time. For example, grain production was even by 4% above average in North Caucasus in the marketing year 2010/11, whereas the regions Volga, Urals and Black Earth were severely hit by the drought with grain production 66%, 62% and 54% below average, respectively.

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

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

Source: Götz et al. 2016b

Figure 2 shows the entire grain producing area affected by the drought in 2010. The extremely high variability of wheat production in the different regions of Russia strongly influences interregional wheat trade flows.

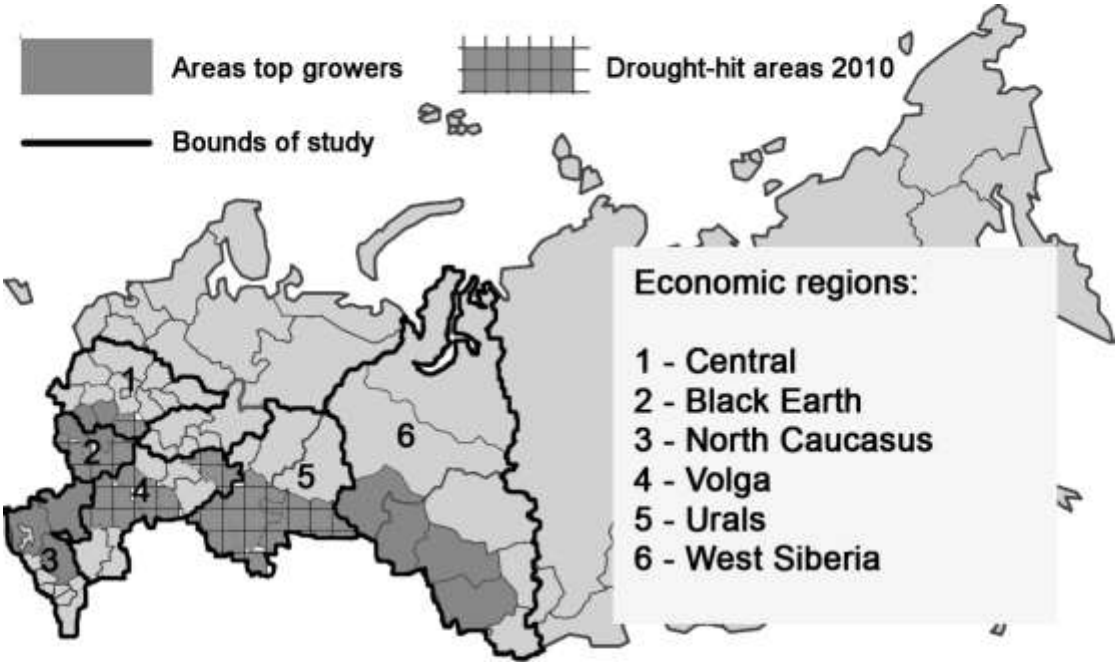
2.2 Regional wheat trade and the influence of the export ban 2010/11

In general, the interregional wheat trade in Russia can be characterized as rather unstable. It is characterized by large variation in the size of trade flows. Even, the direction of trade flows had changed.

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

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

Figure 2: Map of crop-growing regions affected by drought in 2010



Source: Own illustration.

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

The measure had a profound impact on regional wheat trade in Russia. In particular, North Caucasus could no longer supply to the world market and was forced to supply wheat domestically instead. Table 2 shows that North Caucasus directed its flows to the markets which suffered the most from the harvest failure, specifically Black Earth, Central, Volga and Urals. This explains why wheat trade reversal was observed, e.g. between North Caucasus and Volga region. West Siberia was less affected by the drought and also supplied wheat to the domestic grain producing regions which turned into deficit regions in 2010/11, in particular Volga and Urals.

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

Table 2: Interregional grain trade quantities by train, 2010/11

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

Source: Götz et al. 2016b

Trains and trucks are the two primary means of wheat transportation in Russia. Trains are mostly used when the transport distance between regions exceeds 1000 kilometers, while trucks are often preferred on shorter routes. During the export ban 2010/11, availability of trucks for grain transportation was limited as railways were heavily involved in the construction of sport facilities for the winter Olympic games in Sochi. Moreover, the volume of grain exported by North Caucasus to other domestic regions was extremely high and even exceeded the availability of trucks (Gonenko, 2011).

To foster interregional grain trade during the export ban, the Russian government introduced transport subsidy for grain producers located in North Caucasus starting from September 20, 2010. For example, Russian Railways cut delivery fees by half for dispatches heading from North Caucasus towards the regions of Volga, North West and Center. The given subsidy was valid for all grain supplies exceeding 300 kilometers and was removed together with the export ban in July 2011. It should be pointed out that the delivery fee captures only parts of the full transport costs. Other expenses may include storage fees, transportation between the railway station and the grain processing facility, insurance premium etc. The share of the delivery fee in the total transport costs varies significantly amounting to 30% to 70% of transport costs.

The estimated values of the delivery fees for selected market pairs before are presented in Table 3.

Table 3: Costs of wheat transportation between the selected locations in 2010

Pair of markets	Station of origin	Station of destination	Distance (km)	Delivery fee
North Caucasus-Black Earth	Kavkaz	Voronezj	870	781
North Caucasus-Central	Kavkaz	Moscow	1300	1165
North Caucasus-Volga	Kavkaz	Kazan'	1708	1328
Volga-Central	Kazan'	Moscow	812	752
Urals-Central	Kurgan	Moscow	2037	1498
West Siberia-North Caucasus	Novosibirsk	Kavkaz	3800	2576
West Siberia-Central	Novosibirsk	Moscow	3350	2147

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

Source: Own illustration, data: Rosstat 2015.

3 Literature review

This paper adds to the strand of literature focusing on spatial price relations between regional agricultural markets. According to the Law of One Price (Fackler and Goodwin, 2001), the price of two regions are in an equilibrium if the price difference is at most equal to transaction costs of trade between those two regions. The influence of transaction costs on price relationships is captured by thresholds. A price transmission model with one threshold represents the trade costs between two regions when trade is unidirectional. A price transmission model with two thresholds is adequate when trade is observed in both directions which is often characterized by asymmetric trade costs. If price differences are smaller than trade costs and thus trade between two markets is not observed, price adjustments are weak or even not observed compared to when price differences exceed the trade costs and trade flows are observed.

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

Brosig et al. (2010) investigate wheat trade between 28 provinces in Turkey. Results suggest increasing regional segregation that originates from climatic, geographic and infrastructural variations within the country. According to the results, centrally-located markets are integrated quite well, while integration is rather poor between a centre and a periphery region of the country. At the same time, peripheral markets tend to cluster around large production areas. Authors apply a TVECM with one threshold and two regimes to explore effects of transaction costs. In accordance with expectations, they find very slow adjustment to equilibrium between distantly located markets, while adjustment is faster in neighbouring markets.

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

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

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

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

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

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

The effects of the wheat export controls in Russia are also investigated by Fellmann et al. (2014) within simulations based on the partial equilibrium AGLINK-COSIMO model. Though, they follow a national perspective and focus on quantifying the domestic price dampening effect. Further studies addressing domestic wheat price effects of export controls within a price transmission approach are e.g. Djuric et al. (2015), Baffes et al. (2015). An overview on this literature is provided by Götz et al. (2016a).

4 Methodological framework and estimation method

We investigate the price relationships between regional wheat markets in Russia and the effects of the export ban imposed 2010/11. To account for the influence of trade costs, which are highly relevant to the Russian wheat market, we adopt a 3-regime TVECM with 2 thresholds developed by Greb et al. (2013).

We use an innovative Bayesian approach in addition to the usually applied maximum likelihood method to estimate the value of the threshold parameters.

4.1 Econometric model

A three-regime TVECM as proposed by Greb et al. (2013) is given in (1). The dependent variable $\Delta P_t = \left(\Delta P_t^{Market\ 1}, \Delta P_t^{Market\ 2}\right)$ denotes the difference between prices in periods t and

$t-1$ for both markets in question. As the independent variables, $\gamma' P_t$ measures the error-correction term (ECT) which represents the price deviation from the long-run price equilibrium.

Additionally, $\sum_{m=1}^{M} \Delta P_{t-m}$ is the sum of price differences lagged by period m to correct residual correlation, and ε_t denotes a white-noise process with expected value $E(\varepsilon_t) = 0$ and covariance matrix $Cov(\varepsilon_t) = \Omega \in (\mathbb{R}^+)^{2\times 2}$.

$$\Delta P_t = \begin{cases} \rho_1 \gamma' P_{t-1} + \sum_{m=1}^{M} \Theta_{1m} \Delta P_{t-m} + \varepsilon_t, & if\ \gamma' P_{t-1} \leq \tau_1\ (Lower) \\ \rho_2 \gamma' P_{t-1} + \sum_{m=1}^{M} \Theta_{2m} \Delta P_{t-m} + \varepsilon_t, & if\ \tau_1 < \gamma' P_{t-1} \leq \tau_2\ (Middle) \\ \rho_3 \gamma' P_{t-1} + \sum_{m=1}^{M} \Theta_{3m} \Delta P_{t-m} + \varepsilon_t, & if\ \tau_2 < \gamma' P_{t-1}\ (Upper) \end{cases} \qquad (1)$$

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

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

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

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

4.2 Model estimation

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

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

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

where X is a $n \times d$ matrix that compactly stacks together columns of ECTs and values of lagged terms. $P_{RB}(\tau|\Delta P, X)$ is well defined across the space of all possible threshold parameters $\mathrm{T} = \{\tau_{1,}\tau_2 | \min(\gamma' P_t) < \tau_1 < \tau_2 < \max(\gamma' P_t)\}$. In the previous expression, τ_1 and τ_2 are optimal thresholds that separate the space into three regimes and satisfy $\tau_1 < 0 < \tau_2$. Computation is based on a prior $P_{RB}(\tau|X) \propto I(\tau \in T)$ for τ, where $I(\cdot)$ is an indicator function providing switching between regimes.

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

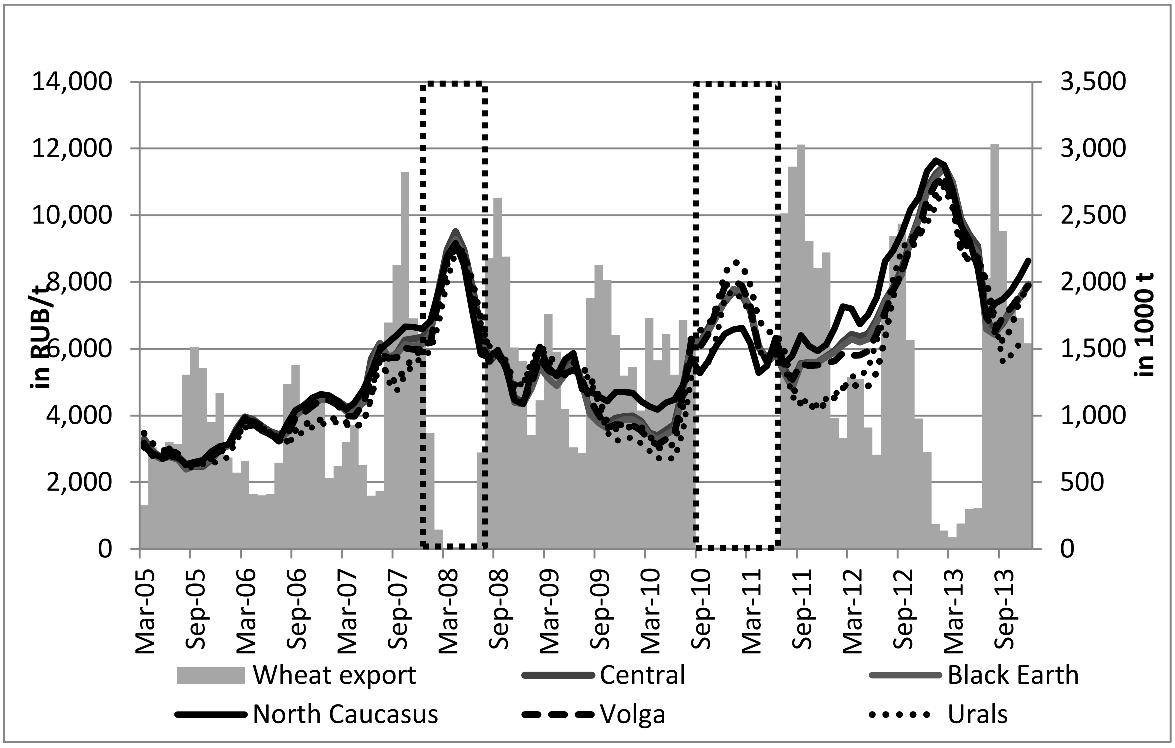
5 Data sets and data properties

To estimate our price transmission model, we use a unique dataset of weekly prices of wheat of class three (Rubel/ton), the most widely traded type of wheat for human consumption in the Russian domestic market. This data is collected by the Russian Grain Union and is not publicly available. The quoted prices are paid by traders to farmers on the basis of ex-works contracts. Our data set comprises regional data for the six economic grain producing regions North Caucasus, Black Earth, Central, Volga, Urals and West Siberia and contains 468 observations (January 2005 until December 2013) (Figure 3).

In addition, we use weekly amounts of grains transported by train between all grain producing regions of Russia as a measure for interregional grain trade flows (source: Rosstat 2014). This data is used as additional information to build the model framework and to interpret results. As an example, Figure 4 gives the price relationship between the regions North Caucasus and Volga as well as North Caucasus and West Siberia (2007-2013) and the corresponding interregional grain trade flows transported by train.

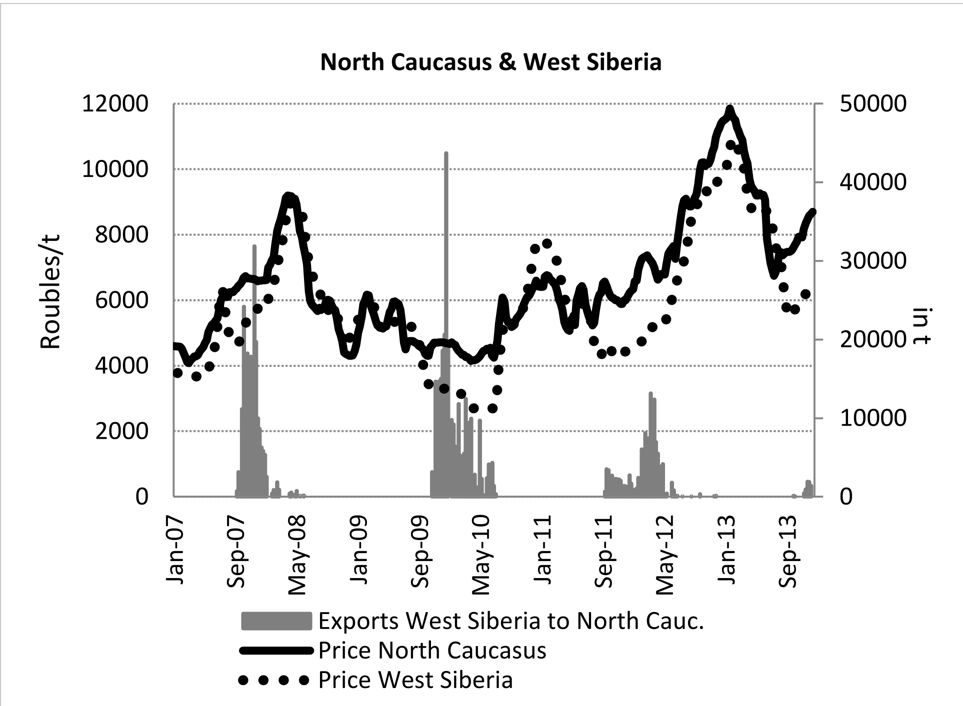
However, Figure 4 makes evident that the regional price relationships are not stable, but rather differ from marketing year to marketing year. In particular, the price of North Caucasus is in some period higher and in other periods lower than in the other regions. Also, the interregional trade flows are highly volatile. This implies that the interregional price relationships, which are depicted in the price transmission model, are highly unstable, and thus parameter estimates may also not be constant. To tackle this issue, we estimate the price transmission model based on one marketing year only which is characterized by relatively stable price relationships.

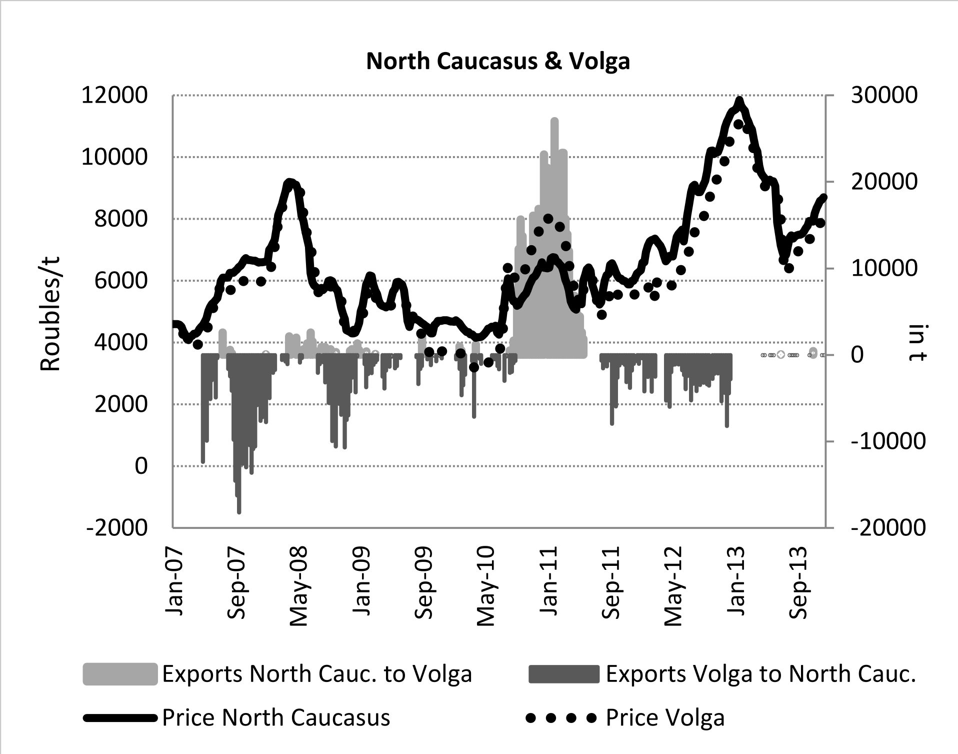
Figure 3: Development of regional wheat prices in Russia in 2005-2013



Sources: Russian Grain Union, GTI.

Figure 4: Regional wheat price relationships and interregional trade flows





Source: Russian Grain Union.

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

Before we begin with the price transmission analysis we test the properties of our data series. Results of the Augmented Dickey-Fuller (ADF) test for a unit root (Appendix, Table 4) suggest that the six price series are integrated of order 1.

Further, to perform bivariate analysis, we construct 15 market pairs by combining each market with all other five regional markets. We apply the Johansen trace test to analyze whether the prices are cointegrated. According to our results, linear cointegration of degree one is not confirmed for 8 out of 15 price pairs for the marketing year 2009/10 but not any price pair for the marketing year 2010/11 at the 10% level (Appendix, Table 5). Thus, in the majority of the cases, linear cointegration is not confirmed. This motivates us to test for non-linear threshold cointegration in the next step.

6 Results

6.1 Threshold test

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

Results of the three tests are given in Tables 6 and 7. Hansen and Seo (2002) test results suggest that the null of linear co-integration can be rejected at 10% level of significance in all cases except the Central-Black Earth market pair of the 2009/10 marketing year and the three price pairs North Caucasus-West Siberia, Black Earth-Urals, Urals-West Siberia of 2010/11. In addition, results of the Larsen (2012) test indicate that 12 out of 15 market pairs of 2009/10 and 8 out of 15 market pairs of 2010/11 reject linear cointegration in favour of threshold cointegration with 2 thresholds at the 10% significance level. These market pairs include Central-Volga, Volga-Urals and Urals-West Siberia for 2009/10 and Central-West Siberia, North Caucasus-Urals, North Caucasus -West Siberia, Black Earth-Volga, Black Earth-Urals, Volga-Urals and Urals-West Siberia (compare Tables 6 and 7).

Overall, threshold cointegration is supported for all 15 wheat price pairs of 2009/10 by at least by one of threshold cointegration test, and for 12 out of 15 price pairs of the 2010/11 marketing year. We consider these results as strong evidence for the existence of threshold effects. We explicitly account for threshold effects in the price transmission analysis by choosing a 3-regime-TVECM for our analysis of price transmission between the Russian regional wheat markets.

Table 6: Tests of threshold cointegration, 2009/10

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

Note: Sample runs from 7/3/2009 to 6/25/2010 (52 obs.)
[a]: H_0: linear cointegration | H_1: threshold cointegration. 1 threshold, trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is 'fixed Regression'.
[b]: H_0: linear cointegration | H_1: threshold cointegration. 2 thresholds, trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is 'fixed Regression'.
[1] Lag=1, intercept=no

Source: own calculations.

Table 7: Results threshold cointegration tests, 2010/11

Price series	Hansen & Seo test (2002) [a]		Larsen test (2012) [b]		
	Sup-Wald test statistic	5% critical value	P-value	Intercept	Lags
Central - Black Earth	**18.477****	18.042	**0.032**	no	2
Central - Volga	**18.477*****	17.512	**0.027**	no	2
Central - Urals	**20.360****	19.903	**0.080**	no	2
Central - West Siberia	**16.407***	17.643	0.358	yes	1
North Caucasus - Central	**15.189****	14.963	**0.081**	yes	1
North Caucasus - Black Earth	**15.038***	15.524	**0.047**	yes	1
North Caucasus - Volga	**23.181****	23.167	**0.030**	no	3
North Caucasus - Urals	**23.871*****	17.998	0.130	no	2
North Caucasus - West Siberia	14.983	17.988	0.264	yes	1
Black Earth - Volga	**23.722****	13.249	0.446	no	3
Black Earth - Urals	11.489	13.571	0.169	no	1
Black Earth - West Siberia	**25.341*****	23.204	**0.040**	no	3
Volga - Urals	**24.684****	23.650	0.203	no	3
Volga - West Siberia	**24.313****	23.285	**0.108**	no	3
Urals - West Siberia	8.536	13.635	0.132	no	1

Note: Sample runs from 7/2/2010 to 6/24/2011 (52 obs.)
[a]: H_0: linear cointegration | H_1: threshold cointegration. 1 threshold, trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is 'fixed Regression'.
[b]: H_0: linear cointegration | H_1: threshold cointegration. 2 thresholds, trimming parameter is 0.05, number of bootstrapping is set to 1000, type of bootstrapping is 'fixed Regression'.

Source: own calculations.

6.2 Parameters of the long-run price equilibrium regression

Table 8 presents the parameter estimates of the long-run price equilibrium regression estimated by ordinary least squares (OLS) method[1]. For the marketing year 2009/10, when trade was freely possible, results suggest that the long-run price transmission parameter decreases and the intercept parameter increases with increasing distance between the regions. This corresponds

[1] We have also used Johansen method to estimate the long-run price equilibrium regression. Results are available from the authors upon request. In general, the estimated parameters are very similar. However, the parameter estimates based on OLS do in some cases comply better with economic theory compared to Johansen method.

with the Law of One Price according to which markets are perfectly integrated if the intercept of the long-run price equilibrium is equal to zero and the slope parameter is equal to one.

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

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

Our results suggest that North Caucasus is the grain producing region which is the least integrated with the other grain producing regions of Russia. North Caucasus is the only major grain producing region with direct access to the world grain market. Thus, different to the other grain producing regions, North Caucasus is also strongly influenced by the world market conditions explaining its rather low integration in the Russian regional grain markets.

Table 8: Parameters of the long-run price equilibrium regression, OLS estimation, 2009/10 and 2010/11

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

Note: All parameters are significant at a level higher than 1%.

Source: Own estimations.

For the marketing year 2010/11, when several regions experienced severe droughts, and exports to the world market were forbidden by an export ban, the slope coefficient increases and the intercept parameter decreases compared to 2009/10 for 13 out of the 15 price pairs. The two exceptions are the neighboring regions Central-Black Earth and Urals-West Siberia, for which the long-run price transmission parameter (almost) remains constant. Obviously, the domestic Russian grain market is characterized by stronger market integration during the export ban. This can be explained by two factors. First, due to the export ban, the influence of the world market conditions on domestic price formation decreases particularly in those regions, which are usually involved in grain export to the world market. Thus, the influence of the common domestic factors increases, particularly in the export-oriented regions which strengthens their integration in the domestic market. This is also reflected in the increase in the long-run price transmission parameter (in percentage), which is strongest for the price pairs involving North Caucasus, the increase varying between about 70% and 200%. Second, due to the severe harvest shortfalls of up to 60% in some regions in 2010/11, interregional trade flows increase strongly and are observed from the surplus regions North Caucasus and West Siberia to the deficit regions (compare Table 1), contributing to the strengthened domestic market integration. This rise in the domestic grain trade was fostered by the implementation of the wheat export ban.

6.3 Estimated parameters of the TVECM

Selected parameters of the 3-regime TVECM, which is estimated for the 15 market pairs for the marketing years 2009/10 and 2010/11 separately are presented in Tables 9 and Table 10. It becomes evident that the vast majority of observations is attributed to the middle regime for 12 out of 15 regional price pairs in 2009/10. For example, for the price pair Central-Black Earth, 40 observations are assigned to the middle regime, whereas 7 observations belong to the lower and one observation to the upper regime. This means that the error term of the long-run price equilibrium between the Central and Black Earth region is usually smaller than the absolute value of the lower and upper threshold, providing evidence that arbitrage opportunities do not exist and the market is efficient. In 2010/11 the number of market pairs for which the majority of observations lies in the middle regime increases to 14 out of the 15 market pairs. This can be interpreted as evidence or the increase in market efficiency during the export ban.

The band of inaction is given as the difference between the absolute value of the upper and lower threshold. The average size of the band of inaction is significantly lower in the marketing year 2009/10 amounting to 0.07 compared to the marketing year 2010/11 amounting to 0.12. For both marketing years the band of inaction is highest for all price pairs which include either Ural or West Siberia, two peripheral regions which are characterized by large distance to the grain consuming and exporting regions and thus high trade costs. Though, the band of inaction is rather low for the price pair Urals-West Siberia, which are neighboring regions and are characterized by strong integration.

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

Estimates of the threshold parameters in 2009/10 generally confirm the influence of distance. For example, for all price pairs which include the Central market, the absolute value of the negative threshold increases with distance (compare Figure 2). In particular, the absolute value of the identified negative threshold is highest for the market pair Central-West Siberia (0.062), two markets which are the most far apart, while it is significantly lower for the price relationship between the markets Central and Black Earth (0.021) and Central and Volga (0.013) which are each neighboring regions. Thus, parameter estimates indicate that it is almost three times costlier to supply wheat from West Siberia to Central, than from Black Earth to Central. The threshold is second highest for the market pair Central-Urals (0.047) which is in line with the actual distance between those markets.

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

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

The increase in the band of inaction in 2010/11 compared to 2009/10 can be explained by the increase of the size of thresholds. Parameter estimates suggest that the size of thresholds had increased compared to 2009/10 for the vast majority of price pairs. The lower threshold increased for all price pairs except one. The identified upper threshold increased for 11 out of the 15 price pairs. These results suggest that interregional trade costs increased in 2010/11 compared to 2009/10.

Information provided by the Russian Grain Union confirms these results. First, the transport costs by railway were twice increased by the government in 2010/11 compared to 2009/10. Further, the destinations of interregional grain trade flows changed during the export ban and grain trade flows were even reversed. Traders had to extend their business to other regions and could not make use of their established business contacts. Thus, transaction costs of trade increased strongly by increasing trade risk. This is particularly relevant for the Russian market which is characterized by a high level of fraud and high risk of contract enforcement.

The influence of distance is also reflected in the size of the regime-specific speed of adjustment parameters and the regime-specific total adjustment. Total adjustment in one regime is calculated as the sum of the absolute value of the respective regime-specific speed of adjustment parameters of the TVECM. In the following we focus on the parameters which are statistically significant at least at the 10% level, and which are of the expected sign.

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

The influence of trade costs is also reflected when comparing the regime-specific speed of adjustment parameters and the total adjustment for each price pair. We find 8 price pairs for 2009/10 and 12 price pairs for 2010/11 out of the 15 price pairs each for which the speed of adjustment parameters and the total adjustment is higher in at least one of the outer regimes (lower and upper regime) compared to the middle regime. This confirms the theory underlying threshold models applied in spatial price transmission, according to which the speed at which deviations from the long-run price equilibrium are corrected, is higher if the price deviations exceed the thresholds which are representing trade costs.

The regime-specific speed of adjustment parameters and total adjustment are increasing for at least one regime in 13 out of 15 cases in 2010/11 compared to 2009/10, confirming once again that the integration of the regional wheat markets was strengthened during the export ban.

Table 9: Results of TVECM, 2009/10 (specification: constant in CE and no-constant in TVECM, lags=3)

Price pair		Lower regime			Middle regime			Upper regime		Total adjustment [Number of obs.]			
	Dependent - indep. variable	**Rho1**	**[Pvalue]**	**Lower Thresh.**	**Rho2**	**[Pvalue]**	**Upper Thresh.**	**Rho3**	**[Pvalue]**	**Lower**	**Middle**	**Upper**	**Band of inaction**
1	**Central - Black Earth**	-0.212	[0.360]	***-0.021***	-0.208	[0.336]	***0.018***	**-0.353**	[0.089]	**0.340**	**0.364**	**0.733**	**0.039**
	Black Earth - Central	**0.340**	[0.072]		**0.364**	[0.035]		**0.380**	[0.015]	[7]	[40]	[1]	
2	**Central - Volga**	-0.100	[0.291]	***-0.013***	-0.207	[0.337]	***0.003***	-0.147	[0.168]	-	-	-	**0.016**
	Volga - Central	0.121	[0.264]		-0.180	[0.408]		-0.081	[0.494]	[17]	[12]	[19]	
3	**Central -Urals**	-0.029	[0.757]	***-0.047***	-0.149	[0.259]	***0.029***	**-0.173**	[0.030]	**0.310**	-	**0.173**	**0.076**
	Urals - Central	**0.310**	[0.004]		0.179	[0.214]		0.100	[0.233]	[17]	[18]	[13]	
4	**Central - West Siberia**	-0.039	[0.646]	***-0.062***	-0.102	[0.311]	***0.021***	**-0.166**	[0.014]	**0.260**	-	**0.166**	**0.083**
	West Siberia - Central	**0.260**	[0.041]		0.082	[0.574]		-0.005	[0.955]	[12]	[17]	[19]	
5	**North Caucasus - Black Earth**	**-0.207**	[0.041]	***-0.021***	**-0.207**	[0.041]	***0.020***	**-0.207**	[0.041]	**0.207**	**0.207**	**0.207**	**0.041**
	Black Earth - North Caucasus	-0.018	[0.809]		-0.018	[0.809]		-0.018	[0.809]	[14]	[16]	[18]	
6	**North Caucasus - Central**	**-0.300**	[0.025]	***-0.030***	**-0.216**	[0.088]	***0.020***	-0.168	[0.136]	**0.300**	**0.216**	-	**0.050**
	Central - North Caucasus	**-0.152**	[0.187]		0.114	[0.299]		-0.031	[0.744]	[7]	[24]	[16]	
7	**North Caucasus - Volga**	**-0.167**	[0.078]	***-0.038***	-0.177	[0.136]	***0.012***	**-0.153**	[0.060]	**0.167**	-	**0.153**	**0.050**
	Volga - North Caucasus	-0.107	[0.276]		-0.074	[0.569]		-0.091	[0.328]	[4]	[26]	[18]	
8	**North Caucasus - Urals**	0.041	[0.684]	***-0.036***	-0.029	[0.820]	***0.024***	-0.064	[0.379]	-	-	-	**0.060**
	Urals - North Caucasus	0.176	[0.132]		0.154	[0.284]		0.081	[0.360]	[11]	[21]	[16]	
9	**North Caucasus - West Siberia**	-0.116	[0.146]	***-0.049***	**-0.125**	[0.036]	***0.029***	**-0.125**	[0.036]	-	**0.125**	**0.125**	**0.078**
	West Siberia - North Caucasus	-0.010	[0.926]		0.057	[0.573]		0.057	[0.573]	[6]	[29]	[13]	
10	**Black Earth - Volga**	**-0.094**	[0.086]	***-0.046***	**-0.146**	[0.052]	***0.011***	**-0.094**	[0.086]	**0.094**	**0.146**	**0.094**	**0.057**
	Volga - Black Earth	0.022	[0.781]		-0.003	[0.979]		0.022	[0.781]	[8]	[26]	[14]	
11	**Black Earth - Urals**	0.063	[0.318]	***-0.059***	0.063	[0.318]	***0.031***	0.005	[0.928]	**0.295**	**0.295**	**0.193**	**0.090**
	Urals - Black Earth	**0.295**	[<0.001]		**0.295**	[<0.001]		**0.193**	[0.016]	[10]	[28]	[10]	
12	**Black Earth - West Siberia**	-0.007	[0.898]	***-0.087***	-0.069	[0.208]	***0.025***	-0.049	[0.375]	-	-	-	**0.112**
	West Siberia - Black Earth	0.106	[0.229]		0.015	[0.859]		0.016	[0.849]	[6]	[26]	[16]	
13	**Volga - Urals**	-0.160	[0.203]	***-0.058***	-0.019	[0.858]	***0.038***	**-0.297**	[0.014]	**0.210**	**0.200**	**0.297**	**0.096**
	Urals - Volga	**0.210**	[0.067]		**0.200**	[0.043]		0.120	[0.245]	[8]	[33]	[7]	
14	**Volga - West Siberia**	-0.141	[0.274]	***-0.056***	**-0.201**	[0.035]	***0.035***	**-0.288**	[0.004]	-	**0.201**	**0.288**	**0.091**
	West Siberia - Volga	0.216	[0.125]		0.098	[0.228]		-0.026	[0.763]	[4]	[38]	[6]	
15	**Urals - West Siberia**	**-0.206**	[0.072]	***-0.027***	-0.186	[0.183]	***0.012***	-0.206	[0.141]	**0.206**	-	-	**0.039**
	West Siberia - Urals	0.213	[0.157]		0.167	[0.324]		0.011	[0.951]	[11]	[22]	[15]	

Table 10: Results of TVECM, 2010/11 (specification: constant in CE and no-constant in TVECM, lags=3)

	Price pair	Lower regime			Middle regime			Upper regime		Total adjustment [Number of obs.]			
	Dependent - indep. variable	**Rho1**	**[Pvalue]**	**Lower Thresh.**	**Rho2**	**[Pvalue]**	**Upper Thresh.**	**Rho3**	**[Pvalue]**	**Lower**	**Middle**	**Upper**	**Band of inaction**
1	**Central - Black Earth**	0.018	[0.964]	***-0.022***	**-0.437**	[0.096]	***0.014***	-0.272	[0.369]	**0.587**	**0.437**	**-**	**0.036**
	Black Earth - Central	**0.587**	[0.098]		0.022	[0.915]		0.301	[0.243]	[6]	[36]	[6]	
2	**Central - Volga**	**-0.690**	[0.005]	***-0.018***	-0.290	[0.161]	***0.008***	-0.168	[0.334]	**0.690**	**-**	**-**	**0.026**
	Volga - Central	-0.142	[0.568]		0.117	[0.566]		0.178	[0.292]	[8]	[27]	[13]	
3	**Central -Urals**	**-0.457**	[<0.001]	***-0.095***	0.042	[0.524]	***0.058***	-0.039	[0.826]	**0.457**	**-**	**0.304**	**0.153**
	Urals - Central	-0.017	[0.873]		0.084	[0.171]		**0.304**	[0.078]	[3]	[41]	[4]	
4	**Central - West Siberia**	**-0.329**	[0.007]	***-0.105***	**0.118**	[0.061]	***0.054***	0.158	[0.131]	**0.329**	**-0.118**	**0.274**	**0.159**
	West Siberia - Central	0.040	[0.772]		0.028	[0.764]		**0.274**	[0.042]	[3]	[38]	[7]	
5	**North Caucasus - Black Earth**	**-0.244**	[0.054]	***-0.090***	**-0.264**	[0.035]	***0.038***	-0.217	[0.121]	**0.244**	**0.264**	**-**	**0.128**
	Black Earth - North Caucasus	-0.014	[0.846]		-0.075	[0.171]		0.008	[0.921]	[2]	[38]	[8]	
6	**North Caucasus - Central**	**-0.239**	[0.010]	***-0.032***	-0.385	[0.397]	***0.004***	**-0.242**	[0.009]	**0.129**	**-**	**0.129**	**0.036**
	Central - North Caucasus	**-0.110**	[0.094]		0.308	[0.154]		**-0.113**	[0.089]	[16]	[14]	[18]	
7	**North Caucasus - Volga**	**-0.308**	[0.049]	***-0.046***	**-0.315**	[0.075]	***0.007***	**-0.260**	[0.066]	**0.054**	**0.315**	**0.103**	**0.053**
	Volga - North Caucasus	**-0.254**	[0.009]		0.033	[0.748]		**-0.157**	[0.042]	[10]	[23]	[15]	
8	**North Caucasus - Urals**	**-0.323**	[0.002]	***-0.099***	**-0.323**	[0.002]	***0.085***	**-0.328**	[0.098]	**0.323**	**0.323**	**0.328**	**0.184**
	Urals - North Caucasus	-0.036	[0.365]		-0.036	[0.365]		-0.149	[0.210]	[4]	[40]	[4]	
9	**North Caucasus - West Siberia**	**-0.381**	[<0.001]	***-0.053***	**-0.370**	[0.011]	***0.038***	**-0.453**	[0.003]	**0.381**	**0.370**	**0.453**	**0.091**
	West Siberia - North Caucasus	-0.048	[0.536]		0.013	[0.921]		-0.134	[0.335]	[10]	[29]	[9]	
10	**Black Earth - Volga**	-0.139	[0.371]	***-0.029***	-0.139	[0.404]	***0.008***	-0.126	[0.401]	**-**	**-**	**-**	**0.037**
	Volga - Black Earth	0.012	[0.948]		-0.056	[0.766]		-0.008	[0.963]	[6]	[22]	[20]	
11	**Black Earth - Urals**	**-0.271**	[0.011]	***-0.103***	0.020	[0.780]	***0.076***	**-0.322**	[0.003]	**0.271**	**-**	**0.322**	**0.179**
	Urals - Black Earth	-0.063	[0.500]		0.039	[0.518]		-0.123	[0.184]	[2]	[44]	[2]	
12	**Black Earth - West Siberia**	**-0.246**	[0.008]	***-0.107***	0.041	[0.430]	***0.071***	-0.063	[0.657]	**0.246**	**-**	**-**	**0.178**
	West Siberia - Black Earth	-0.150	[0.186]		0.104	[0.126]		0.003	[0.984]	[2]	[44]	[2]	
13	**Volga - Urals**	**-0.194**	[0.027]	***-0.107***	-0.092	[0.163]	***0.069***	**-0.225**	[0.027]	**0.194**	**-**	**0.225**	**0.176**
	Urals - Volga	-0.018	[0.812]		0.015	[0.791]		-0.043	[0.624]	[2]	[43]	[3]	
14	**Volga - West Siberia**	-0.104	[0.170]	***-0.105***	0.041	[0.529]	***0.046***	0.105	[0.439]	**-**	**-**	**0.418**	**0.151**
	West Siberia - Volga	0.032	[0.679]		0.061	[0.376]		**0.418**	[0.005]	[4]	[37]	[7]	
15	**Urals - West Siberia**	0.053	[0.513]	***-0.061***	0.039	[0.619]	***0.029***	0.039	[0.619]	**0.318**	**0.300**	**0.300**	**0.090**
	West Siberia - Urals	**0.318**	[0.012]		**0.300**	[0.020]		**0.300**	[0.020]	[3]	[36]	[9]	

7 Comparison with the corn market in the USA

To assess how well the wheat market of Russia is functioning, we analyse integration and efficiency of the corn markets in the main grain producing regions of the USA. The corn market of the USA seems is particularly suitable for comparison since it is characterized by rather high variation in the level of production and strong domestic trade flows to balance supply and demand of corn. We assume that the corn market of the USA is one of the most efficient and integrated grain markets in the world characterized by well-developed transport and storage infrastructure and high market transparency, serving as a benchmark for assessing efficiency and integration of the Russian wheat market in this study.

Corn is the primary grain produced in the USA, accounting for more than 80% of total grain production (NASS, 2016). For comparison, wheat has a 60% share in total grain production in Russia. Moreover, USA is the world's largest exporter of corn occupying 35%-40% of total corn exports world-wide (ERS 2016). Nonetheless, 80-90% of the corn production in the USA is supplied to the domestic market. Due to the rapid expansion of biofuel production the industrial use of domestically grown corn has increased significantly and is exceeding its usage for animal feed since 2010. Share of corn used for biofuel production accounts for 40% of total corn usage (ERS, 2016). Ethanol plants are usually established close to the corn-producing regions. Corn is primarily transported by truck from the elevators to the plants. The majority of corn is grown in the so-called "corn belt" region ranging over the states Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Kansas, Ohio and Missouri and accounting for about 80% of total corn production of the USA. Similar to Russia, the size of corn production in the USA is characterized by large regional fluctuations (Table 11). For example, corn production in Illinois varied between 65% in 2012 and 132% in 2014 of the average corn production of the previous 3 years. Nonetheless, the volume of harvested corn is quite stable on the national level.

Corn transportation in the USA is mainly based on trucks, rails and barges. On average 80% of domestic corn transfers is performed by trucks since it is cost advantageous on shorter distances (less than 500 kilometres). The rest of domestic transportation for longer distances is realized by rails. Barges are suitable for long-distance transportation wherever waterway is available. About 60% of totally exported volume is delivered to the coastal borders via barges primarily from the "corn belt" region southwards to the Mississippi Gulf ports. The remaining 30%-40% of the corn exported is transported by rail to the harbors. Table 12 illustrates cost advantages of selected transportation modes depending on the distance covered. Trucks are the cheapest transportation mode within distances less than 500 kilometres. Barges are in general the least costly mode of transportation, supposing these regions have direct access to a river. Alternatively rail transportation is used over longer distances.

Compared to Russia, transportation logistics function more efficiently and delivery costs are lower in the USA. The influence of trade costs is usually reflected in the strength of market integration between spatially separated regions. We estimate the long-run price equilibrium for selected regional price pairs. As our data base we use weekly silo selling prices for yellow corn (AMS 2016). Table 13 shows preliminary estimates for the long-run price transmission elasticity for selected markets in the USA, which decrease with increasing distance between the markets. However, the influence of distance in the corn market of the USA seems to be significantly weaker compared to the wheat market of Russia (compare Table 7).

Figure 5 graphically makes evident that the influence of distance on the long-run price transmission parameter seems to be significantly stronger in Russia compared to the USA. It suggests that the influence of distance was stronger during the 2009/10 marketing season compared to when trade to the world market was not possible.

Table 11: Corn production developments in the states of the "corn-belt" of the USA (2004-2015), in % of the average of previous 3 years

State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Iowa	122	106	98	110	100	111	92	104	81	101	111	118
Illinois	126	95	97	122	110	99	90	95	65	122	132	105
Nebraska	124	113	95	117	107	117	99	104	85	113	108	113
Minnesota	119	114	101	101	103	109	108	97	110	100	91	111
Indiana	121	114	97	111	97	104	97	93	67	133	132	91
South Dakota	147	111	65	123	133	150	93	105	83	137	119	113
Kansas	133	137	86	123	111	134	109	81	70	107	127	120
Ohio	126	114	98	114	86	114	106	102	85	131	114	88
Wisconsin	97	116	104	112	93	109	117	116	82	93	107	111
Missouri	150	94	99	118	100	111	86	88	64	135	183	100
USA total	**124**	**108**	**96**	**117**	**105**	**111**	**98**	**98**	**85**	**117**	**115**	**105**

Note: USA total considers corn production in all states.

Source: Own illustration, data: NASS 2016.

Table 12: Estimated costs of corn transportation in the U.S. by different modes of transportation and distance covered in 2010

Distance (km)	Barge	Rail	Truck

200	-	-	13
300	-	27	18
500	-	28	26
1000	16	37	-
2000	26	42	-
2600	41	43	-

Note: Delivery fee is recognized as the charge to be paid in US-$ for transporting 1 metric ton. Barge rates represent shipping costs calculated at spot rates towards the southbound direction along the Mississippi River to the ports of New Orleans[1] on October 05, 2010 (when trade capacity and correspondingly, barge rates are at their peak). The value of rail delivery rates is estimated on October 01, 2010 corresponding to the peak transportation season. Truck per-mile rates for the 3rd quarter in 2010are calculated on three different levels depending on the distance covered: $4.15 (25 miles), $2.4 (100 miles), and $2.28 (200 miles).

Source: Own illustration, data: AMS (2016).

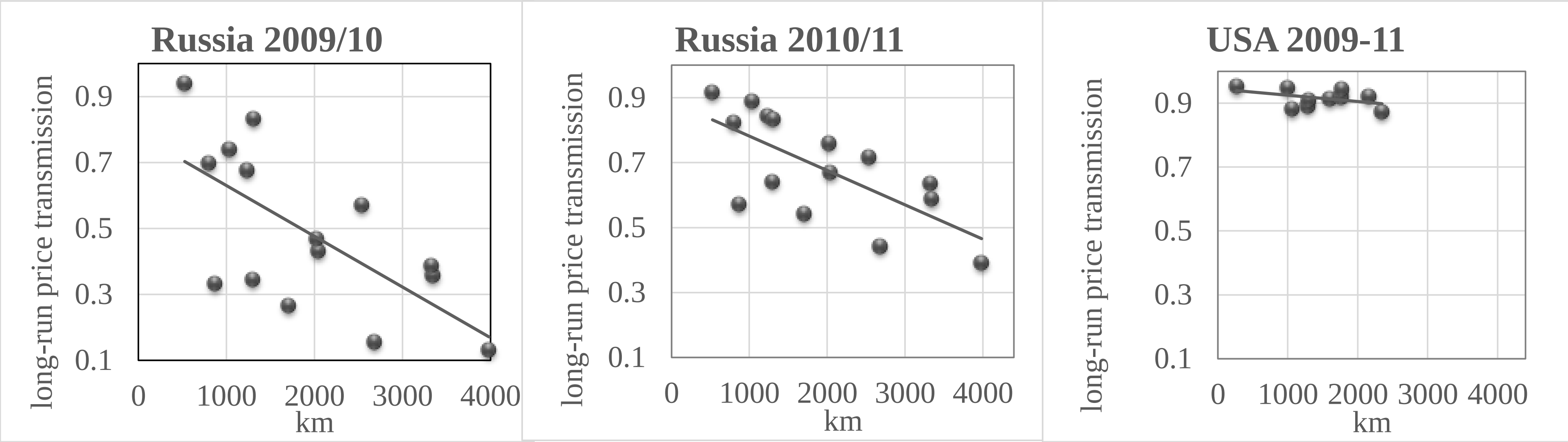
Table 13: Long-run price transmission elasticity and distance for selected price pairs

Price pairs		Long-run price transmission elasticity	Distance (km)
Dependent variable	**Independent variable**		
Texas	Kansas	0.954	272
Virginia	Ohio	0.948	1001
Texas	Missouri	0.882	1064
Texas	South Dakota	0.846	1123
Texas	Minnesota	0.892	1290
Texas	Iowa	0.91	1305
Virginia	Missouri	0.914	1600
Texas	Ohio	0.92	1765
Virginia	Iowa	0.944	1773
Virginia	Minnesota	0.922	2160
Virginia	South Dakota	0.873	2348
Virginia	Kansas	0.988	2593

Source: Own estimations.

[1] Per ton rates are following for the given locations: Cairo-Memphis $16.1, St. Louis $21.5, Lower Ohio $26.3, Lower Illinois River $29.9, Cincinnati $30.5, Mid-Mississippi $33.3, Twin Cities (Minnesota) $40.6.

Figure 5: Relationship between the long-run price transmission parameter and distance between the regions



Source: Own illustration.

8 Conclusions

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

In general, the results of the price transmission analysis for Russia demonstrate the strong influence of distance between the grain producing regions on their price relationships. In particular, the band of inaction and the upper and the lower threshold increase with distance between the regions of the price pairs, whereas the long-run price transmission elasticity, the speed of adjustment parameter and the total adjustment decrease with distance. The speed of adjustment parameters and total adjustment are highest for neighboring regions.

Price pairs involving North Caucasus are characterized by particularly low long-run price transmission elasticity, speed of adjustment parameters and total adjustment, demonstrating that the influence of the world market price is strongest in the exporting region North Caucasus, which reduces its regional integration in the Russian wheat market.

The thresholds are highest for price pairs involving Urals and West Siberia, reflecting the relatively high trade costs due to the peripheral location of those regions within the Russian wheat market.

Our results suggest that the integration of the regional wheat markets strengthened during the wheat export ban in 2010/11, which can be explained by the increase in interregional trade flows. In particular, regime-specific speed of adjustment parameters increased in 2010/11 compared to 2009/10 for many price-pairs. Further, we find that the size of thresholds and the band of inaction increasing in 2010/11 compared to 2009/10. We trace this back to increasing transport costs and also increasing trade risk of interregional grain transactions. The increasing trade risks results from the change in export destinations requiring to involve new trade partners. Obviously, the transport subsidy was too low to prevent that total transaction costs of interregional trade increased during the export ban period. This results confirms that in general the risk of business is particularly high in Russia due to a high degree of fraud and the difficulties to enforce contracts.

The comparison of the long-run price transmission parameter of the Russian wheat market with the preliminary results for the corn market of the USA makes evident that the regional corn market of the USA is stronger integrated compared to Russia. Also, the influence of distance is substantially higher in the Russian market compared to the USA.

Our study offers several important implications in terms of trade policy and food security. First, strengthening market integration between the grain production regions could contribute to decrease price volatility within the regions of Russia. If price signals were faster transmitted from deficit to surplus regions, and the transaction costs of trade were decreased, incentives for interregional trade from surplus to the actual deficit regions would be strengthened and contribute to cushion the price increasing effects of regional production shortfalls.

This in turn would reduce the incentives for the government to implement export controls on grain market which in the long-run strongly negatively affect the further development of the grain sector.

In future research we will extend the price transmission analysis of the USA corn market to a TVECM to broaden the comparison of the grain markets of Russia and USA to additional characteristics as e.g. arbitrage opportunities, the speed of adjustment to deviations from the price equilibrium and the size of transaction costs.

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Annex

Table 4: Augmented Dickey-Fuller test for prices in levels and first differences

Variable	Determ. component	Lags	Test-stat
	Constant & trend	1	-2.329
	Constant & trend	0	-4.513***
	Constant & trend	1	-2.409
	Constant & trend	0	-6.945***
	Constant & trend	1	-2.850
	Constant & trend	0	-3.700***
	Constant & trend	3	-2.478
	Constant & trend	2	-3.811***
	Constant & trend	2	-2.539
	Constant & trend	1	-2.859***
	Constant & trend	1	-2.109
	Constant & trend	0	-4.820***

Note: Sample runs from 7/3/2009 to 6/24/2011 (104 obs.) Prices are given in natural logarithmic form. Critical values of the test statistic are -3.153 (10%), -3.454 (5%) and -4.051 (1%). The asterisks refer to the significance at 1% (***), 5% (**) and 10% (*) levels. Lag length selection is based on Schwarz Information Criterion. One-sided p-values are from MacKinnon (1996).

Source: Own calculations.

Table 5: Johansen's test on linear cointegration 2009/10 and 2010/11

Price series	number cointegrating vectors H0	H1	2009/10 trace statistic	2009/10 p-value	2010/11 trace statistic	2010/11 p-value
Central - Black Earth	0	1	29.117	0.002	**7.243**	**0.881**
	1	2	4.069	0.402	**1.907**	**0.796**
Central - Volga	0	1	22.569	0.024	**10.527**	**0.588**
	1	2	8.474	0.068	**0.834**	**0.971**
Central - Urals	0	1	28.369	0.003	**8.989**	**0.737**
	1	2	5.584	0.225	**1.620**	**0.851**
Central - West Siberia	0	1	22.341	0.026	**6.718**	**0.914**
	1	2	6.243	0.173	**1.069**	**0.942**
North Caucasus - Central	0	1	21.807	0.030	**21.807**	**0.030**
	1	2	6.322	0.167	**6.322**	**0.167**
North Caucasus - Black Earth	0	1	20.400	0.048	**6.711**	**0.915**
	1	2	3.573	0.480	**0.695**	**0.983**
North Caucasus - Volga	0	1	**24.184**	**0.137**	**10.501**	**0.591**
	1	2	**5.578**	**0.226**	**1.939**	**0.790**
North Caucasus - Urals	0	1	27.717	0.004	**14.390**	**0.264**
	1	2	3.840	0.437	**2.059**	**0.766**
North Caucasus - West Siberia	0	1	**17.452**	**0.117**	**14.834**	**0.236**
	1	2	**5.319**	**0.250**	**0.596**	**0.990**
Black Earth - Volga	0	1	**13.779**	**0.305**	**3.230**	**0.999**
	1	2	**5.651**	**0.220**	**0.717**	**0.981**
Black Earth - Urals	0	1	**17.166**	**0.126**	**7.130**	**0.889**
	1	2	**2.367**	**0.704**	**1.602**	**0.855**
Black Earth - West Siberia	0	1	**12.940**	**0.369**	**4.504**	**0.990**
	1	2	**1.639**	**0.848**	**1.050**	**0.945**
Volga - Urals	0	1	**36.504**	**0.001**	**7.584**	**0.857**
	1	2	**13.459**	**0.007**	**0.766**	**0.977**
Volga - West Siberia	0	1	**36.504**	**0.001**	**7.584**	**0.857**
	1	2	**13.459**	**0.007**	**0.766**	**0.977**
Urals - West Siberia	0	1	**17.093**	**0.129**	**12.089**	**0.441**
	1	2	**6.817**	**0.136**	**2.775**	**0.624**

Note: Sample runs from 7/3/2009 to 6/25/2010 (52 obs.); model specification: 3 lags, constant in cointegration equation, no constant in VECM; 5 % critical values are 20.262 (rank=0) and 6.165 (rank=1); p-values are from MacKinnon, Haug & Michelis (1999).

Source: Own calculations.

Volatility of Domestic Wheat Prices

Export Restrictions and Market Uncertainty: Evidence from the Analysis of Price Volatility in the Ukrainian Wheat Market, GÖTZ, L., K. GOYCHUK, T. GLAUBEN, AND W. H. MEYERS, *Selected Paper, Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.*

Export Restrictions and Market Uncertainty: Evidence from the Analysis of Price Volatility in the Ukrainian Wheat Market

Linde Götz[a], Kateryna Goychuk[b],Thomas Glauben[a], and William H. Meyers[b]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany, [b] Food and Agricultural Policy Research Institute at the University of Missouri-Columbia, USA

Abstract

The impact of export restrictions on market uncertainty has not been investigated before. This paper analyses the development of price volatility in the Ukrainian wheat market characterized by export restrictions during the commodity price peaks 2007/08 and 2010/11 within a dynamic conditional correlation GARCH model. We conclude that the export controls in Ukraine have not significantly reduced price volatility on the domestic wheat market. On the contrary, our findings suggest that the multiple and unpredictable political interference of the Ukrainian government on the wheat export market has substantially increased market uncertainty which led to pronounced additional price volatility in the market. The highly uncertain and unpredictable environment of wheat markets with restricted exports has dramatic consequences for the grain sector in Ukraine and prevents its further development.

1 Introduction

Since the beginning of the XXI century, agricultural prices and volatility started to increase and led to agricultural commodity price peaks in 2007/08 and 2010/11. According to forecasts, this trend will continue in the coming decades primarily driven by growing world population and global income growth. OECD/FAO (2012) projects that global demand for cereals will reach about 3 billion tons by 2050, which requires the global annual grain production to increase by 30%. The three large grain-producing countries of the former Soviet Union, Kazakhstan, Russia and Ukraine (KRU) could play a significant role for heightened global grain production and trade, given substantial investments in grain production. Liefert et al. (2013) estimates that the KRU countries could provide 22% of world grain exports by 2021. Grain yields could be increased by intensified use of fertilizer and seeds of high quality. Also, grain production might be increased by re-cultivating abandoned land. The future development and the role the grain sectors could play for global markets is strongly determined by the agricultural policy pursued by the governments of the KRU countries. In particular, Russia and Ukraine restricted their wheat exports by export taxes (Russia, 2007/2008 and Ukraine 2011/12) an export ban (Russia, 2010/2011) and export quotas (Ukraine, 2006-2008 and 2010/2011) during the recent commodity price peaks. Export restrictions aim to stabilize prices on the domestic market by preventing the transmission of dramatically increasing world market prices, and ultimately to dampen domestic food price inflation. Theoretically, by reducing the export quantity, wheat export restrictions increase the supply on the domestic market which decreases domestic wheat prices (Mitra and Josling 2009). However, by reducing the domestic price, export restrictions for wheat create disincentives for investments in the domestic grain sector, decrease the efficiency of the wheat market (Goychuk and Meyers, 2013), and hinder the mobilization of the KRU's wheat production potential. This effect will be amplified if the restrictions are introduced and managed in a discretionary and non-transparent way, as particularly in Ukraine, creating a highly uncertain and unpredictable market environment. Export restrictions also affect the world market by increasing the level and volatility of the international price.

While the effect of export restrictions on the world market (e.g. Martin and Anderson, 2011; Anderson and Nelgen 2012a; see Sharma 2011 for an overview) and on the domestic market (e.g. Götz et al. 2013, 2012; Abbott, 2012; Anderson and Nelgen 2012b; Grueninger and von Cramon-Taubadel 2008) has been identified in various studies, their impact on domestic market uncertainty and price volatility has not yet been investigated comprehensively. Anderson and Nelgen (2012b) use the standard deviation, the coefficient of variation and the Z-statistic of the domestic price relative to that of the border price as indicators for domestic market instability. The analysis is conducted for 75 countries for all agricultural products for 1955 to 2004. Results suggest that governmental market interventions only slightly increase domestic price stability. Götz et al. (2013) identify an increase in the standard error of domestic prices in Russia and Ukraine during restricted exports within a Markov-switching error correction model. They conclude that the export restrictions could not prevent the decrease of domestic market stability in times of high and volatile world market prices.

This paper aims to analyze the influence of export controls on domestic market uncertainty and price volatility in the case of the wheat markets in Ukraine. We hypothesize that export restrictions, particularly if they are implemented on short notice and their design is changed multiple times, increase market risk and might induce additional price variations on the domestic market. Brümmer et al. (2009) have identified a causal link between market instability and policy interventions. Investigating the wheat market in Ukraine they find increased residual variance within a Markov-switching vector error correction model in times of ad hoc and frequently uncoordinated domestic policy interventions.

In this paper we address the following research questions: How did price volatility on the domestic market in Ukraine develop during the export quota system compared to open trade? And how strong was the relationship between the volatility on the Ukrainian and the world wheat market? We address these research questions by investigating the development of price volatility on the Ukrainian wheat market within a multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach. For comparison, we include the German[1] wheat market, which did not experience export restrictions during the food price peaks of 2007/2008 and 2010/2011, as reference case in our analysis. Also, the French wheat export price is considered as a measure for the world market price in our model.

Section 2 gives some background information on the export quota system in Ukraine. Section 3 describes our research method, and the data is presented in section 4. Section 5 gives empirical results, and conclusions are drawn in section 6.

2 Wheat Trade Policy Interventions in Ukraine

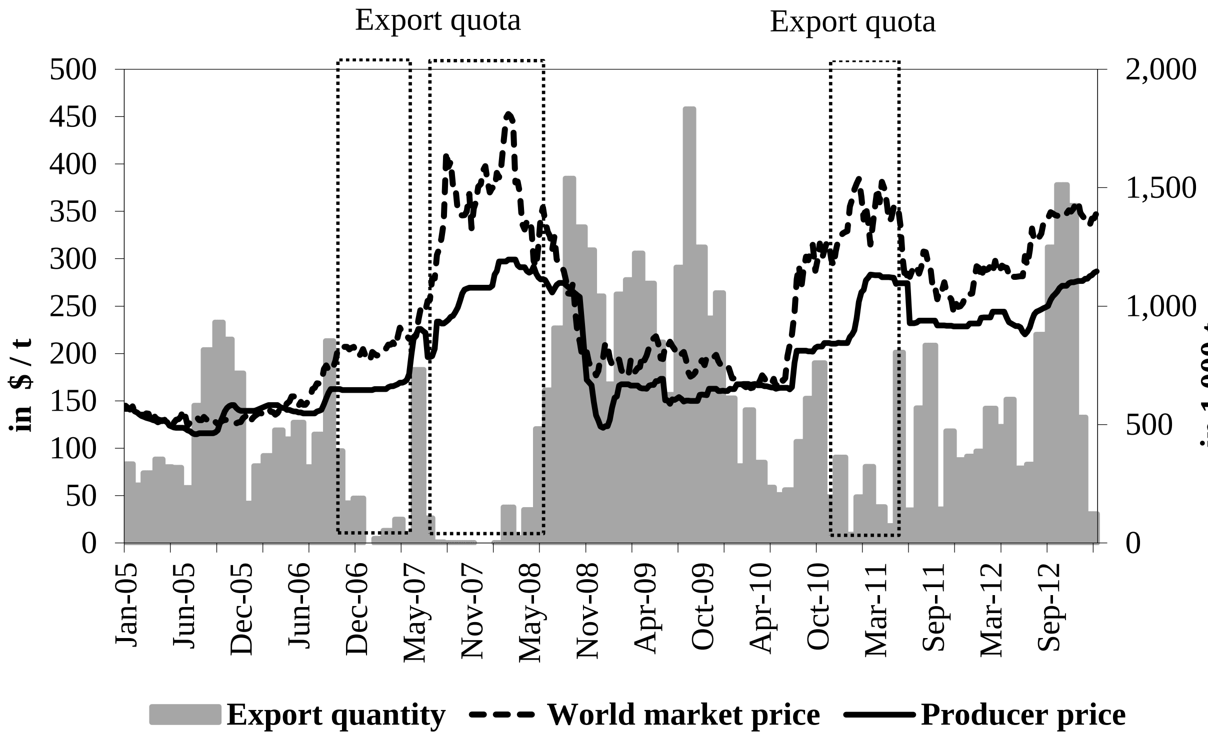
The government of Ukraine quantitatively limited wheat exports during the two recent commodity price booms by an export quota which was implemented within a governmental license system. Export quotas allow exports up to the amount as specified by the size of the quota. Export quotas varying between 3,000 tons and 1.2 million tons were in force from October 2006 until May 2008 and again from October 2010 until May 2011. Figure 1 shows the development of the Ukrainian wheat grower price (Milling wheat class 3, ex warehouse) and the world wheat market price (French soft wheat, FOB, Rouen) with wheat exports.

These trade policy interventions were accompanied by a dramatic increase in political uncertainty since 1) the export quotas were implemented on short notice 2) the size of the quota was changed multiple times, and 3) their distribution came along with massive corruption, particularly in 2010/2011.

[1] Though, the EU suspended wheat import taxes from January to October 2008 and again from February to June 2011.

For example, the wheat export quota implemented in 2010 became effective rapidly such that ships already loaded with wheat could not leave the harbor. As a result, several hundred thousand tons of wheat sat in storage temporarily on ships in Ukrainian harbors causing high additional costs to exporters (APK Inform 2010). According to traders' information, this implied that contracts could not be fulfilled, which negatively affected international reputation of traders exporting from Ukraine. Further, the export quota implemented 2006-2008 was first announced in October 2006 to amount 400,000 tons, but it was reduced to 3,000 tons in December 2006. In February 2007 the government gave notice of an increase of the quota to 230,000 tons; however, this increase was not realized. The export quota was abandoned in June 2007 but was reintroduced in July and set at a prohibitive level of 3,000 tons. The notified expansion of the export quota by 200,000 tons in fall 2007 was also not realized. In March/April 2008 the export quota was increased by 1 million tons and finally removed in May 2008 (APK Inform 2010).

Figure 1: Development of domestic wheat prices and exports of Ukraine compared to the world market



Sources: Own illustration; data: GTIS (2013), APK-Inform (2013), HCGA (2013)

Also, the wheat export quota introduced in October 2010 was first announced to last until January 2011 but in December 2010 it was prolonged to March 2011, and again in February it was extended further to remain effective until the end of June 2011. Also, the majority of the export licenses were distributed to a state owned company in 2010. Foreign grain trading companies did not receive any export licenses unless they paid bribes and thus experienced high economic losses due to foregone exports.

3 Data

We conduct our volatility analysis on the wheat market based on 417 weekly observations for the domestic price in Ukraine and Germany, and the world market price from January 2005 until December 2012. We use the ex-warehouse price of milling wheat of class III of Ukraine (APK-Inform 2013; see Figure 1) and the average warehouse delivery price of bread wheat of Germany (AMI 2013) as measures for the domestic wheat price. We use the French FOB price for soft wheat of class 1 (HGCA 2013) at the port of Rouen, the primary harbor through which wheat is exported by the EU, as the relevant world market price for Ukraine and Germany. All prices are absolute prices and are converted by weekly exchange rates into US $/t.

4 Methods

To capture the effects of the export restrictions on domestic market uncertainty we investigate price volatility development on the Ukrainian market and its relationship with the world market price within a multivariate GARCH approach using a dynamic conditional correlation (DCC) specification (Engle 2000). For comparison, we also investigate volatility developments on the German wheat market which did not experience any export controls during the commodity price peaks.

In our empirical procedure we proceed in the following steps:

1) Fit the returns data series by an ARMA(p,q)
2) Test the ARMA residuals on heteroscedasticity (ARCH effects) by the Lagrange Multiplier (LM) test
3) Fit the ARMA residuals of each series by a univariate GARCH(n,m) model if ARCH errors are confirmed
4) Use the estimated parameters of the univariate GARCH models to specify the multivariate DCC-GARCH model

We use the DCC-GARCH approach (Engle 2002) to examine and compare the dynamics of volatility of the world wheat prices and domestic wheat prices of Ukraine and Germany. Multivariate GARCH models are common methods used to study volatility in the time series.

They allow for both analyzing the volatility dynamics of a particular series of interest and investigating volatility correlations and transmissions among several series. More specifically, DCC models are used to approximate a dynamic conditional correlation matrix that can be used to evaluate the level of interdependency between the series over time.

Consider the following VAR model:

$$y_t = a_0 + \sum_{i=1}^{p} a_i y_{t-i} + \varepsilon_t \quad (1)$$

where y_t is a 3x1 vector of returns price series r_{it} of the wheat market of Ukraine, Germany and the world market (France) with $r_{it} = \ln\left(\frac{p_{it}}{p_{it-1}}\right)$ where p_{it} is the wheat price in market i at time t, a_0 is a 3x1 vector of drifts, and ε_t is a 3x1 vector of error terms. ε_t has the following conditional variance-covariance matrix:

$$H \equiv D_t R_t D_t \quad (2)$$

where $D_t = \text{diag}\{\sqrt{h_{jj}}\}$, j = 1,….,J, is a 3x3 matrix of the standardized disturbance variances from the univariate GARCH models generated for each series. A univariate GARCH (1,1) model can be represented as follows:

$$h_{jj,t} = \gamma_j + \alpha_j\, \varepsilon^2_{j,t-1} + \beta_j h_{jj,t-1} \text{ for all j = 1,...,3} \quad (3)$$

with $\varepsilon^2_{j,t-1}$ being squared lagged residuals from (1), and $h_{jj,t}$ is a time-varying standard deviation that is further used in defining a GARCH-DCC model.

R_t from (2) is a 3x3 symmetric dynamic correlations matrix that is defined in a following form:

$$R_t = (\text{diag}(Q_t))\text{-}1/2 * Q_t(\text{diag}(Q_t))\text{-}1/2 \quad (4)$$

$$\text{where } Q_t = \{\rho_{ij,t}\} = (1 - \alpha - \beta)\overline{Q} + \beta\, Q_{t-1} + \alpha(u_{t-1}u'_{t-1}) \quad (5)$$

In equation (5), $Q_t = \{\rho ij,t\}$ is a time varying covariance matrix of standardized residuals from (1),$\overline{Q_t}$ is unconditional variance-covariance matrix obtained from estimating a univariate GARCH in equation (3), and α and β are vectors of non-negative adjustment parameters satisfying α + β <1. Parameter α indicates the impact of the lagged error term (or, in other words, the role of the previous shocks) on the own series' volatility in a current period. Parameter β represents the effect of price volatility in the previous period on volatility in the current period.

The primary focus of the GARCH-DCC model is on obtaining conditional correlations $q_{ij,t}$ in R_t:

$$q_{ij,t} = \rho_{ij,t} / \sqrt{\rho_{ii,t}} \sqrt{\rho_{jj,t}} \quad \text{with } -1 < q_{ij,t} < 1 \tag{6}$$

Engle (2002) suggests using a two-step approach to estimate the DCC model by maximizing the following log-likelihood function:

$$L = \{-\frac{1}{2}\sum_{t=1}^{T}[n\log(2\pi) + \log|D_t|^2 + \varepsilon_t' D_t^{-2}\varepsilon_t]\} + \{-\frac{1}{2}\sum_{t=1}^{T}[\log(R_t) + u_t' R_t^{-1}u_t - u_t' u_t]\} \tag{7}$$

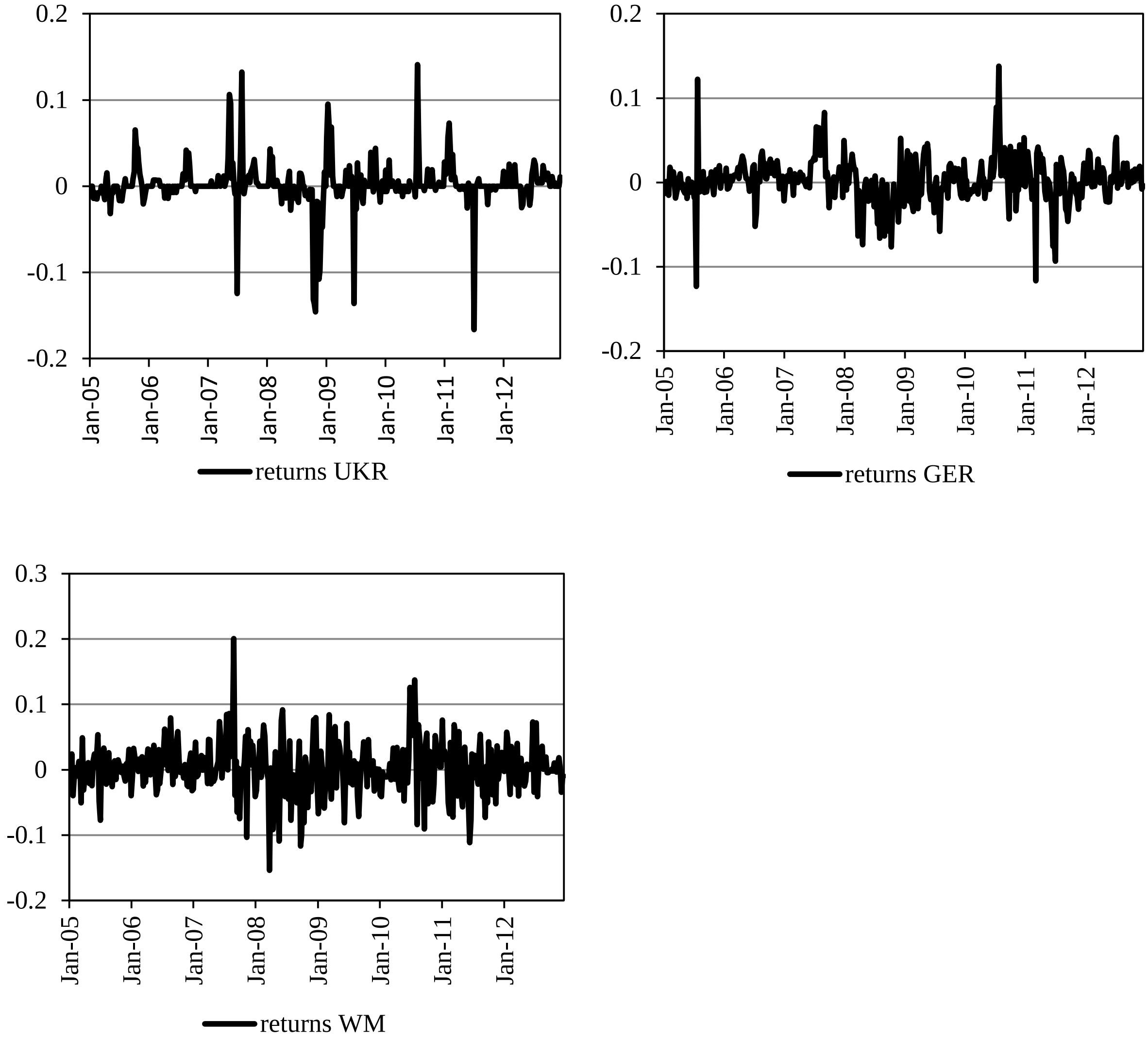
The terms between the first brackets are volatility components, and between the second ones is the correlation component of the log-likelihood function. Parameters D_t are obtained in the first step and then are used to estimate the correlation component in the second step.

Overall, implementation of the DCC-GARCH model requires several steps that are captured in figure 2. First unit root tests are performed on the series of interest to check for their stationarity, and in order to fit a proper model (ARMA vs. ARIMA). In our analysis, series were found to be first-difference stationary, therefore, we selected an ARIMA model. The next step is to perform an ARCH-LM test on the residuals from the ARIMA model. If ARCH errors are confirmed, ARIMA residuals are used to fit a univariate GARCH (1,1) models for each series of interest. The estimated parameters from the univariate GARCH models are further used to specify the GARCH-DCC model.

5 Empirical Results

Prior to the model estimation we determine the order of integration of the data series within the Augmented Dickey Fuller test, the Phillips-Perron test and the Kwiatkowski-Phillips-Schmidt-Shin unit root test. All three tests provide evidence for unit root presence in the series. Test results for the data series in first differences suggest that the price series for Ukraine, France, and Germany are I(1). Figure 3 shows the price series as returns data (first differences of the data in logarithm) and Table 1 gives some distribution characteristics thereof.

Figure 2: Returns data for Ukraine, Germany and the world market



Source: Own illustration.

Table 1: Characteristics of the returns series

	Ukraine	Germany	World market
mean	0.0016	0.0024	0.0021
standard deviation	0.0267	0.0266	0.0384
coefficient of variation	16.277	11.260	18.625
skewness	-1.238	-0.141	0.1000
kurtosis	15.530	4.899	2.715
DF-statistic	-6.53***	-5.354***	-6.009***

Source: Own calculations.

The mean of the returns series is highest for Germany, followed by the world market price and Ukraine. Though, standard deviation and the coefficient of variation indicate that price fluctuations are highest for the French world market price, followed by the domestic price for Ukraine and Germany. Skewness results indicate that the German price and the French world market price are relatively symmetrically distributed, while prices for Ukraine are less symmetrically. Excess kurtosis is highest for Ukraine and suggests that the data series are not normally distributed.

In the next step we proceed with the Box-Jenkins methodology and find the ARIMA(1,0) model to best fit our data based on the Schwarz (SBC) criterion[2]. Table 2 displays some diagnostics of the ARIMA(1,0) residuals of the price series. The Ljung-Box test for serial correlation finds residuals not serially correlated, and therefore, the lag structure of the ARIMA models is sufficient. However, the results of the Jarque-Bera normality tests indicate all models exhibit non normality in residuals, which has to be accounted for when interpreting results.

Table 2: Diagnostic test results

	Ukraine	**Germany**	**World market**
Ljung-Box Q(15) autocorrelation test	14.01 (0.52)	21.07 (0.13)	17.85 (0.27)
Jarque-Bera normality test	5731.15 (0.000)***	1521.42 (0.000)***	103.81 (0.000)***
ARCH(12) LM test	21.91 (0.016)**	29.61 (0.003)***	27.42 (0.007)***

Notice: p-values are in the brackets; asterisks denote levels of significance (* for 10 percent, ** for 5 percent, *** for 1 percent)

Source: Own calculations

Finally, based on the results of the ARCH-LM test, we conclude that variances of the analyzed series vary over time implying univariate GARCH(n,m) models to fit the data best.

2 In case of the Ukrainian and world market wheat prices, SBC indicates an ARIMA(1,0) model to be optimal. For the German price series, SBC suggests an ARIMA(1,4) model. However, due to the lack of significance of the MA(q) coefficients, we select an ARIMA(1,0) model for the German series as well.

5.1 Development Conditional Volatility

The appropriate order of the GARCH(n,m) is selected in accordance with the minimum AIC and maximum log-likelihood value up to order 3. The results show that for all series, a GARCH(1,1) fits our data best[3]. The model estimates are provided in Table 3.

For the three analyzed series GARCH estimates α and β are significant at least at the 5 percent level. The sum of α and β is smaller but close to one for all three series, which ensures that the GARCH process is mean-reverting, and is suggestive of a high degree of volatility persistence. More specifically, a large α coefficient means that the series is susceptible to external shocks, whereas a high β coefficient implies that there is a strong impact of the own-variance on the volatility of the series. As can be seen from the table, the volatility of the German and even more of the French world market price series is characterized by a low α and a high β coefficient, indicating a high impact of the own-variance and thus high persistence of the volatility whereas external shocks are of lower importance for the observed volatility pattern. This is, however, not the case with the Ukrainian wheat series. A relatively large α combined with a low β suggest that the volatility of the Ukrainian wheat farm prices is rather sensitive to the external shocks and that persistence of price volatility is low. These volatility characteristics become also evident in Figure 3, which displays conditional variances of the three series. The high susceptibility of the Ukrainian prices to external shocks is reflected in the many pronounced spikes of the conditional variance. However, since persistence of this volatility is low, the conditional volatility quickly returns back to its mean in the aftermath. In contrast, the high persistence of volatility of the world market prices is reflected in the two long-lasting downward paths after the volatility spikes in August 2006 and in July 2010.

Characteristics of the distribution of the conditional variances are provided in Table 4 and Figure 4. The mean and the coefficient of variation of the conditional variance are lowest for Ukraine and highest for the world market price. Thus, on average, volatility is lower on the domestic Ukrainian than on the German wheat market. Though, skewness is highest for the Ukrainian series, and the largest values for the conditional variance are observed for the Ukrainian price series as well. The histogram for the Ukrainian series makes evident that conditional variance is very low for many observations but that excessive conditional variance is observed at several points of time.

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[3] Before determining the order of the GARCH models, we select the most appropriate distribution based on the AIC, BIC and the log-likelihood criteria. For all 3 data series the student t-distribution turned out to be the most suitable.

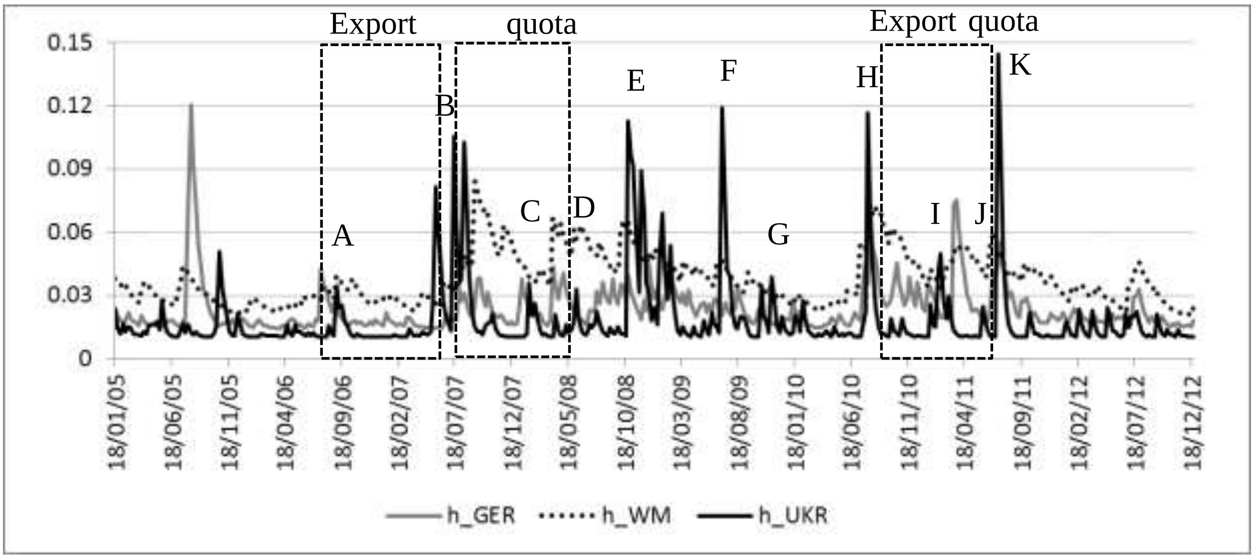
Table 3: Parameter estimates of the conditional variance function (univariate GARCH)

	Germany	Ukraine	World market
θ_1	0.00 (0.04)**	0.00 (0.00)***	0.00 (0.16)
α_0	0.00 (0.91)	-0.00 (0.75)	-0.00 (0.95)
α_1	0.37 (0.01)**	0.74 (0.00)***	0.14 (0.02)**
β_1	0.56 (0.00)***	0.25 (0.00)***	0.83 (0.00)
$\alpha_1 + \beta_1$	0.93	0.99	0.97
log-likelihood value	1041	1270	809

Notice: Asterisks denote levels of significance (* for 10 percent, ** for 5 percent, *** for 1 percent); p-values are given in parentheses.

Source: Own calculations.

Figure 3: Conditional variances of Ukrainian (h_UKR), German (h_GER) and world market prices (h_WM)



Notice: Additional information on the political incidences (letters A to K) are given in the appendix.

Source: Own illustration.

Table 4: Distributional characteristics of the conditional variances

	Ukraine	**Germany**	**World market**
mean	0.019	0.023	0.038
standard deviation	0.018	0.011	0.012
coefficient of variation	1.056	2.091	3.167
skewness	3.86	3.559	0.928
kurtosis	16.814	19.725	0.424
minimum	0.011	0.015	0.021
maximum	0.145	0.121	0.084

Source: Own calculations.

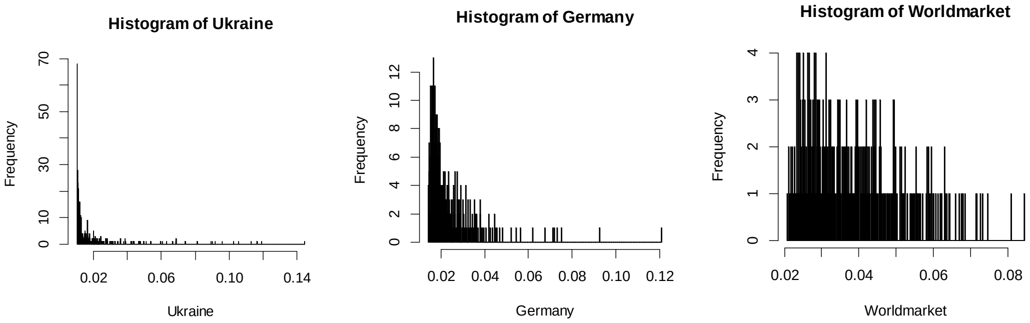
From this it can be concluded that the domestic wheat market in Ukraine is characterized by on average low price volatility compared to the German or the world wheat market. Though, excessive price volatility prevails on the Ukrainian market in a couple of very short periods of time, exceeding the variance observed for the German and the world wheat market.

Figure 5 focuses on the difference between the conditional variance for Ukraine and Germany, and its relationship with the variance of the world market. It becomes evident that this difference is high when the conditional variance of the world market price is rather high, particularly during fall 2007 until the beginning of 2009, concurrently to the commodity price peak on the world market and in the aftermath, and again in fall 2010 until early summer 2011 during the second phase of high world market prices. This shows that contrasting to the German market, the Ukrainian wheat market did not follow volatility development on the world market and suggests that domestic factors might be of greater importance for explaining volatility development on the Ukrainian market.

To investigate the possible domestic factors relevant for the wheat price volatility in Ukraine, we identify all political incidences regarding the wheat market in Ukraine for the time periods characterized by excessive price volatility. The points of time of the political interventions are indicated by capital letters in Figure 3, and further explanations are provided in the appendix.

Detailed analysis of the policy environment during the analyzed period makes us conclude that the spikes in volatility of the Ukrainian series coincide with (and are possibly caused by) several types of political events in the domestic market. It should be pointed out that market

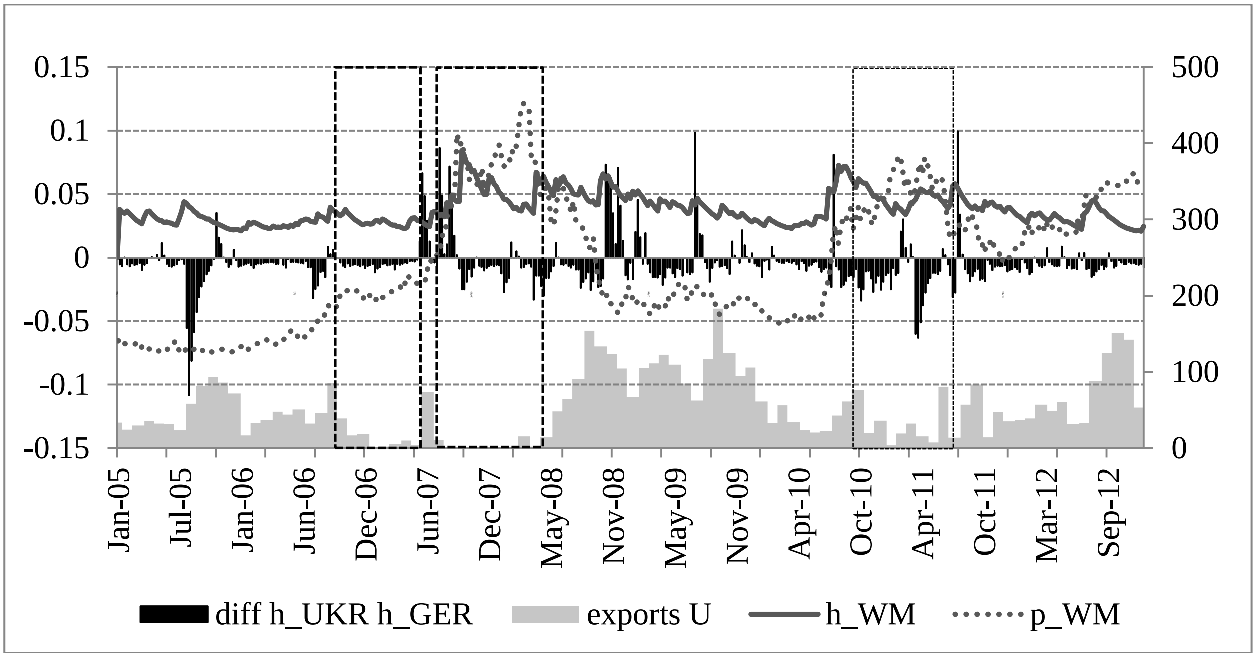
Figure 4: Histograms of the Conditional Variances



Source: Own illustration.

Interventions as such do not necessarily lead to increased volatility. Rather, increased volatility prevails in times of increased market risk which is often caused by political statements and announcements which imply a change in the market conditions. For example, when export quotas are introduced in October 2010, increased volatility cannot be observed in the Ukrainian market. However, a variance spike is observed a few weeks before, when Russia introduced a wheat export ban in August 2010, which induced the question whether Ukraine would follow Russia in controlling its wheat exports, which was heavily discussed in the media in Ukraine.

Figure 5: Dynamics conditional variances for Ukraine and Germany



Notice: diff h_UKR h_GER corresponds to the difference between the conditional variance of the wheat price in Ukraine and in Germany (primary axis); p_WM indicates the world market price in US$/t (secondary axis); exports U gives Ukraine's wheat exports in 1000 t (secondary axis).

Source: Own illustration.

5.2 Development conditional correlations

To investigate volatility interdependencies, we focus on the correlation pattern between the Ukrainian and the world market prices in comparison to the respective relationship of the German prices. To specify our model framework, we follow Engle and Sheppard (2001) to test the null hypothesis on constancy of the conditional correlations for both pairs of series. We reject the hypothesis based on the χ^2 test statistic (Table 5) at a 1% significance level which motivates us to choose a DCC-GARCH model framework allowing for time-varying conditional correlations. We use the univariate GARCH results to fit the DCC-GARCH model for the three series. The estimated parameters of the correlation equation are presented in Table 5 and Figure 6. Results suggest that the α^{DCC} parameter is significant at the 5% level, while the β^{DCC} parameter is not found to be significant for both Ukraine and Germany. In particular, parameters α^{DCC} and β^{DCC} can be interpreted as the "news" and "decay" parameters capturing the effects of innovations on the conditional correlations and their persistence, respectively (Gardebroek et al. 2012). From this we conclude that we have a significant "news" effect for both price pairs, but that this effect is not persistent.

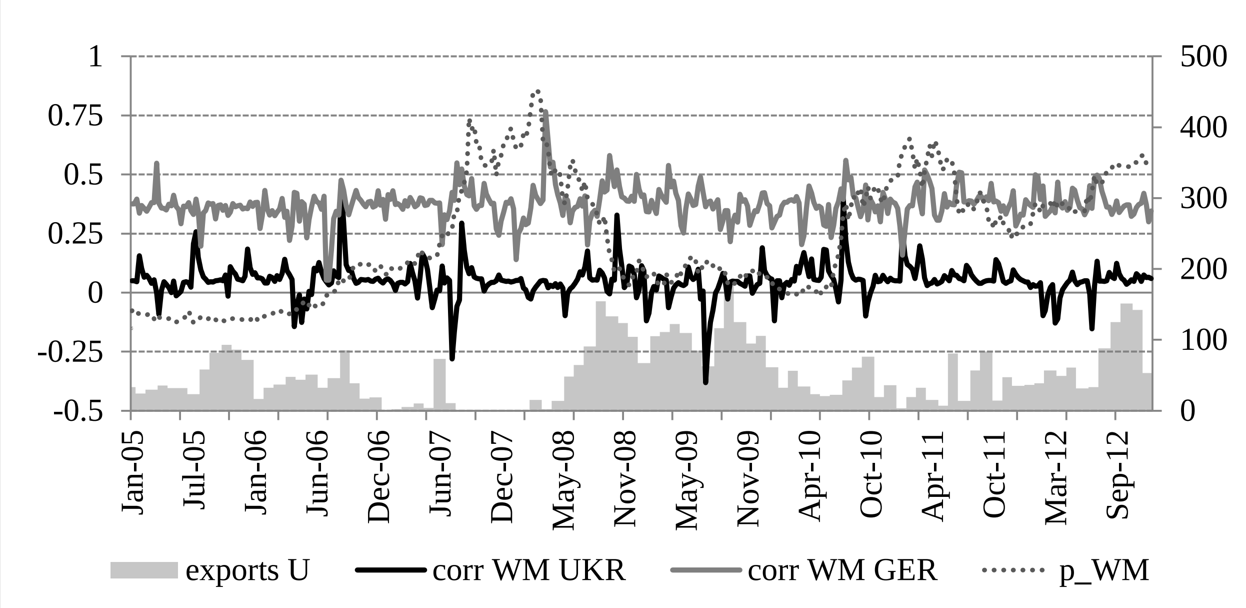
Table 5: DCC-GARCH model estimates

	Ukraine-France	Germany-France
Dccα	0.07(2.45)**	0.05 (2.17)**
Dccβ	0.00 (0.00)	0.32 (0.61)
P_{hat} (DCC)[8]	0.05	0.37
χ^2-test: $R_t = R$[9]	305.5***	442.9***

Notice: Asterisks denote levels of significance (* for 10 percent, ** for 5 percent, *** for 1 percent). t-values are given in parentheses.

Source: Own calculations.

Figure 6: Development of the conditional correlations for the price pairs Ukraine-world market (corr WM UKR) and Germany-world market (corr WM GER)



Source: Own illustration.

On average, the volatility correlation between the Ukrainian and the world market (0.05) is significantly lower compared to the German and the world market (0.37). In terms of variation of volatility correlations across time, it is comparable across both series - standard deviations of the dynamic conditional correlations amount to 0.06 for the Ukraine-France price pair and 0.07 for the Germany-France price pair. Figure 6 shows the development of the estimated dynamic conditional correlations for the price pairs Ukraine - world market and Germany - world market.

6 Conclusions and Discussion

The empirical results of this study indicate that contrasting to the German and the French world market price, volatility on the wheat market in Ukraine exhibits high susceptibility to external shocks and low impact of own variance and thus low persistence. This leads to a couple of short periods of time in which excessive volatility prevails, and is reflected in relatively high skewness of the distribution of the conditional variance. Contrasting to the German market, the Ukrainian wheat market did not follow volatility development on the world market 2007/08 and 2010/11, which suggests domestic factors to be of greater importance for observed volatility in this market.

Detailed analysis of the policy environment provides strong evidence for the accordance of phases of high volatility with the occurrence of rumors and the announcement of changes in wheat market trade policy by the Ukrainian government, especially the implementation and extension of the temporary export restrictions.

Further, our empirical results suggest on average lower conditional correlation between volatility in Ukraine and the world market compared to Germany and the world market. We also provide strong statistical evidence for the nonconstant, dynamic development of these correlations. The relatively low correlation between the Ukrainian and the world market price volatility compared to Germany can be explained by the high non-tariff trade barriers and high marketing costs in Ukraine. In particular, to export wheat to the world market, a trader has to receive y a number of different certificates which costs money and time. Also, due to outdated and insufficient transport and storage facilities, marketing costs are rather high. This implies that the margin between the export and the farmers' price is substantially higher than in Germany, and thus the farmers' price level and volatility is less closely related to the world market price. However, our analysis does not provide evidence for significantly lower correlation of the Ukrainian with the world market price volatility in times of export restrictions compared to free trade, as suggested by economic theory.

We conclude that the export controls in Ukraine have not significantly reduced price volatility on the domestic wheat market. On the contrary, our findings suggest that the multiple and unpredictable interference of the Ukrainian government on the wheat export market has substantially increased market uncertainty which led to pronounced additional price volatility in the market.

The highly uncertain and unpredictable environment of wheat markets with restricted exports has dramatic consequences for the grain sector in Ukraine and prevent its further development. Business in the Ukrainian wheat market is dominated by spot market contracting with immediate delivery, whereas forward contracting is of rudimentary importance (Chamber of Commerce 2011). Forward contracts, typically with a horizon of 18-24 months, bear a high risk that they cannot be fulfilled due to temporary export restrictions. Since agricultural finance is dependent on futures contracts, the Ukrainian wheat market is underfinanced which negatively effects investments in grain production and global food security.

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Annex

Political interventions relevant to the wheat market in Ukraine (compare Figure 3).

A: September 2006: Ukrainian government announces the introduction of export quotas in October 2006, but the size of the quota remains unclear; market experts talk a lot about this in the media.

B: The export quota is lifted on some grains in May (e.g. barley) and for wheat in June 2007; the export quota is reintroduced on July 1, 2007 in light of a severe drought

C: The Ukrainian government announces the increase in the size of the export quota on February 4, 2008 but this is not realized; on Feb 4, the Ukrainian commission on distributing export quotas meets and makes decisions on the exports quotas until March 31

E: Towards the end of 2008, the GASC (governmental import company of Egypt) complains about quality issues regarding wheat originating in Ukraine and removes wheat originating in Ukraine from its list (meaning that Ukrainian exporters cannot participate in the wheat tenders)

H: Russia introduces a wheat export ban at the beginning of August; this induces discussions in the media whether Ukraine will follow Russia and impose export quotas (so it is the changing market conditions which induce price volatility)

I: The Ukrainian government announces the extension of the wheat export quota until the end of June 2011

J: On June 10, the Ukrainian President signs a law to introduce a wheat export tax on July 1.

K: Towards the end of July, the GASC announces that it considers allowing wheat originating in Ukraine to be included in the next wheat tender (after it has been off the list for 3 years); this was realized for the wheat tender at the end of October (so this increased volatility is not caused by the removal of the export quota)

3.2 Effects of Wheat Export Controls on Domestic Flour and Bread Prices

Export Restrictions - Do Consumers really benefit? The Wheat-to-Bread Supply Chain in Serbia, DJURIC, I. AND L. GÖTZ, *revised version resubmitted to Food Policy*

EXPORT RESTRICTIONS - DO CONSUMERS REALLY BENEFIT? THE WHEAT-TO-BREAD SUPPLY CHAIN IN SERBIA

Ivan Djuric[a] and Linde Götz[a]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany.

Abstract

Our approach combines price transmission and gross margin analysis at different stages of the wheat-to-bread supply chain. Results suggest that the effects of export restrictions on the end consumer prices for bread and thus food price inflation heavily depend on the price behavior of the intermediates. In contrast to theory, consumers in Serbia experienced welfare losses despite comprehensive governmental market interventions. In particular, consumers were confronted with increasing flour and bread prices which cannot be fully explained by increasing production costs, whereas mills, bakeries and retailers increased their profits. Thus export controls in combination with high price volatility in the supply chain has to be considered as a further factor determining food price inflation.

Key words: export restrictions, gross margin, Markov-switching, price transmission, Serbia, supply chain.

JEL classification: C22, I31, P22, P23, Q11, Q18.

1 Introduction

Many countries intervened in their agricultural import and export markets to curb food price inflation during the two recent commodity price peaks in 2007/08 and 2010/11. In doing so, each country aimed to increase domestic supply, which should dampen domestic agricultural prices and ultimately counteract domestic food price inflation.

Many studies have addressed the effects of trade interventions on international prices (e.g. Yu et al., 2011; Anderson, 2012; Anderson and Nelgen, 2012; Martin and Anderson, 2012; Rutten et al. 2013; Jensen and Anderson, 2014), while other studies have investigated the export controls' effects on domestic producer prices (e.g. Ihle et al., 2009; Götz et al., 2013; Baylis et al., 2013; Djuric et al., 2015; Baffes et al., 2015). However, analyses on the export controls' effects on domestic end consumer prices are scarce (e.g. Diao et al., 2013; Maletta and Balbi, 2014; Nogués, 2014; Wong, 2014). Nevertheless, there is a strand of literature which uses price transmission analysis to investigate the determinants of food price inflation (compare Mc Corriston, 2015).

This paper addresses this research gap by developing a research framework that allows us to identify the effects of the wheat export restrictions and supplementary policies on end consumer prices, with a focus on how prices were transmitted and gross margins were altered by actors at the different stages along the wheat-to-bread supply chain. We focus on Serbia, a small wheat exporting country and EU accession candidate, which restricted wheat exports both in 2007/08 and 2011.

Wheat supply in Serbia is of strategic importance because it provides a foundation for the milling and feed production industries. Besides its importance for the domestic market, Serbian wheat and flour exports are important for food security in its neighboring countries (e.g. Bosnia and Herzegovina, Macedonia, Montenegro and Albania). Thus, substantial changes in wheat and flour prices could have a significant impact on the agricultural and food processing sectors in Western Balkan countries. Aside from the study of Djuric et al. (2015), which analyzes the impact that governmental interventions had on the domestic wheat producer prices in Serbia from the spatial price transmission perspective, this is the first study to investigate vertical price relationships Serbia's agro-food sector.

Our research question is whether consumers really benefitted from wheat export restrictions in Serbia, or if other members along the wheat-to-bread supply chain were able to realize advantages. Our approach involves analyzing vertical price transmission between the wheat and flour as well as the flour and the bread end consumer price to uncover possible changes in price relationships along the wheat-to-bread supply chain by using a Markov-switching vector error-correction model (MSVECM). To evaluate which actor of the supply chain benefitted or lost from those changes, we also investigate the development of the gross margin of the milling and baking industry during the export restrictions. We assess the gross margin based on actually observed prices and compare it to the unobserved gross margin which we simulate, assuming that the government would not have intervened in the market. Finally, we assess the change in consumers' expenses for bread.

The paper is structured as follows. Section 2 provides a literature review concerning the effects of export controls on price relationships along the supply chains, while section 3 briefly describes the theoretical background for accessing the short-run welfare effects of an export ban. Section 4 explains the methodology and data used for the analysis. Empirical results and discussion are provided in section 5. Finally, section 6 provides summary and conclusions of the study.

2 Literature review

From a general perspective of the price transmission literature, we contribute to the studies investigating the factors which determine price transmission along the stages of the food supply chain and ultimately dictate food price inflation.

Focusing on the dimensions of competition in the food sector Lloyd et al. (2015) point out that market power influences price transmission and the extent of food inflation by changing the food industry markup. However, the potential to increase the markup in a non-competitive environment in the food sector depends on several additional factors as e.g. the nature of the retail demand function (McCorriston et al., 1998), the existence of economies of scale in the food industry cost function (McCorriston et al., 2001), buyer power which could outweigh seller power (Weldegebriel, 2004), and the extend of market power at succeeding stages of the supply chain, which is also called “double marginalization” (McCorriston and Sheldon, 1996).

More specifically, this paper contributes to the strand of literature that focuses on the effects of trade interventions, particularly export controls, on price relationships along domestic supply chains during periods of high international commodity prices.

The study by Grueninger and von Cramon-Taubadel (2008) investigates the effects of the wheat export quota system in Ukraine. These authors find that the export quota had a negative impact on producers, whereas the wheat export quota was beneficial for the milling and feeding industries, which managed to increase their margins.

Nogués (2014) evaluates the influence of export taxes, quantitative export restrictions and supplementary market interventions as governmental subsidies and target prices on producer and consumer prices for wheat, maize and soybean in Argentina since 2006. Nogués finds that flour mills benefited from subsidies paid on flour sold on the domestic market, whereas wheat producer prices were dampened by the export tax and export quota comparable to the effects of an export tax of 40%. Furthermore, the ad-valorem tariff equivalent of quantitative restrictions on maize and maize flour had a price increasing effect of 21% which was higher than the 20%

export tax. In contrast to wheat and maize prices, the ad-valorem equivalent of quantitative controls on soybean exports had a little effect on domestic soybean price changes.

Wong (2014) investigated wheat, maize and rice export bans and tariff breaks in Ecuador during the global commodity price peak in 2007/08. Comparing the development of prices and indices for wheat, flour and bread, Wong finds that the policy interventions in the wheat sector were not effective in stabilizing domestic food prices during the crisis period. Rather, prices of bread and other wheat products increased sharply. Wong concludes that milling companies and some bakeries profited from this policy, whereas consumers had to pay higher food prices. Wong also argues that the similar results are observed for the maize sector in Ecuador. In contrast to wheat and maize sectors, Wong argues that policy interventions in the rice sector were effective in stabilizing domestic rice prices during the commodity price peak in 2008. Supported by domestic rise purchase, domestic rice producers and milling companies also benefited from the governmental interventions together with consumers.

Maletta and Balbi (2014) investigate the effects of the removal of import barriers on consumer prices in Bolivia. These authors find that bakers and noodle-makers increased their gross margin in the crisis period by raising end consumer prices, which can be explained neither by increases in the flour wholesale price nor increases in other inputs such as energy, industrial processing and transportation.

Götz et al. (2015) investigate the effects of wheat export restrictions imposed in Kazakhstan, Russia, and Ukraine (RUK countries) on price developments along the wheat-to-bread supply chain. The findings indicate that the profits of the large milling industry in Russia and Ukraine were considerably higher when emergency policies were in place compared to free trade conditions. However, the increase in bread prices in the RUK countries can be traced back to the increase in wheat and flour prices, as well as other production costs such as labor and energy. Thus, in contrast to the milling industry, the bakery industry in the RUK countries has not profited from export controls.

This paper also adds to the existing price transmission literature on usage of a Markov-switching model framework for analyzing the influence of food crises and policy interventions on vertical price relationships in general. For example, Brümmer et al. (2009) use a MSVECM to investigate the impact of policy measures on vertical price transmission between wheat and flour prices in Ukraine. Results indicate that intensive policy interventions in Ukraine contributed to domestic wheat and flour price instability. Concerning the price transmission approach, this study is closest to our analysis. However, we extend this approach by using the results from our model to simulate the laissez-faire policy case to identify who benefited and who lost along the supply chain. Besides the abovementioned study, there are only a few papers that apply MSVECM in vertical price transmission analysis. For example, Rezitis et al. (2009) use MSVECM to identify the impact of the Common Agricultural Policy (CAP) reforms on the lamb sector in Greece. Busse et al. (2012) used MSVECM to investigate the vertical price transmission along the biodiesel supply chain in Germany between 2002 and 2008. These authors argue that different governmental policies (mainly support for bio diesel production) contributed to uncertainty and instability on the German biodiesel supply chain.

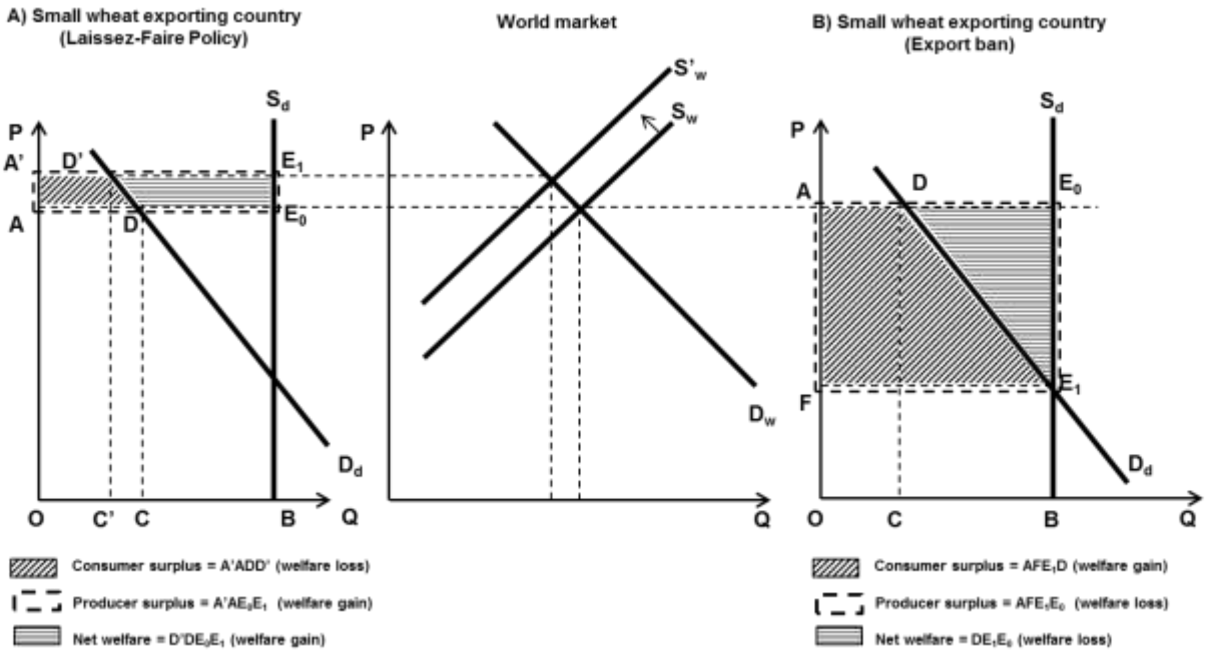
3 Welfare effects of an export ban

The Serbian government radically intervened on the domestic wheat, flour and bread markets by using numerous ad hoc policy measures during the global commodity price peaks of 2007/08 and 2010/11(see Djuric, 2014). The governmental interventions were triggered by rapidly increasing wheat exports and strongly increasing global, regional and domestic wheat prices. The government justified its policy, especially wheat export ban, with the threat of running out of wheat and flour stocks for domestic consumption, thus risking high food prices that could affect consumers negatively.

For accessing the short-run welfare effects of an export ban we present a simplified theoretical framework. Unlike large countries, a small exporting country (e.g. Serbia) has no influence on the net wheat supply on the world market, and thus has no influence on the world wheat market price.

Figure 1, A, depicts the situation of a small country exporting freely wheat to the world market. We suppose that the world wheat market price is determined according to the equilibrium between the world market supply (S_w) and the world demand for wheat (D_w). We also assume that the domestic wheat supply (S_d) is completely inelastic in the short-run, and that OB represents the quantity of wheat produced domestically. Under free trade conditions, and disregarding trade costs, the domestic wheat price is equal to the world market price OA. At this price level, the quantity of wheat demanded domestically is equal to OC, and CB is the amount of wheat that will be exported.

Figure 1: Short-run welfare effects: export ban and laissez-faire policy (small country).



Note: The labels in Figure 1 are explained within the text.

Source: Own illustration.

Suppose that the world wheat supply decreases significantly due to a harvest shortage in large exporting countries. This shock will cause the world supply curve (S_w) to shift to the left (S'_w), thus increasing the world market price to the level OA'.

If the government of the small wheat exporting country in question does not interfere in the wheat export market, i.e. it follows a laissez-faire policy, the world market price increase is fully transmitted to the domestic market and increases the domestic price to OA'. This decreases domestic demand to OC' and increases exports to C'B. Therefore, consumers experience short-run welfare losses (A'ADD'), whereas producers realize welfare benefits (A'AE_0E_1). Under the assumption of a fully inelastic domestic supply, overall net welfare will be positive (D'DE_0E_1) since the producers' welfare gain is greater than the consumers' welfare loss.

However, if the government of the small wheat exporting country instead implements an export ban (Figure 1, B), exports decrease to zero and the harvested wheat is supplied completely to the domestic market. This increases the domestic supply from OC to OB and decreases the domestic wheat price to the level OF.

A new equilibrium between domestic supply (S_d) and domestic demand (D_d) is established in E_1, characterized by an increase in consumers' surplus (AFE_1D), and thus a welfare gain for the consumers. On the contrary, wheat producers experience welfare losses (AFE_1E_0); farmers have to sell their wheat on the domestic market at a lower price and cannot benefit from the higher world market prices. Consequently, since the producers' welfare loss is greater than the consumers' welfare gain, the overall net welfare effect of the wheat export ban for the whole economy is negative (DE_1E_0) in the short run.

In summary, the theoretical considerations show that consumers should benefit from the export ban in the short run due to a temporary price reduction on the domestic wheat market compared to the laissez-faire policy case. Thus, if the domestic wheat-to-bread supply chain is efficient and competitive, the expected decrease in wheat prices should be reflected in the decrease in flour and bread prices as well, at least to a certain extent, depending on the percentage share of each component in the final product (Gardner, 1975). Nevertheless, if the market is imperfectly competitive, the change in flour and bread prices will greatly depend on the markup changes (Lloyd et al., 2015).

4 Methods and data

4.1 Model framework

We develop a model framework to identify who benefitted and who lost from the wheat export restrictions. Central to our approach is the analysis of price transmission along the wheat-to-bread supply chain. We start with the analysis of the price transmission behavior of the mills vis-a-vis the bakeries, which is followed by investigating the price transmission behavior of the bakeries and retailers regarding end consumers. This is supplemented by the analysis of the development of the gross margin of the milling industry and the baking industry and retailers. In particular, we measure the size of the processors' and retailer's gross margin in the period of the export ban and compare it to the unobserved hypothetical situation of free trade assuming laissez-faire policy. We simulate the unobserved gross margin presuming free trade making use of the estimated price transmission parameters. Finally, we also investigate the development of the consumers' expenses for bread.

Essential to our approach is that we differentiate between large and small mills and similarly between large industrial bakeries and small bakeries. Large processors in the wheat-to-bread supply chain distinguish from small processors by that they dispose over own storage capacities for wheat. They buy wheat primarily during the harvest and store it in their silos. Thus, wheat price developments on the spot market outside the harvest period are not relevant to large processors.

4.1.1 Vertical price transmission

To investigate the price behavior of the wheat-to-bread supply chain members (i.e. milling industry, baking industry and retailers), we analyze the dynamics of the transmission of price changes from wheat to flour prices and from flour to bread prices. We assume that a change in the mills' price behavior vis-à-vis bakeries, and bakers' and retailers' price behavior vis-à-vis consumers lead to a change in the degree of price transmission. Since large mills and bakeries dominate the wheat processing industry in Serbia, the strong increases in the spot market wheat price during the export ban 2007-08 and 2011 should not be fully transmitted to the flour and bread prices, requiring perfect competition. Thus, the transmission of price changes during the export ban period compared to the "normal" periods of less volatile wheat prices should decrease. We suppose that if a reduction in price transmission is not identified, this could be interpreted as evidence for the mills and bakeries exerting market power by transmitting wheat price changes over proportionately and thus managing to benefit from the wheat export controls.

We choose a flexible Markov-switching model framework which allows the price transmission parameters to change due to a change in the price behavior of the milling and baking industries.

We use the Markov-switching vector error-correction model (Krolzig, 1997) as a model framework for our price transmission analysis:

$$\Delta p_t = \upsilon(S_t) + \alpha(S_t)(\beta' p_{t-1}) + \sum_{i=1}^{k-1} A_i(S_t)\Delta p_{t-i} + u_t \qquad (1)$$

where Δ is the first difference operator; p_t represents the vector of the prices; υ gives the vector of intercept terms; α is the vector of the speed of adjustment coefficients; β is the cointegrating vector representing the long-run equilibrium of the prices; A_i are the matrices containing the short run parameters of the system, and u_t is the error term.

The state variable $S_t = 1, \dots, M$ is an unobserved variable indicating which of the M possible regimes governs the MSVECM at time t. Terms $\upsilon(S_t)$, $\alpha(S_t)$, and $A_i(S_t)$ show the dependence of these parameters on the state variable S_t.

One of the main characteristics of the Markov-switching model (Hamilton, 1989) is the assumption that the data generating process underlying the state variable (S_t, equation 1) follows a Markov-chain. Thus, the probability of switching to a new state (S_{t+1}) is independent of the regime's history and only depends on the state of the proceeding period (S_t). Estimating a

MSVECM is based on maximizing the likelihood function with the Expectation-Maximization algorithm[1] (compare Krolzig, 1997).

4.1.2 Gross margin analysis

We investigate the miller's and bakers' gross margin to assess whether they experienced a benefit or a loss during the governmental market interventions, distinguishing between small and large mills and bakeries. In particular, the gross margin for small mills and bakeries is calculated based on the spot market wheat price, since they usually do not dispose over own grain storage facilities, and thus are forced to buy wheat continuously from the spot market. On the contrary, the gross margin for large mills and bakeries is assessed based on the price of wheat which is bought right after the harvest and stored, as it is relevant for larger industrial mills and bakeries disposing over own storage facilities. Details on the calculations of the price of stored wheat are given in the appendix A.1. We measure the size of the gross margins during the export ban and compare it to the unobserved hypothetical situation of free trade assuming laissez-faire policy[2]. If the gross margin increases (decreases) compared to if the government would not have intervened in the market (laissez-faire policy), then it can be concluded that the profits of the mills and bakeries had increased (decreased).

The mills' gross margin[3] is given by

$$\text{Gross margin} = R_t - p_t^w - C_t \quad (2)$$

Where R_t is the gross revenue, p_t^w is the relevant wheat price and C_t are other costs.

We simulate flour prices assuming free trade by utilizing the estimated parameters of the price transmission analysis.

The bread gross margin is calculated as the difference between the observed retail end consumer bread price and the wholesale bread price. The wholesale bread price is calculated based on the estimated bread producer price. Thus, the bread producer price is calculated based on the costs of flour T500, gross wages, energy and other common costs (general costs and amortization).

Considering that the bread retail price is actually set by retailers, we investigate the development of the bakers' and retailers' distributable gross margin, where the laissez-faire

1 The estimation procedure is available in the MSVAR package (Krolzig, 2006) for the matrix programming language Ox (Doornik, 2002).

2 Detailed description of the data and methods used in the laissez-faire case is provided in the appendix A.2.

3 The mills' gross margin strongly depends on the flour extraction technology. The details of our assumptions are given in the appendix A.3.

policy serves as the reference case. The distributable gross margin is estimated as the difference between the bread's gross margin (as previously explained) and the retailers' minimum gross margin of 10% of the retail bread price. If the distributable gross margin is smaller than zero it indicates a loss and a profit if it is larger than zero. On the other hand, if the estimated bread gross margin is below the minimum retailers' gross margin, the large industrial bread producers have to cover the difference by either squeezing their operating margin, or by being forced to make losses. Thus, the distributable bread margin is estimated in order to access the welfare effects of the governmental interventions on bakers and retailers.

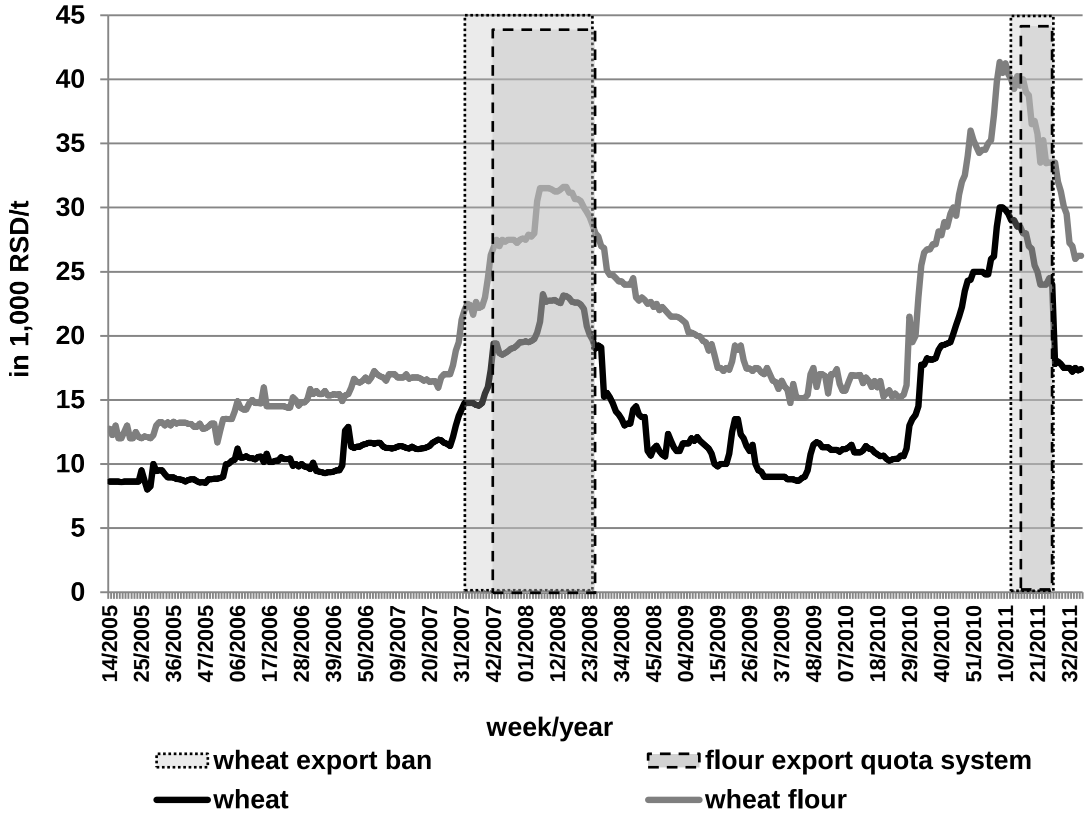
4.1.3 Consumers' expenses for bread

To assess the welfare effects of the governmental market intervention on end consumers, we investigate how consumers' expenses for bread developed in 2008 compared to 2007. Based on the data provided by the study of living standards in Serbia for 2002-2007 (Statistical Office of the Republic of Serbia, 2008), we distinguish between the total expenditures of poor and non-poor households.

4.2 Data

We use the average weekly wheat grower prices (milling quality) measured as the silo selling price (p_t^w), and average weekly wheat flour (type T500) mill selling prices as an aggregate measure of the flour wholesale price (p_t^f) in our price transmission analysis (Figure 2). Both price pairs are in natural logarithms covering 335 observations from April 2005 until August 2011.

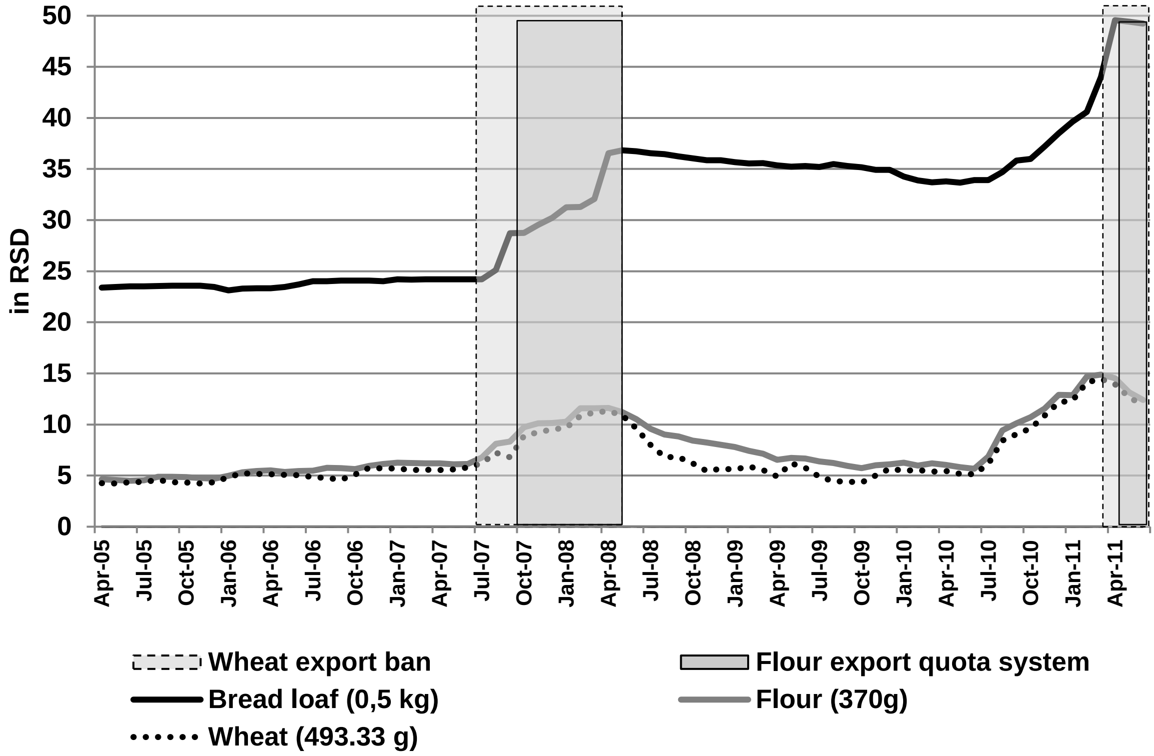
Figure 2: Average weekly wheat and flour prices in Serbia, 2005-2011.



Source: Serbia's Grain Fund and GEA Info Center, own illustration based on the model specification.

The data is supplemented by average monthly prices from January 2007 until October 2011 (58 observations) for flour of type T400, T850, fodder flour, bran and "other" flour types. Further, we use the average monthly end consumer bread prices from April 2005 to July 2011 (75 observations) given in RSD/loaf (Figure 3).

Figure 3: Average monthly wheat, flour and bread prices in Serbia, 2005-2011.



Note: Wheat and flour prices are recalculated for the amount needed to produce one bread loaf (500g loaf).

Sources: Serbia's Grain Fund, GEA Info Center, and SORS, own illustration.

For estimating the T500 flour prices under the hypothetical laissez-faire policy case (see appendix A.2) we decided to use the Hungarian average weekly wheat silo selling prices ($p_i^{w\_la}$) because: a) Hungary is Serbia's most important competitor in regional wheat markets; b) wheat prices in Serbia and Hungary are highly correlated when wheat exports are not restricted; c) the Hungarian wheat export market remained open during the global commodity price peaks. Hungarian prices account for the period from June 2007 to December 2011, and are recalculated to the RSD/kg.

In addition to the main datasets, for the estimation of the bread production costs we use the data concerning average wages in the food processing sector, prices for electricity and diesel (fuel). All of the data are monthly and given in RSD per person or unit.

5 Empirical results and discussion

5.1 Price behavior of mills and bakers

The following results refer to the vertical price transmission along the wheat-to-bread supply chain. The ADF test (Dickey and Fuller, 1979) and KPSS test (Kwiatkowski et al., 1992) both indicate that the Serbian wheat producer prices, flour prices, and bread prices are nonstationary and integrated of order 1 (Table 1, A). Furthermore, the same results are obtained by conducting the modified ADF test (Perron, 1989; Perron and Vogelsang, 1992; Banerjee et al., 1992; Vogelsang and Perron, 1998), which accounts for a structural break in price series. The Johansen's test on cointegration (Johansen, 1995) suggests that both price pairs (wheat-flour and flour-bread) are co-integrated (Table 1, B) even if we account for structural breaks. Thus, the preconditions for utilizing a Vector Error Correction Model (VECM) to analyze price dynamics between these three series are met.

The results of the τ-Test (Hansen and Johansen, 1999) indicate that the cointegration vectors in both VECM models are stable. Furthermore, the results of the he Chow breakpoint test (Chow, 1960) indicate the existence of multiple structural breaks. Thus, we decided to use restricted regime-switching models which allow for a possible change in the short-run price transmission parameters between different regimes but assume that the long-run price equilibrium between the two series is stable. Relying on the Granger Causality test results we decided to estimate MSVECM model for the flour-wheat prices, and MSECM for the bread-flour prices.

We select the final specifications of the MSVECM and MSECM according to the Akaike Information criterion (AIC), which suggested a model with 3 regimes and 2 autoregressive parameters (MS(3)VECM(2))[4] for flour-wheat prices, and a model with 2 regimes and 6 autoregressive parameters (MS(2)ECM(6)) for bread-flour prices. Our optimal models are of the MSIAH type, which allows the intercept (I), the short-run price transmission, the autoregressive parameters (A), and the variances/heterogeneity (H) to switch between the regimes.

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4 The obtained number of regimes should be considered with caution. The Monte Carlo analysis conducted by Ihle and von Cramon-Taubadel (2008) concerning the performance of the Expectation-Maximization-Algorithm (EMA) to simulate the data that are generated by a MSVECM model demonstrates that only around 42% of the of all observations are correctly identified by the EMA method. These results indicate that the EMA method might not be able to identify the true regimes of MSVECM. Nevertheless, these authors argue that their results cannot be generalized and that results greatly depend on the assumptions made before the simulation.

The results of the flour-wheat price transmission model (MSVECM) are illustrated in Figure 4, which shows the smoothed regime probabilities and indicates the probability level that one observation is most likely attributed to a given regime.

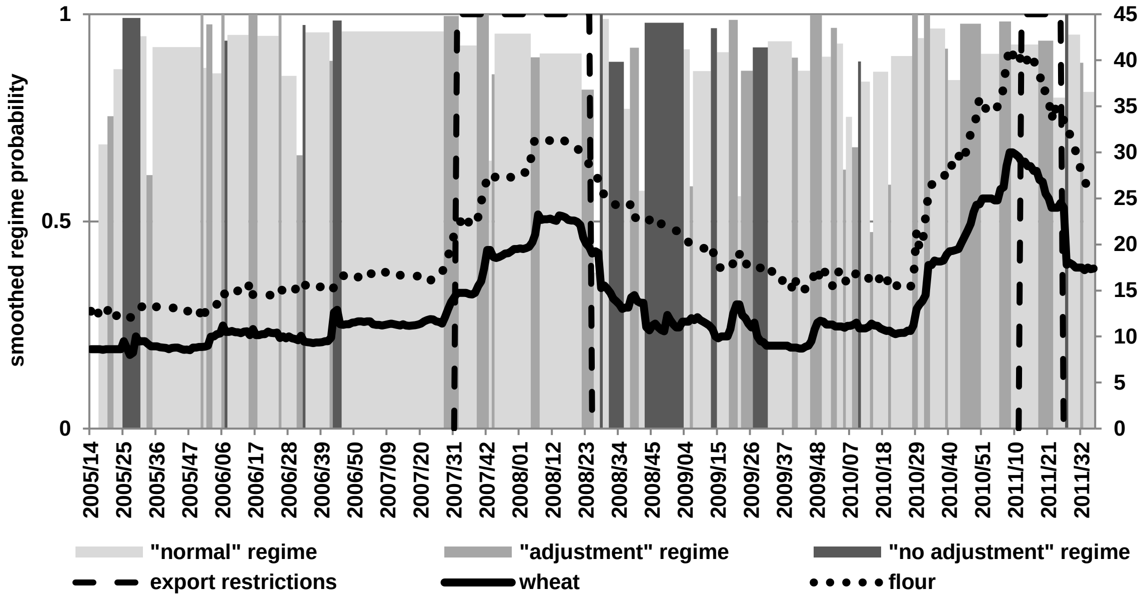
Table 1 Unit root and Johansen's cointegration tests.

Unit root tests									
Series	Augmented Dickey-Fuller test			KPSS test			modified Augmented Dickey-Fuller test (structural break)		
	test statistic	specification	5 % critical value	test statistic	specification	5 % critical value	test statistic	specification	5 % critical value
$\ln p_t^w$	0.646	1 lag	-1.942	0.170	15 lags, constant and linear trend	0.146	-3.544	break: intercept	-4.860
$\ln p_t^f$	1.037	0 lags	-1.942	0.187	15 lags, constant and linear trend	0.146	-2.670	break: intercept	-4.860
$\ln p_t^b$	-1.667	1 lag, constant and linear trend	-3.473	1.050	6 lags, constant	0.146	-4.104	break: intercept	-4.860
$\Delta \ln p_t^w$	-15.465	0 lags	-1.942	0.082	8 lags, constant	0.463	-16.525	break: intercept	-4.444
$\Delta \ln p_t^f$	-19.006	0 lags	-1.942	0.099	11 lags, constant	0.463	-21.810	break: intercept	-4.860
$\Delta \ln p_t^b$	-5.597	0 lags	-1.945	0.180	4 lags, constant	0.463	-8.572	break: intercept	-4.860

Johansen's cointegration test								
number of cointegrating vectors		specification	rank test	p-value	5 % critical value	(accounting for structural breaks)		
H_0	H_1					rank test	p-value	5% critical value
wheat-flour								
0	1	2 lags, constant	21.698	0.032	20.262	34.14	0.000	23.59
1	2		2.692	0.640	9.165	3.14	0.869	12.85
flour-bread								
0	1	2 lags, constant	26.372	0.006	20.262	25.67	0.023	23.85
1	2		3.102	0.562	9.165	5.71	0.540	12.84

Note: Number of lag length is selected according to the AIC.

Figure 4: Regime classification for MS(3)-VECM(2) (flour-wheat price relationship).



Source: Own illustration based on the model specification.

Our model identifies 3 regimes: “normal”, “adjustment”, and “no adjustment”. The “normal” regime is characterized by relatively small values of the residual standard errors for both flour and wheat equations (Table 2). The adjustment coefficient for flour is negative and significant (-0.094), while the adjustment coefficient for wheat is insignificant. This indicates that in the “normal” regime only flour prices error-correct towards the long-run equilibrium. The average error-correction term is close to zero (0.023), which indicates a very small deviation (on average) from the equilibrium.

Table 2: Parameter estimates of the MS(3)-VECM(2) (flour-wheat price relationship).

Variable	Regime: Normal		Regime: Adjustment		Regime: No adjustment	
	Δp^f	Δp^w	Δp^f	Δp^w	Δp^f	Δp^w
Constant	0.059**	-0.004	0.152**	-0.140**	0.021	-0.107
	(0.015)	(0.008)	(0.060)	(0.049)	(0.015)	(0.082)
ECT_{t-1}	-0.094**	0.006	-0.225*	0.232**	-0.030	0.112
	(0.023)	(0.012)	(0.093)	(0.076)	(0.020)	(0.111)
$\sigma_{\varepsilon}^{f/w}$	0.019	0.011	0.051	0.035	0.014	0.088
Constant restricted in the ECT	0.626		0.675		0.682	
Average ECT	0.023		-0.034		0.089	

Note: Standard errors appear in parentheses; ** statistical significance at 1%; * statistical significance at 5 %.

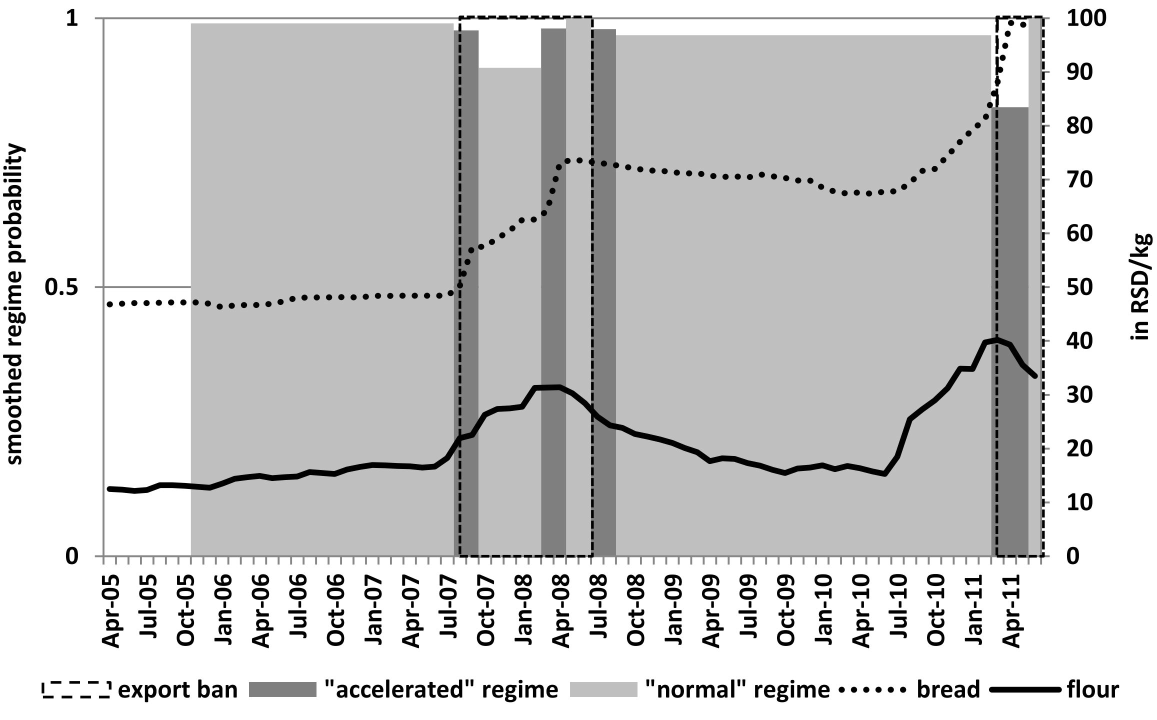
Source: Own calculation.

The “adjustment” regime is characterized by the 3-fold increase in residual standard error for flour (σ_ε^f = 0.051) and wheat (σ_ε^w= 0.035) compared to the “normal” regime. Furthermore, the adjustment coefficient for flour prices becomes 2.5 times higher compared to the “normal” regime. An interesting feature of this regime is that the adjustment coefficient for wheat prices is also significant, which indicates that both flour and wheat prices error-correct towards the equilibrium. Also, our results indicate the existence of a contemporaneous correlation between flour and wheat prices, meaning that flour prices almost immediately react to the changes in wheat prices.

The “no adjustment” regime is characterized by the lowest residual standard error for flour (σ_ε^f = 0.014) and highest for wheat (σ_ε^w= 0.088) compared to the “normal” and “adjustment” regimes. This indicates almost no change in flour prices compared to the large changes in wheat prices. An interesting feature of this regime is that the adjustment coefficients for both flour and wheat prices are not statistically significant, which indicates a lack of error-correction towards the equilibrium.

Concerning the bread-flour model, smoothed regime probabilities of the MSECM model are presented in Figure 5, while the selected parameters estimates are presented in Table 3.

Figure 5: Regime classification for MS(2)-ECM(6) (bread-flour price relationship).



Source: Own illustration based on the model specification.

Our bread-flour MSECM model identifies two regimes: “normal” and “accelerated”. The main difference between the regimes is the regime-specific error correction term (ECT). In the “normal” regime, ECT is -0.032, which means that the time needed to correct 50% of long run deviation will take about 21 months. On the other hand, the ECT in the “accelerating” regime is -0.174 (more than five times higher than in the “normal” regime); it takes about 4 months to correct 50% of the long-run deviations.

Table 3: Parameter estimates of the MS(2)-ECM(6) (bread-flour price relationship).

Variable	Regime	
	Normal	Accelerated
Constant	0.001 (0.001)	-0.011 (0.007)
ECT_{t-1}	-0.032*** (0.006)	-0.174*** (0.012)
$\sigma_{\varepsilon}^{b/f}$	0.008	0.006

Note: Standard errors appear in parentheses; ** statistical significance at 1%; * statistical significance at 5 %.

Source: Own calculation.

The results obtained for the MS(2)-ECM(6) indicate that the “accelerated” regime coincides with the periods of market uncertainty, i.e. periods of governmental interventions in both 2007/08 and 2011 (Figure 5).

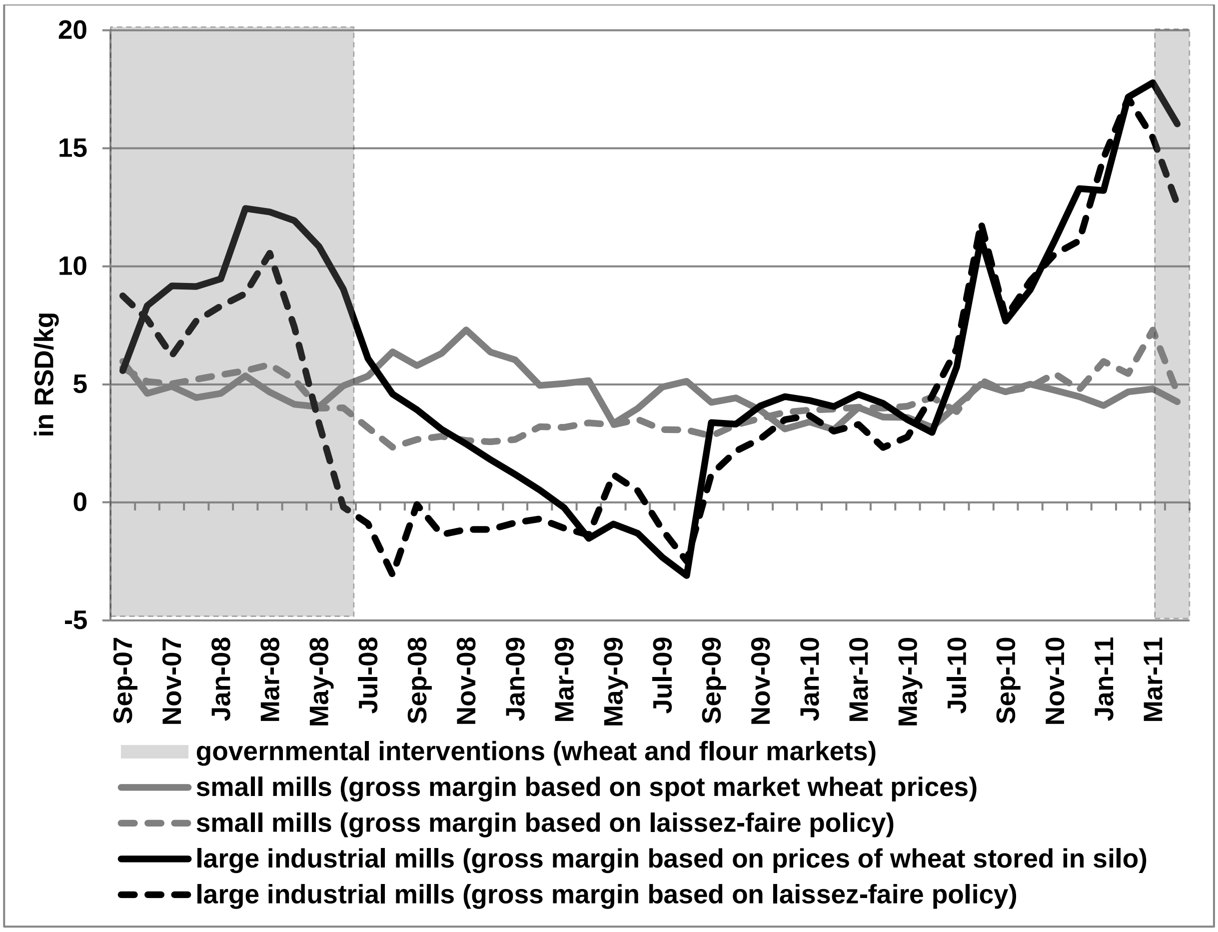
To summarize, our price transmission results indicate that the long-run equilibrium between flour-wheat and bread-flour prices did not change due to the governmental interventions. Nevertheless, in the case of the bread-flour model, the “accelerate” regime, characterized by the significant increase in the adjustment coefficient, coincides with the period of the governmental interventions. This means that the baking industry was faster in adjusting bread prices according to the flour price changes. Also, each period of the “accelerated” regime was characterized by the increase in bread-flour margin. Furthermore, the results from the flour-wheat model indicate the absence of flour price adjustments right after the period of the governmental interventions, which led to the increased flour-wheat margin. Overall, our obtained results run contrary to our hypothesis that given perfectly competitive markets, large increases in the spot market wheat price are not necessarily transmitted to the downstream levels of the wheat-to-bread supply chain. Thus, we suspect that the milling and baking industries might benefit during, and especially immediately following, the governmental interventions.

5.2 Development of the mills' gross margin and welfare effects

Although the price transmission results do not indicate that the millers changed their pricing behavior vis-à-vis the bakeries, the mills' welfare could change due to a change in the relationship between the flour production costs and the mills' flour selling price, which is reflected in the gross margin.

The estimated mills' gross margins for small and large industrial mills are shown in Figure 6. We can observe that the estimated flour gross margin of large industrial mills (9.92 RSD[5]/kg on average) is substantially higher than for small mills (4.76 RSD/kg, on average) in times of wheat export restrictions. In particular, large industrial mills were able to more than double (+108%) their gross margins compared to the small mills.

Figure 6: Estimated millers' gross margin per kg of flour.



Note: Detailed description of the laissez-faire policy is provided in the appendix.

Sources: Serbia's Grain Fund, GEA Info Center, Zitovojvodina, and SORS, own illustration.

5 The average exchange rate for the observed period (September 1, 2007 – May 31, 2008): 54.362 USD/RSD.

We compared the estimated gross margins of large industrial and small mills with the gross margins development in the laissez-faire case. For doing so we simulated the flour price developments based on the following model:

$$\ln p_i^{f\_la} = \underset{(0.221)}{0.626} + \underset{(0.059)}{0.974} \ln p_i^H + u_t \tag{3}$$

where $p_i^{f\_la}$ is the estimated flour price in the laissez-faire case, p_i^H is a specific wheat price[6] used for the estimation, and u_t is the error term. Considering that the "normal" regime prevails in the flour-wheat price transmission model (section 5.1), we use the estimated regime-specific long-run equilibrium constant (constant restricted to the ECT term, Table 2) from the "normal" regime to estimate the flour prices in the laissez-faire case. The slope coefficient (0.974) is retrieved from the linear VECM model.

Finally, the results obtained from comparing the estimated gross margins (from the observed and stored wheat prices) of both small and large industrial mills with their gross margins estimated for the laissez-faire case indicate the following: A) Even in a situation in which the Serbian government would not intervene on the market (laissez-faire policy), the gross margin of small mills would have been almost at the same level (5.23 RSD/kg on average compared to 4.76 RSD/kg, Figure 6)). Nevertheless, it is clear that small mills had an opportunity to widen their gross margins after the wheat export restriction was cancelled because the flour prices declined much slower than they would in the hypothetical case (Figure 6); B). The large industrial mills benefited from the wheat export restriction, especially prior to the cancellation of the policy measures (30 % higher gross margin compared to the hypothetical case, Figure 6).

Overall, our estimations suggest that both small and large industrial mills were able to benefit from the governmental crisis policy.

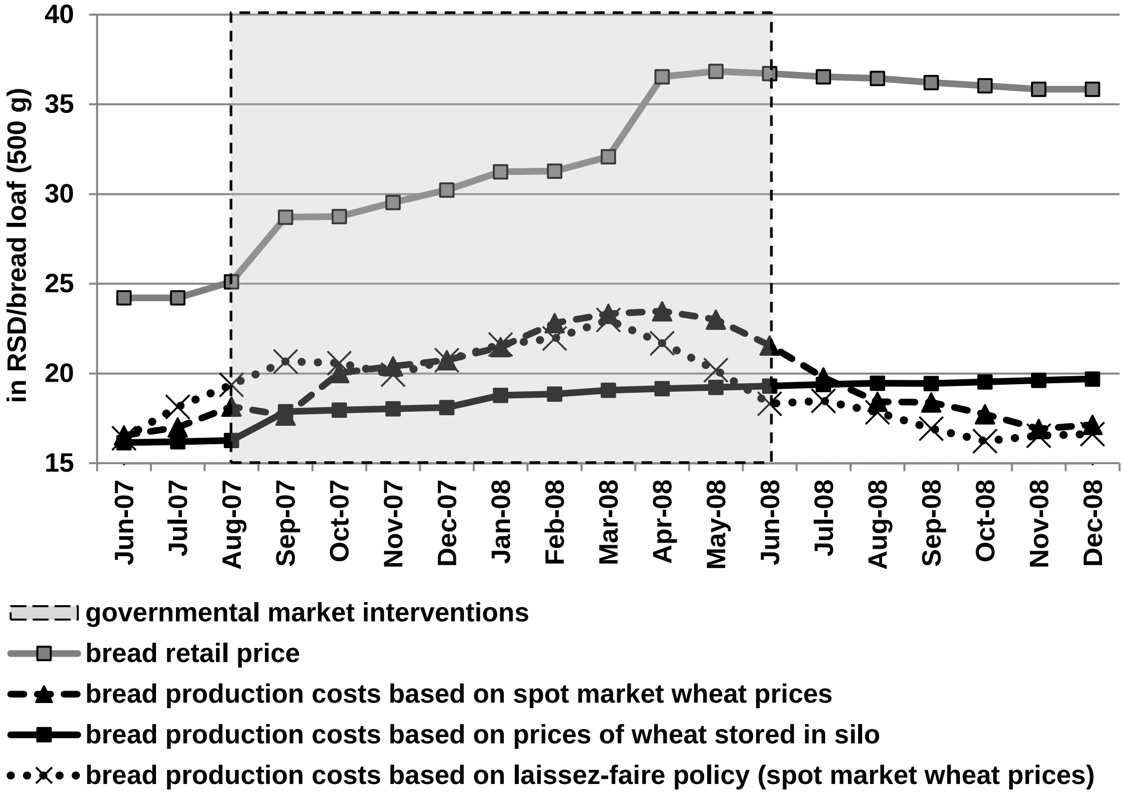
5.3 Structure and development of bread production costs

Figure 7 shows the summary of bread producer price estimations. The results indicate that large industrial bread producers were affected by significant wheat and flour price increases on the spot market only during the harvest in July and August 2007. Thus, the significant wheat and flour price increases on the spot market did not affect the bread production cost structure during the observed period of wheat export restriction because they were implemented after the harvest

[6] More details are provided in section 4.2 (data) and in the appendix A.2.

in 2007. Nevertheless, the bakers (together with retailers) successfully increased the end consumer price of bread, which was wrongfully justified by increases in the wheat and flour spot market prices (Figure 7).

Figure 7: Estimated bread producer prices, 2007-2008.



Note: Detailed description of the laissez-faire policy is provided in the appendix.

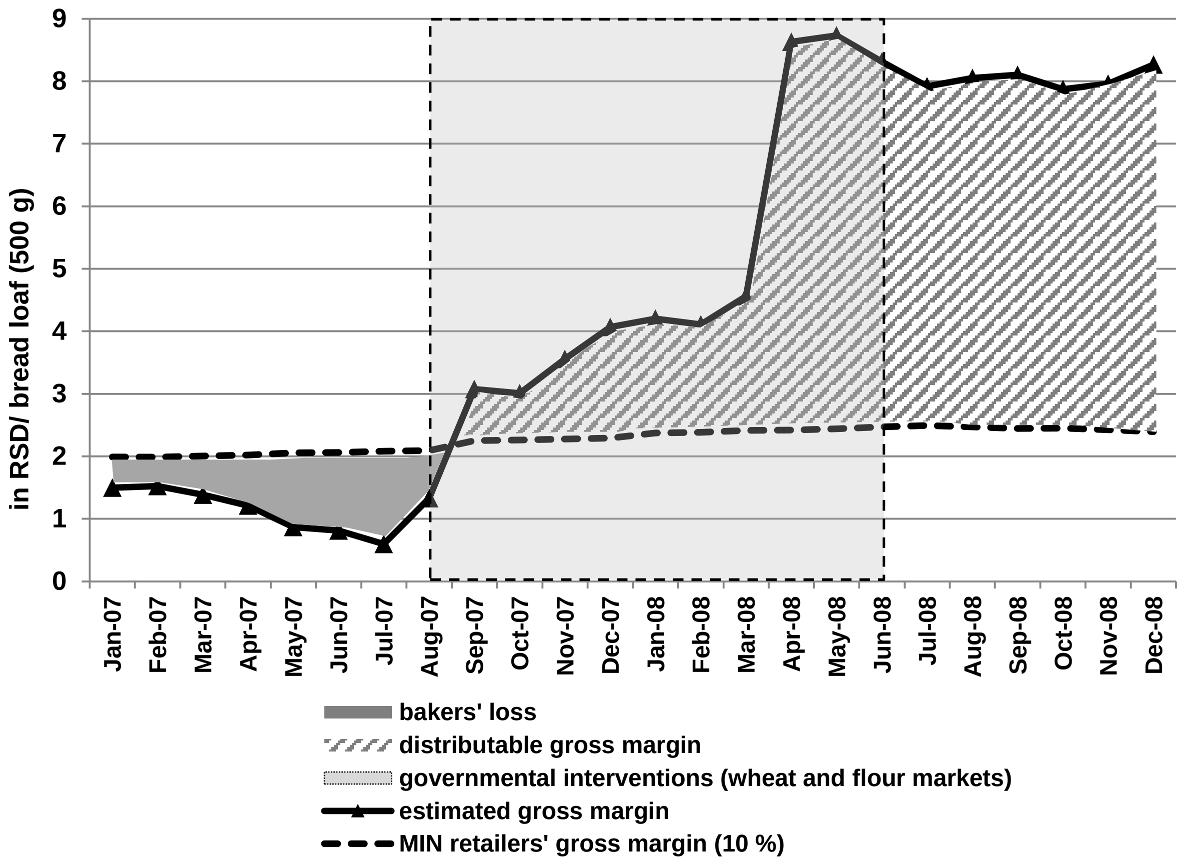
Source: Zitovojvodina and Serbia’s Grain Fund, own calculation and illustration.

Without the governmental market interventions (laissez-faire policy), the large industrial bread producers (and retailers) would not have been able to realize the second dramatic bread price increase in April 2008, particularly because the hypothetical wheat market prices (i.e. Hungarian wheat prices - see appendix) were exhibiting a strong downward trend at this time period. Thus, compering the estimated bread production costs with the production costs estimated under the hypothetical scenario, it is clear that bakers used the situation of the high spot market wheat prices to increase the price of bread, and justified it with the high production costs (Figure 7).

5.4 Development of bakers’ and retailers’ gross margin and welfare effects

In addition to the bread producer price and the wholesale bread price estimations, we estimate the distributable gross margin of large industrial bread producers and retailers. The results presented in Figure 8 indicate that large industrial bread producers had to squeeze their net (operating) margin, or even to accept a net loss in producing so-called "social" bread before the observed period of wheat export restriction (August 2007-June 2008). According to experts, bakers were always on the edge of profitability when producing the so-called "social" bread. However, potential losses from this type of bread production were covered by a high net (operational) margin gained from other bakery products. After the implementation of the wheat export restriction and two significant bread price increases (August and November 2007, Figure 3), large industrial bread producers and retailers improved their situation by being able to widen their gross margins significantly (+267% compared to the gross margin in August 2007); in our results this is indicated as a significant increase in the distributable gross margin (Figure 8). Thus, we argue that the significant increase in bread prices was wrongly justified by increases in wheat spot market prices.

Figure 8 Estimated distributable gross margin.



Source: Zitovojvodina and Serbia's Grain Fund, own calculation and illustration.

5.5 Consumers' expenditures for bread and state budget expenses

The significant bread price increase (+50%) hit the poorest population the most. According to the Study of Living Standard in Serbia for 2002-07 (SORS, 2008), about 490,000 people were identified as poor in 2007 (6.6% of the total population). If we compare the monthly available expenditure of a poor household family (20,875 RSD[7]/month) with the average monthly expenditure for bread and cereals (about 2,027 RSD/month for a three member household), we can see that the expenditure for bread and cereals is about 10% of their total expenditure in 2007. Compared with the average expenditure for bread and cereals in 2008 (2,653 RSD[8]/month), poor households' expenditure increased to 14.22% in 2008 compared to 2007, mainly due to the bread price increase.

6 Conclusions

We have developed an approach combining price transmission and gross margin analysis at different stages of the supply chain to address the question of the welfare effects of price changes induced by export controls along the food supply chain.

In contrast to welfare economic theory, our results suggest that consumers in Serbia experienced welfare losses during the global commodity price peaks in 2007/08 and 2011 despite comprehensive governmental market interventions. It becomes evident that the effects of the export restrictions on the end consumer prices for bread heavily depend on the price behavior of the intermediates along the industrialized wheat-to-bread supply chain.

Our price transmission results indicate that milling and baking industries transmitted significant wheat price changes observed during the wheat export ban over proportionally to end consumers.

Concerning the milling sector, our results show that widening the gross margin for both small and large industrial mills cannot be justified with the increase of flour production costs. Comparing actual with simulated price developments under the laissez-faire policy, results indicate that large mills widened their gross margins (+30%) during governmental interventions, while small mills particularly widened their gross margins (+131%) in the aftermath of the governmental interventions. Thus, our results suggest that both small and large industrial mills were able to benefit from increasing wheat prices despite the governmental market interventions both in 2007/08 and 2011.

Furthermore, our results indicate the large industrial bread producers and retailers were successful in increasing the end consumer price of bread, which was wrongfully justified by

[7] The average exchange rate in 2007: 58.432 USD/RSD.
[8] The average exchange rate in 2008: 55.695 USD/RSD.

increases in the wheat and flour spot market prices (not relevant to them due to own wheat storage capacities). Compared to the laissez-faire case, the large industrial bread producers, and especially retailers, benefited substantially from the governmental interventions in 2007/08 by being able to obtain the distributable bread margin. Thus, in contrast to expectations, bakeries—and even more so the retailers—benefited most from the governmental market interventions, whereas end consumers lost due to significant increases in bread prices. In particular, our calculations suggest that poor households' expenditures for bread and cereals increased by over 14% in 2008 compared to 2007.

This study has provided further evidence that the effectiveness of implementing an export restriction to dampen domestic food inflation is highly questionable. The intended food price dampening effects can be offset by the price behavior of the actors along the food supply chain. Our results have made evident that several actors of the food supply chain have changed their price behavior. In particular, it seems that an environment of high price volatility with strongly increasing price levels, which was reinforced by the governmental market interventions, which also included the wheat export ban (Djuric et al. 2015), facilitates the actors along the wheat-to-bread supply chain to increase their gross margin by over-shifting the cost increases. Thus, ultimately, food price inflation is not dampened but rather boosted. More generally, this paper contributes to the price transmission literature by providing evidence for the volatility of prices with strong price increases observed along the food chain as a further factor influencing the extent of price transmission and ultimately food price inflation (compare Lloyd et al. 2015).

Instead of using an export restriction as an initial crisis policy option, the Serbian government should consider strengthening domestic safety net measures that target the most vulnerable consumers; this would help poor consumers cope with increased bread prices far more.

In particular, instead of trying to dampen domestic food prices, it would be a more effective and in the long-run cost-efficient response of the government to allow domestic food prices to increase and instead only focus on the most vulnerable population sections to adapt to high consumer prices within social safety nets. For example, food vouchers, food subsidies or direct income transfers should be targeted at the household income of poor people. To ensure that such safety-net measures can be implemented in a crisis situation in the short term, the existence of well-targeted social assistance programs needs to be ensured. However, export controls remain an attractive measure for policy makers since different to social safety net measures they do not cause any budgetary costs.

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Annex

A.1 Calculation of the price of stored wheat

The price of stored wheat is calculated as

$$p_{t+i}^{wst} = [(\overline{p_h^w + p_{h+1}^w})\gamma]\omega_i \qquad \text{(A. eq.1)}$$

where p_{t+i}^{wst} represents the price of wheat stored until time i, p_h^w is the wheat spot market price during the first month of the harvest (the wheat harvest in Serbia usually starts in July), p_{h+1}^w is the spot market price in the second month of the harvest (the harvest rarely extends to the first days of August), and γ stands for the silo handling costs, which include costs for quality control and the physical transfer of wheat into a silo. The parameter ω_i represents the monthly storage costs (1% per month).

A.2 Simulation of the mills' gross margin in the case of laissez-faire policy

Table A.2.1 provides an overview on the data bases utilized to assess the development of the flour gross margin of small and large mills. We compare the flour gross margin during the export ban with the simulated flour gross margin assuming that the government had not intervened in the wheat export market (laissez-faire policy). For small mills, the flour gross margin during the export ban is estimated based on observed spot market wheat and flour prices. In contrast, for large mills the relevant wheat price is the price of stored wheat since we assume that large industrial mills dispose over own silos.

The gross margin of flour assuming laissez-faire policy is simulated for small mills based on the observed spot market price of wheat in Hungary (see data description in section 4.2). The flour price is simulated based on the Hungarian wheat spot market price and the parameters of the long-run price equilibrium between the Serbian wheat and flour spot market prices (section 5.2, equation 3). These parameters are estimated within this study in the framework of a MSVECM (section 4.1).

The flour price is simulated according to

$$\ln(\widehat{p_t^f}) = \beta_0 + \beta_1 ln\, p_t^w \qquad \text{(A. eq.2)}$$

where β_0 (constant) and β_1 (long-run price transmission parameter).

The gross margin of flour assuming laissez-faire policy is simulated for large mills similar to the small mills. The exception is that instead of Hungarian spot market wheat prices we use the Hungarian price of stored wheat.

Table A.2.1 Data bases used for the assessment of the change of the flour gross margin of small and large mills

	Small mills	Large mills
Flour gross margin during export ban policy	*Wheat price*: spot market wheat price observed in Serbia; *Flour price*: spot market flour price observed in Serbia.	*Wheat price*: price of stored wheat (see appendix A.1) *Flour price*: spot market flour price observed in Serbia.
Simulated flour gross margin assuming laissez-faire policy	*Wheat price*: observed spot market wheat prices of the Hungarian market; *Flour price*: flour prices are simulated based on Hungarian wheat spot market prices and parameters of the long-run price equilibrium between Serbian wheat and flour spot market prices, which are retrieved from the estimated MSVECM regime “normal” (Table 2).	*Wheat price*: price of stored wheat calculated based on the Hungarian wheat price observed during harvest plus storage costs; *Flour price*: flour prices are simulated based on Hungarian wheat spot market prices and parameters of the long-run price equilibrium between Serbian wheat and flour spot market prices which are retrieved from the estimated MSVECM regime “normal” (Table 2).

Source: Own illustration

A.3 Assumptions about the flour extraction technology

The mills’ gross margin strongly depends on the flour extraction technology, i.e. determining the produced flour type and rate of extraction. Our calculations are based on a flour extraction[9] technology that yields 53% of flour type T500, 15% of flour type T400, 10% of flour type T850, 20% of fodder flour, and 2% of other by-products. The mills’ revenue (R_t) at time (t) is calculated based on the extraction rate (Er) for each flour type (M) valued by the respective weekly spot market flour prices (p_t^f):

[9] We selected this flour extraction technology because it yields high percentage of the flour type T500 which is used for the production of the social bread. For different extraction technologies in Serbia see Prpa (2004).

$R_t = \sum_{M=1}^{k} Er(M) p_t^f$ (A. eq. 3)

$$Er(M) = \begin{cases} Er_1 \; if \; M = 1 \\ \vdots \\ Er_n \; if \; M = k \end{cases}$$ (A. eq. 4)

where $Er \in \{1, \ldots, n\}$ and $M \in \{1, \ldots, k\}$ depend on the selected flour extraction technology. Thus, in our case Er_1= 0.53, Er_2=0.15, Er_3=0.1, Er_4=0.2, and Er_5=0.02. Also, in this case M=1 corresponds to flour type T500, M=2 to flour type T400, and so on.

In calculating the mills gross margin we also account for fixed packaging costs of 0.5 RSD/kg, corresponding to C_t in equation 2 (section 4.1.2).

Wheat Export Restrictions in Kazakhstan, Russia, and Ukraine: Impact on Prices along the Wheat-to-Bread Supply Chain, GÖTZ, L., I. DJURIC AND T. GLAUBEN, in: SCHMITZ, A. AND W. H. MEYERS: *Transition to Agricultural Market Economies: The Future of Kazakhstan, Russia and Ukraine*, Chapter 19: 191-203, Commonwealth Agricultural Bureaux International (CABI), 2015.

WHEAT EXPORT RESTRICTIONS IN KAZAKHSTAN, RUSSIA, AND UKRAINE: IMPACT ON PRICES ALONG THE WHEAT-TO-BREAD SUPPLY CHAIN

Linde Götz[a], Ivan Djuric[a], and Thomas Glauben[a] [1]

[a] Leibniz-Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany.

Abstract

Kazakhstan, Russia, and Ukraine (KRU) are among the grain-exporting countries that implemented wheat-export restrictions between 2007 and 2011 during the global commodity price peaks. This chapter provides an overview on the price effects induced by wheat-export controls in the KRU region. It becomes evident that the domestic price effects of export controls were heterogeneous among the KRU countries, and that domestic prices were only insulated partially from international price developments. Also, export controls increased, rather than decreased, domestic wheat-price volatility. Furthermore, the effectiveness of export controls as an instrument to protect against high food prices is questionable, particularly in the case of wheat that is transformed to an end-consumer product in a complex supply chain. In all three KRU countries, the intermediate milling industry did not transmit the price increases of the wheat price to the flour price. Instead, the milling industry increased the flour price proportionally which increased bread production costs and led to higher bread prices throughout the KRU region.

1 Introduction

During the recent price booms on world agricultural markets in 2007/08 and 2010/11, many countries attempted to insulate their domestic markets from price developments on the world market and to stabilize domestic prices through trade-policy interventions (Djuric *et al.*, forthcoming). Exporting countries implemented export controls by decreasing or even banning exports, whereas importing countries reduced or even completely eliminated import restrictions

[1] The authors gratefully acknowledge financial support by the German Federal Ministry of Food and Agriculture and the Federal Office for Agriculture and Food. The authors are grateful to Martin Petrick for providing helpful comments on an earlier version of this chapter.

to reduce the influence of high world market prices on domestic price levels (Martin and Anderson, 2012). Governments can reduce domestic prices by decreasing exports and increasing domestic supply. Canceling or reducing import tariffs creates additional incentives to import goods that can decrease export prices and increase domestic supply. One way to respond to high world market prices is through trade-oriented policy measures aimed at curbing domestic food price inflation. During the 2007/08 food crisis, roughly 37 countries implemented export barriers and 59 countries removed import restrictions (FAO, 2008). Among these countries were the three large grain-exporting countries of Kazakhstan, Russia and Ukraine (KRU), all of which were members of the Former Soviet Union.

Export controls are generally implemented by three means: export taxes, quotas, and bans. Export taxes increase the costs of exporting, depending on the size of the tax, thereby reducing competitiveness on the world market (they also can make exports unprofitable if the tax is set too high). Export quotas limit exports to the size set by the quota. Export bans forbid exports such that no quantity of the respective product can be exported (Mitra and Josling, 2009; Sharma, 2011). For example, Kazakhstan implemented a wheat export ban in 2008, Russia implemented wheat export taxes in 2007/08 and a wheat export ban in 2010/11, and Ukraine established a wheat-export-quota system in 2006-2008 and 2010/11.

This chapter provides an overview on the price effects of export restrictions implemented by the KRU countries. It explains governmental interventions on wheat-export markets in each of the KRU countries and describes price and export developments in general. The *intended* price effects of export controls on the domestic market and the *accidental* price effects on the world market are addressed by explaining their theoretical background and providing empirical evidence. This chapter focuses on the development of prices along the wheat-to-bread supply chain and simulates the profits achieved during export controls. Finally, it points out the dramatic consequences of grain-export controls for the KRU countries and for global food security.

2 Export Restrictions in the KRU Countries

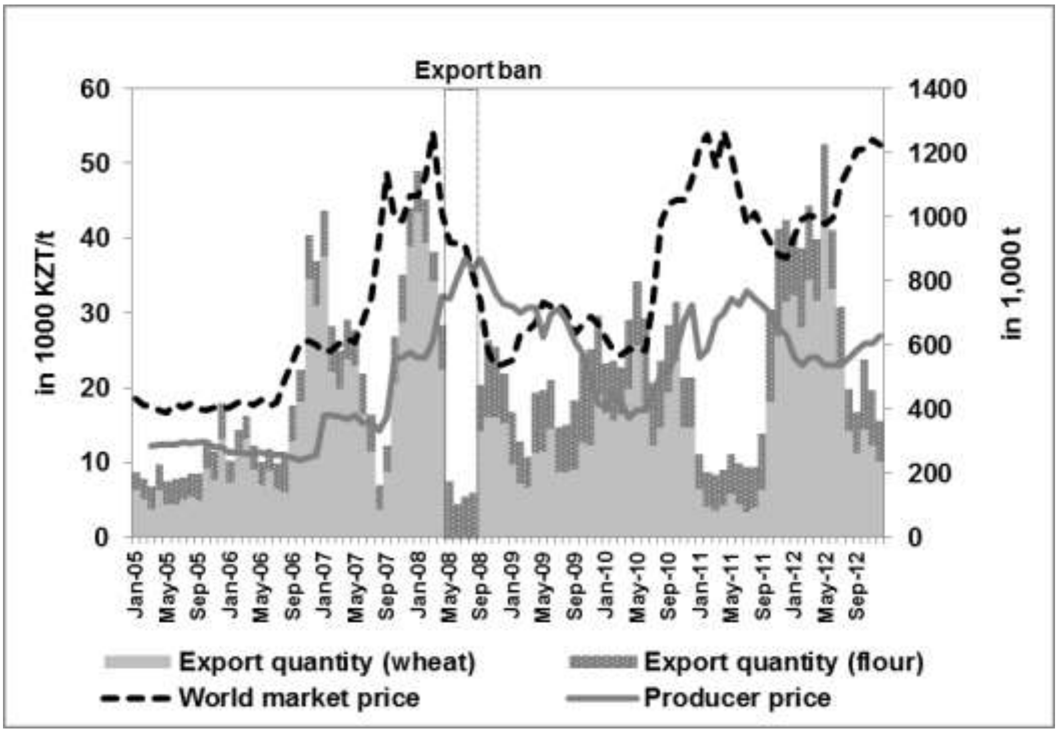
This section provides an overview on the chronology of the export controls implemented in the KRU countries and describes the price and export developments on their domestic wheat markets. Export restrictions were introduced in Kazakhstan during the food crisis of 2007/08, whereas trade remained open during the 2010/11 international commodity price peak. In light of the very high world market prices and strongly increasing wheat exports, the Kazakhstani government introduced a grain-export-licensing system in September 2007 that was controlled by the Ministry of Agriculture. Under this system, grain was allowed to be exported only by companies that were able to satisfy certain conditions such as having their own production and storage facilities, and by companies exporting at least 5000 metric tons (mt) of grain. This regulation was valid until January 2012.

In response to significant grain- and bread-price increases in September 2007, the Kazakhstani government formed a stabilization fund for wheat intervention. The state-controlled Food Procurement Corporation secured about 180,000 mt of wheat for intervention purposes (USDA, 2008). In addition, the government signed a Memorandum of Understanding (MOU) with grain traders, proclaiming that domestic wheat prices should not be increased until the new harvest. According to the MOU Agreement, wheat traders were to deliver a minimum of 1.2 million metric tons (mmt) of wheat to the domestic market before the next harvest (AgraFood East Europe, 2008a). However, when the 1.2 mmt of wheat were already sold on the domestic market by April 2008, the domestic wheat price started to skyrocket (AgraFood East Europe, 2008b). In response, the government immediately introduced an export ban to protect domestic consumers from high food prices that remained in force until September 2008.

From Figure 1, it is evident that the export ban was unsuccessful when reducing the domestic wheat price. On the contrary, the domestic wheat price was temporarily higher than the world wheat market price. According to official statistics, however, no wheat exports occurred during the export ban, although substantial wheat-flour exports could be observed. Additionally, Figure 2 shows that the export ban was introduced when the Russian wheat producer price peaked in 2008, suggesting that the export ban insulated domestic prices in Kazakhstan from domestic prices in Russia rather than from world market-price developments.

Wheat exports in Russia were limited by an export tax of 10% that was established in November 2007 and was increased to a prohibitive level of 40% in December 2007. This export tax remained in effect until July 2008. Later, Russia restricted wheat exports again during the 2010/11 commodity price peak.

Figure 1: Development of world market price, producer price, and export quantities in Kazakhstan, 2005-2012



Note: Wheat grower prices for Kazakhstan are regional prices for the Almaty region.

Source: APK-Inform (2013); HGCA (2013); GTIS (2013); Authors' illustration.

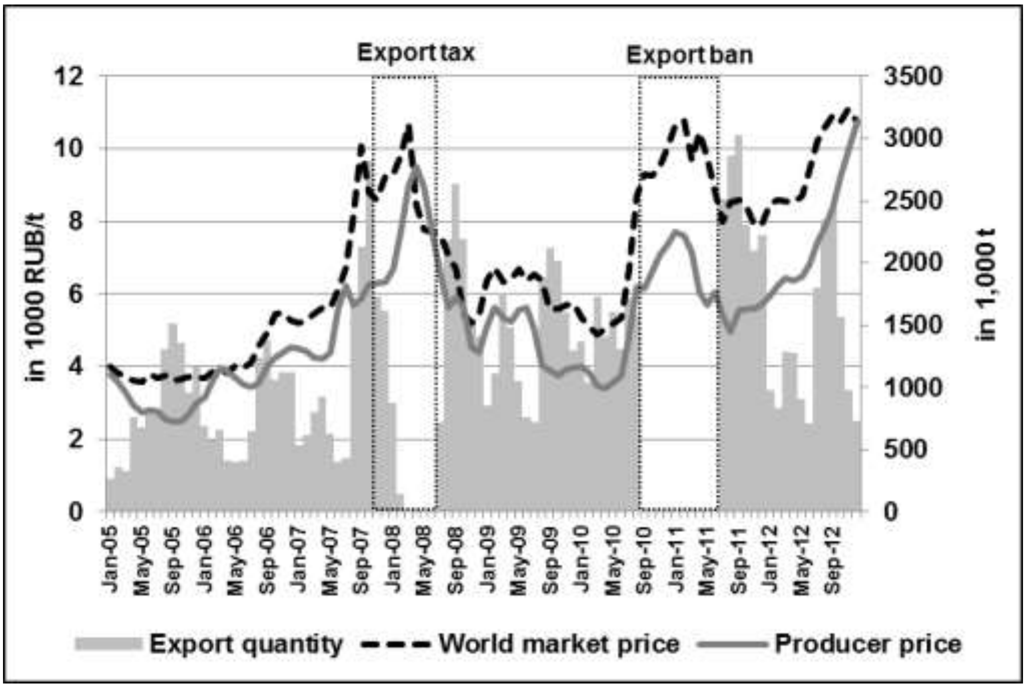
Figure 2: Development of producer price for Russia and Kazakhstan, and Kazakhstani exports to Russia, 2005-2012

Note: Wheat grower prices for Kazakhstan are regional prices for the Almaty region.

Source: APK-Inform (2013); HGCA (2013); GTIS (2013); Authors' illustration.

Figure 3 shows that the export tax in Russia was only partially successful when reducing domestic wheat prices. In particular, early 2008 domestic prices increased beyond world market-price levels. The strong increase in domestic wheat prices might have been caused by increased wheat storage in expectation of even higher world market prices. During the export ban the domestic prices were continuously lower than was the world market price.

Figure 3: Development of world market price, producer price, and export quantities in Russia, 2005-2012



Note: Prices for Russia are average prices for the Central Federal District.

Source: APK-Inform (2013); HGCA (2013); GTIS (2013); Authors' illustration.

An export quota system was implemented in Ukraine during both world market-price peaks within a governmental licensing system. Export quotas varying between 3000 mt and 1.2 mmt were in force from October 2006 until May 2008, and again from October 2010 until May 2011. In addition, Ukraine implemented wheat export taxes of 9% in July 2011 that were removed in October 2011. The size of the quota was changed repeatedly and the quota system was extended multiple times, both of which created high market uncertainty. For example, the wheat export quota in 2010 came into effect so rapidly that ships already loaded with wheat could not leave the harbour, thereby causing high additional costs to the exporters (APK-Inform, 2013). As a consequence, contracts could not be fulfilled which eroded the reputation of traders exporting from Ukraine. There were also questions about the transparency in the distribution of the export quotas in 2010. Figure 4 shows that the difference between the world and the domestic wheat price increased substantially when the export-quota system was in effect (Götz *et al.*, 2012; Goychuk and Meyers, 2013).

Figure 4: Development of world market price, producer price, and export quantities in Ukraine, 2005-2012.

Note: Wheat grower prices for Ukraine are national averages.

Source: APK-Inform (2013); HGCA (2013); GTIS (2013); Authors' illustration.

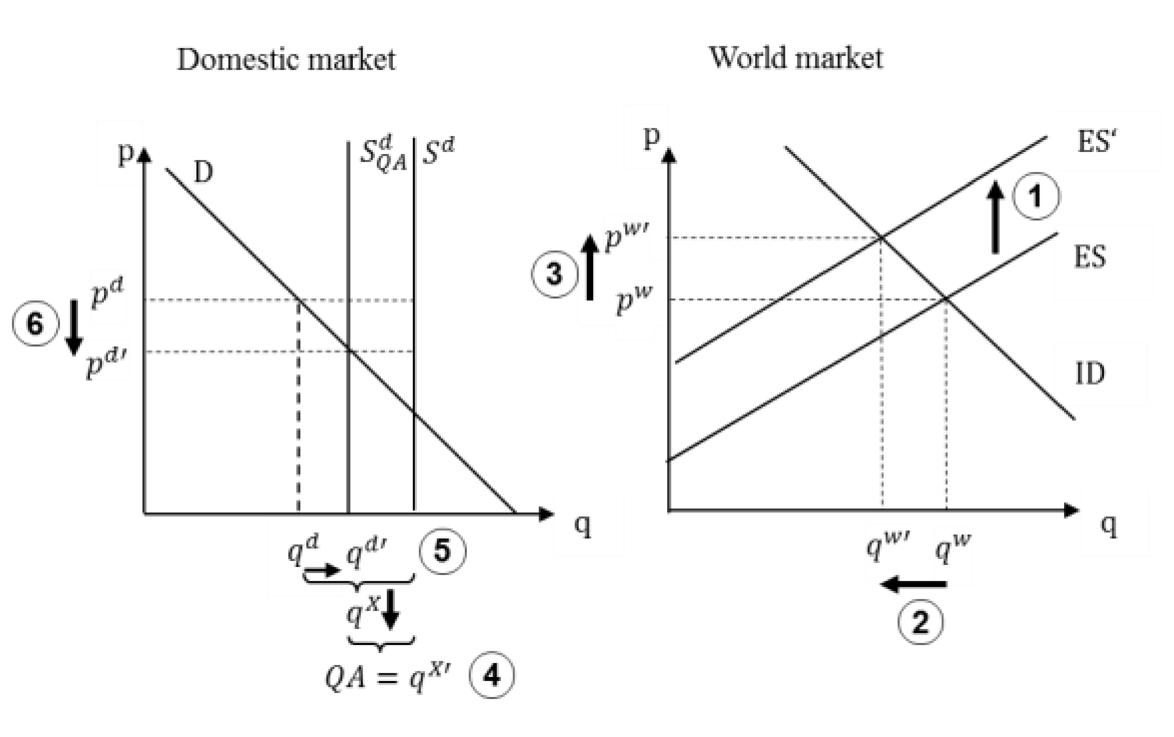
3 Theoretical and Empirical Price Impacts of Export Controls

Export restrictions influence the level of the price prevailing on the domestic market. In addition, export controls may have accidental effects on the world market-price level and may induce additional price volatility.

3.1 Domestic Price Effects

As indicated above, by decreasing the export quantity, export controls aim to increase domestic market supplies to reduce domestic wheat market prices. This price development can be theoretically explained within a market diagram. As an example, Figure 5 illustrates the domestic price and quantity effects of an export quota within a partial-equilibrium framework.

Figure 5: Price and quantity effects of an export quota on the domestic market



Note: Labels in Figure 5 are explained within the text.

Source: Authors' illustration adapted from Götz *et al.* (2012).

Suppose we observe a situation on the world market similar to 2006, when adverse weather conditions led to a relatively low wheat harvest in Ukraine and Australia (Grueninger and von Cramon-Taubadel, 2008), thus reducing the world wheat-export supply. This can be depicted graphically by the movement of the export supply (*ES*) of wheat on the world market from *ES* to ES' (Figure 5, 1). Thus, the amount of wheat traded on the world market decreases from q^w to $q^{w\prime}$ (Figure 5, 2), and the world market price increases from p^w to $p^{w\prime}$ (Figure 5, 3). If Ukraine implements an export quota the size of *QA*, Ukrainian wheat exports decrease from q^X to $q^{X\prime}$=*QA* (Figure 5, 4). Suppose that export controls are implemented at the beginning of the harvest; thus, domestic supply S^d is fully inelastic, and the domestic supply of wheat increases from q^d to $q^{d\prime}$ (Figure 5, 5). As a result, the domestic price level decreases from p^d to $p^{d\prime}$ (Figure 5, 6). The more the exports are reduced, compared to the open trade regime, the larger is the increase of supply on the domestic market, and the more the domestic price should decrease.

However, as Figure 1, Figure 3, and Figure 4 show, the domestic wheat prices in the KRU countries generally continued to increase in times of export controls, provided that the world market price was increasing. Due to the temporary nature of these restrictions, domestic wheat prices remain related with the world wheat-market price even in times of export controls. Thus, the price-reducing effect of export restrictions might be counteracted by the increasing price effects induced by rising world market prices. Empirically, we observe domestic wheat prices in the KRU countries increasing in parallel to elevating world market prices during export controls but rising to a lesser extent than when trade is freely possible.

The domestic price effects of export restrictions can be identified within a price-transmission model that captures the transmission of price changes from the world market to the domestic market. The insulation of domestic prices from world market-price developments decreases long-run price transmission and weakens the integration between these prices. Temporary changes in price transmission caused by export restrictions can be identified by nonlinear regime-switching, price-transmission models. This approach is followed by Götz *et al.* (2013a) for Russia and Ukraine within a Markov-Switching Error Correction model, and a smooth transition cointegration model for Ukraine by Götz *et al.* (2012). The degree of price insulation resulting from export restrictions in the KRU countries is measured as the percentage decrease of long-run price transmission. As Figure 1 makes evident, even the domestic-price level increased beyond the world market-price level. The results of the price-transmission models suggest that wheat export controls reduce the transmission of price increases from the world wheat market to the respective domestic market by 15%-20% for Russia, 30% for Ukraine, and 0% for Kazakhstan compared to when wheat exports were possible.

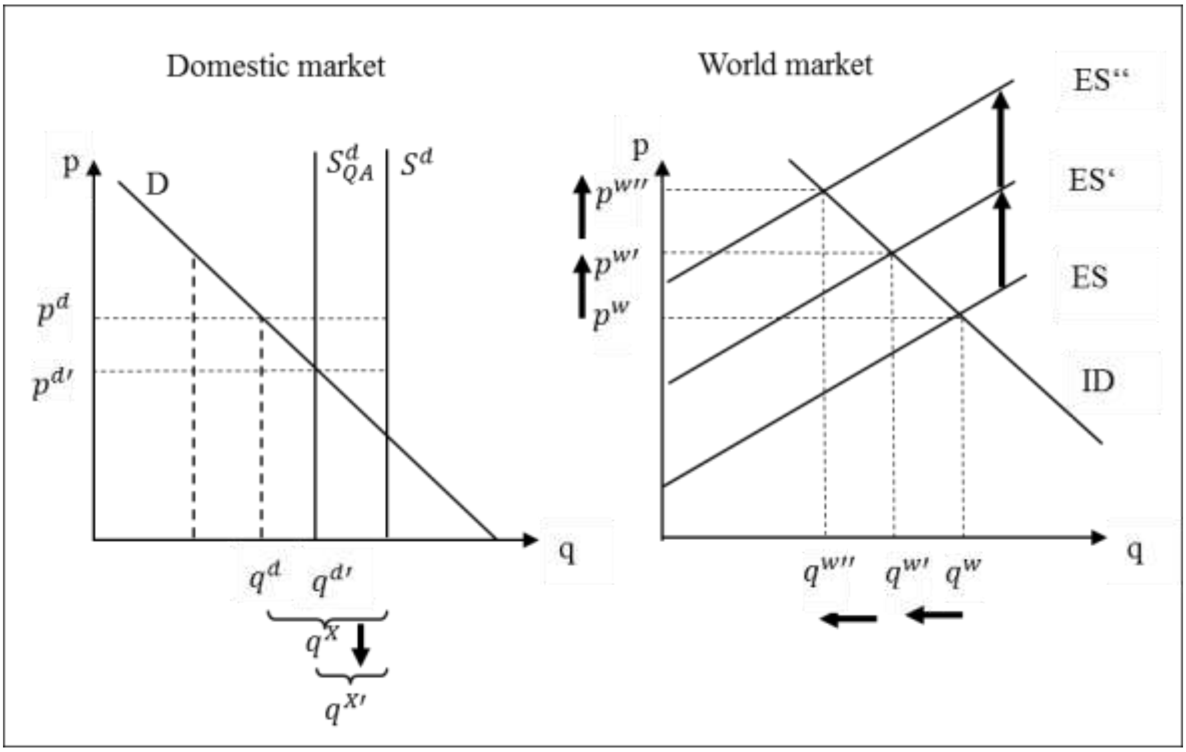
3.2 World Market Price Effects

Export restrictions are criticized for their additional price-increasing effects on the world market (Dollive, 2008; Dawe and Slayton, 2011; Martin and Anderson, 2012). In general, an export quota and an export ban are not permitted by the World Trade Organization (WTO), and only an export tax is in line with WTO regulations. However, temporary export restrictions *applied to prevent or relieve critical shortages of food stuffs or other products essential to the exporting contracting party* are exempted from this rule (Sharma, 2011). Even small countries have a price-increasing effect on the world market if many small exporting countries implement export controls simultaneously (Martin and Anderson, 2012).

Suppose a large exporting country limits its exports to insulate its domestic price from the increased world market-price level, $p^{w\prime}$. This further decreases the wheat export supply on the world market to ES'' (Figure 6, 1), and further increases the world market price to $p^{w\prime\prime}$ (Figure

6, 2). Even small countries have a price-increasing effect on the world market if many small exporting countries implement export controls simultaneously (Martin and Anderson, 2012).

Figure 6: Feedback price effect of an export quota on the world market



Note: Labels in Figure 6 are explained within the text.

Source: Authors' calculations.

Anderson and Nelgen (2012) and Martin and Anderson (2012) investigate the feedback effects of price-insulating behavior on the world market price. According to their calculations, the world wheat market price increased by about 70% between 2005/06 and 2008. These authors estimate that 19%-29% of this price increase was caused by the feedback effects of increasing export barriers by exporters, as well as by removing import barriers by importing countries worldwide.

3.3 Effects on Price Volatility

Export restrictions influence both price levels and price volatility. As indicated above, implementing export restrictions, particularly in the case of export quotas in Ukraine, brought a dramatic increase in market uncertainty for several reasons: the Ukrainian export quotas were implemented on short notice, the size of the quota was changed and prolonged several times, and the quota licenses were distributed in a non-transparent way. Thus, export restrictions make market conditions unreliable and difficult to foresee, thereby increasing market risk and ultimately leading to additional price volatility.

The effects on domestic market uncertainty were investigated by Götz *et al.* (2013c) using the generalized autoregressive conditional heteroskedasticity (GARCH) approach. Figure 7 depicts the development of volatility in the Ukrainian wheat market, measured as the conditional variance of the return price series for each price observation given the variance in the previous period. It is evident that the Ukrainian wheat price is highly susceptible to external shocks as reflected in the many pronounced spikes of the conditional variance. Also, high volatility coincides with political market interventions. For example, as shown in Figure 7, volatility spike A coincides with the announcement of an export-quota system by the Ukrainian government. The point of time of spike B matches with the temporary lift of export quotas and their unexpected reintroduction. High volatility phase C coincides with the quota increase that was announced but not realized. It also coincides with the commission meetings concerning the distribution of the export licenses. Spike D occurred when an export ban was introduced in Russia, which induced extensive discussions in the Ukrainian media about whether export controls would also be introduced in Ukraine. Spike E occurred when an extension of the export quota in Ukraine was announced. These results confirm that export restrictions increase price volatility temporarily that is caused by increased market uncertainty.

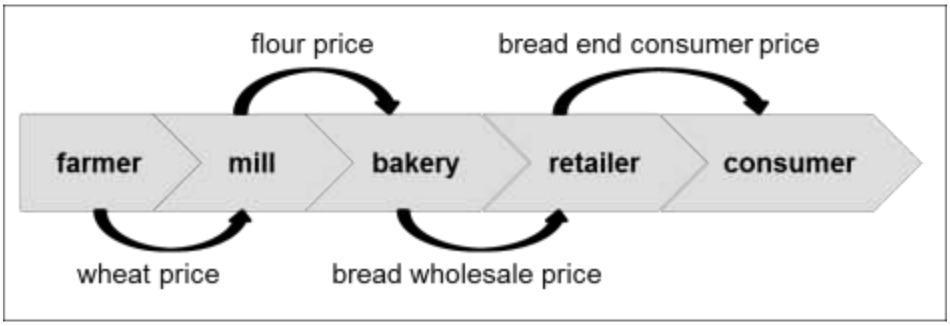
Figure 7: Development of price volatility in the Ukrainian wheat market

Source: Adapted from Götz *et al.* (2013c).

4 Price Developments along the Wheat-to-Bread Supply Chain

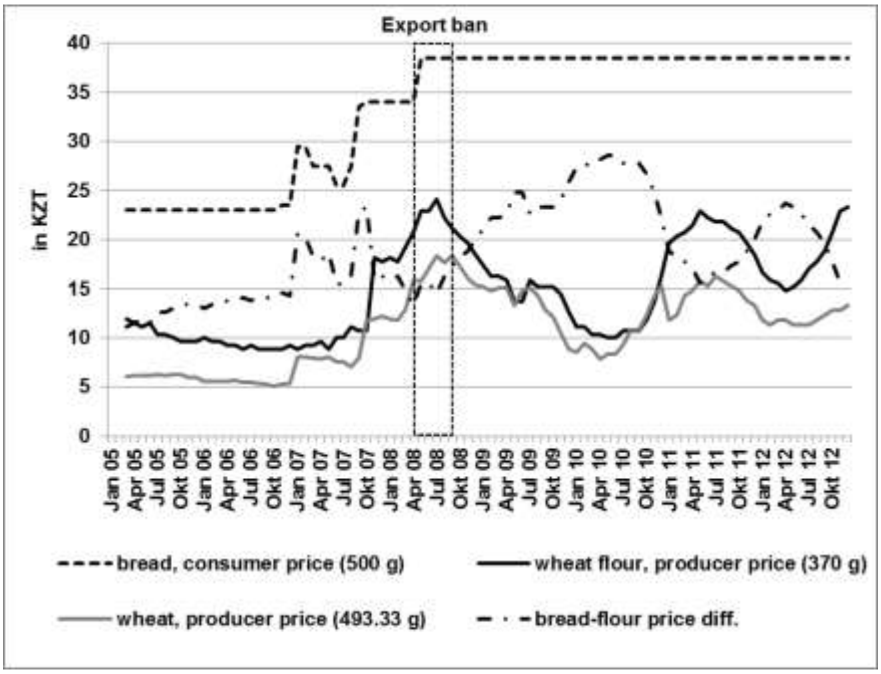
Export restrictions are generally motivated by the aim to secure sufficient supply on domestic markets and to curb domestic food price inflation. In the case of wheat-export controls, domestic wheat-price reductions must be transmitted by the intermediaries such as mills, bakeries, and retailers along the wheat-to-bread supply chain (Figure 8) to have a decreasing effect on the end-consumer-bread price, and to reduce domestic food-price inflation. In the following analysis, we provide an overview on wheat-, flour-, and bread-price developments for each of the KRU countries. Figure 9, Figure 10, and Figure 11 illustrate the development of prices for the amount of wheat and flour required to produce one loaf of bread (0.5 kg).

Figure 8: Wheat-to-bread supply chain



Source: Adapted from Götz *et al.* (2013b).

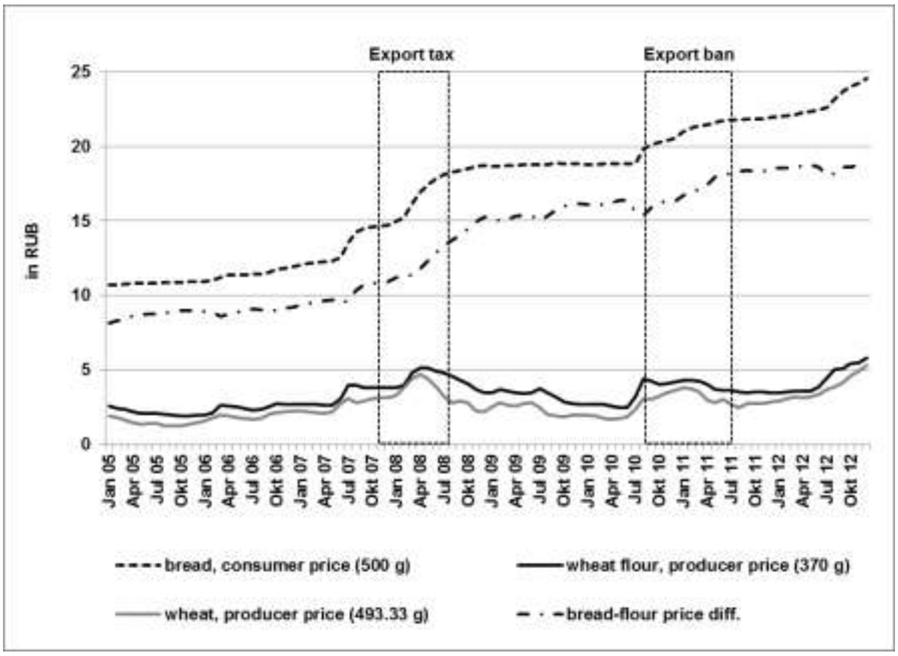
Figure 9: Wheat-, flour-, and bread-price developments in Kazakhstan



Note: Kazakhstani tenge (KZT) is the national currency of Kazakhstan.

Source: APK-Inform (2013); Authors' illustration.

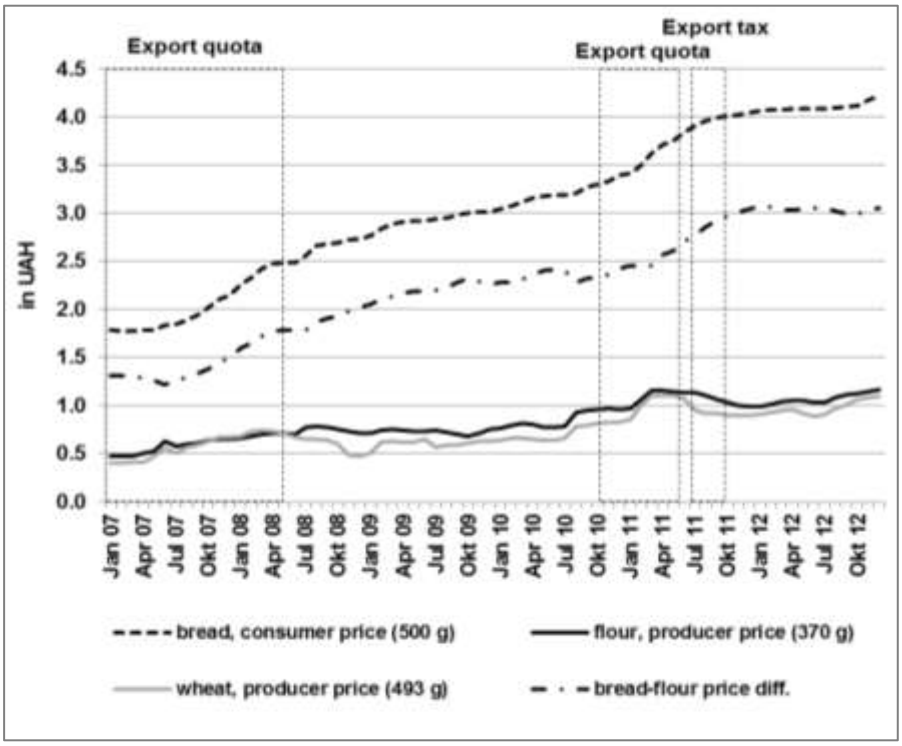
Figure 10: Wheat-, flour-, and bread-price developments in Russia



Note: Russian ruble (RUB) is the national currency of Russia.

Source: APK-Inform (2013); Authors' illustration.

Figure 11: Wheat-, flour-, and bread-price developments in Ukraine



Note: Ukrainian hryvnia (UAH) is the national currency of Ukraine.

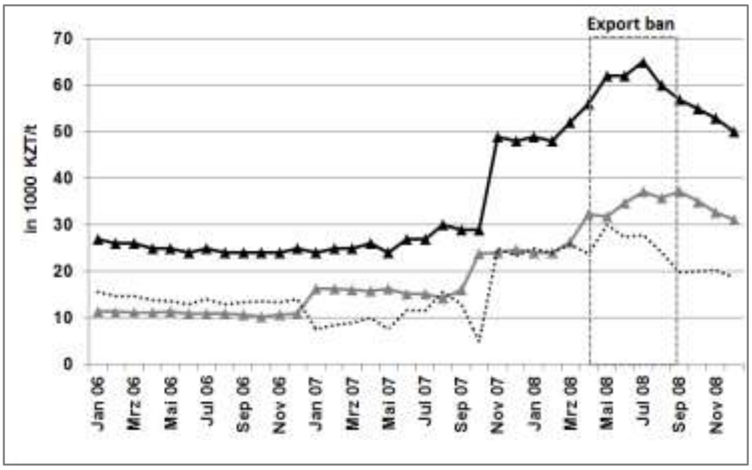
Source: APK-Inform (2013); Authors' illustration.

During the export ban in Kazakhstan, the wheat-producer price and the bread end-consumer price both increased substantially, whereas the flour price decreased after the initial price increases were observed. This resulted in a strong increase of the bread-flour-price difference toward the end of the export ban. Under the export-tax system in Russia, wheat and flour prices increased which contributed to the rise of the bread end-consumer price. In contrast, wheat and flour prices did not increase during the export ban, whereas the bread end-consumer price rose. The increase in the bread-flour-price margin observed during the export ban resulted from the increase of other bread-production costs, especially labour and energy costs. Relatively moderate increases for wheat, flour, and bread prices are observed in Ukraine during both export quota systems. The increase in the bread-flour-price margin during both phases of export quotas (similarly to Russia and Kazakhstan) can be traced back to the input-cost increase of flour, labour, and energy.

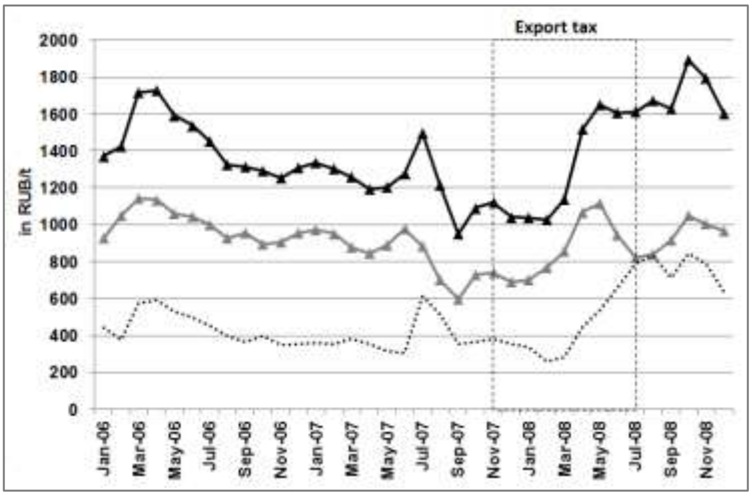
The flour-wheat-price margin for the KRU countries is presented in Figure 12. It becomes evident that the flour-wheat-price difference increased during the export controls for all three countries. In Russia and Ukraine, the increase is observed particularly toward the end of the time period with controlled exports. The flour-wheat-price difference increased right after the implementation of the export ban in Kazakhstan while later it decreased, particularly toward the end of the export ban. To investigate whether the increase in the flour price, relative to the wheat-producer price, is justified by increased flour-production costs, we calculated the mills' profits and simulated the flour-production costs (includes other costs such as labour, electricity, fuel, water, and additional materials, with the total costs equally about 81% for wheat flour and 19% for other costs) (Djuric *et al.*, 2012). The simulation was conducted for large industrial mills that have their own silos and buy wheat during harvest at rather low prices. Therefore, we conducted the simulation based on the wheat price during the previous harvest plus respective storage costs.

Our first results indicate that the profits of the large Russian mills amounted to an average of about 177 RUB/mt prior to the governmental interventions (January 2006 to November 2007). During the export-tax system, the mills' profits increased by about 20%. In the aftermath of the interventions, the average mill's profit dropped considerably by about 65% compared to the profits obtained during the interventions. In summary, the large mills in Russia could increase their profits and thus could benefit from export controls. After the export controls were removed, profits of the large mills decreased substantially. Qualitatively, similar results were obtained for Kazakhstan and Ukraine; however, the mills' profits seem to be significantly higher in Kazakhstan compared to Russia and Ukraine.

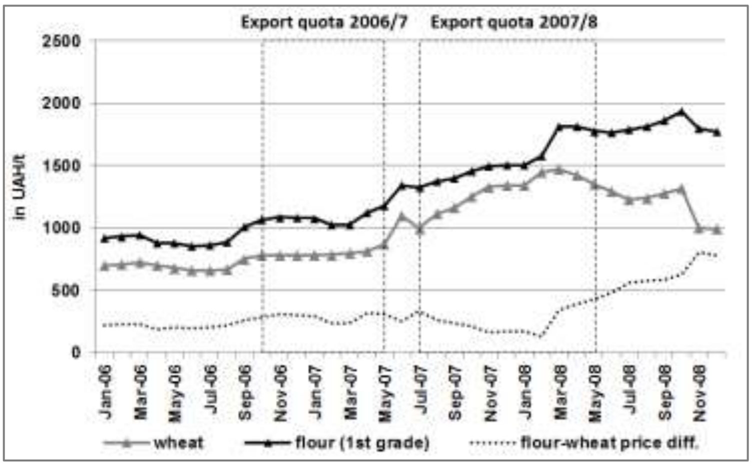
Figure 12: Flour-wheat-price margin in the KRU countries



a) Kazakhstan



b) Russia



c) Ukraine

Source: APK-Inform (2013); Authors' illustration.

Similarly, we calculated the bread-production costs and simulated the bread margin which is the difference between the bread-end-consumer price and the bread-production costs. The first results suggest that the bread-price increases observed in times of export controls in the KRU countries were caused by rising production costs. Thus, small bakeries faced both increased flour costs and production costs that decreased the bread margin. Therefore, bakeries seemed to have not achieved additional profits during the export controls in the KRU countries. In contrast, Djuric *et al.* (2012) found that bakeries were able to achieve considerably higher profits during the wheat-export ban in Serbia in 2007/08. Thus, not only miller, but also bakeries, benefited from the governmental interventions.

5 Conclusions

This chapter provided an overview of the price effects of export restrictions for wheat implemented by the KRU countries during the 2007/08 and 2010/11 commodity price peaks. It was shown that the domestic prices for the KRU countries were relative to the world market prices even with export controls. Thus, the export restrictions had only limited success for insulating the domestic prices. Also, heterogeneity was observed in the domestic price effects of the export controls. In particular, results of the price transmission analyses show that the export ban in Kazakhstan could not decrease the transmission of world wheat-market-price changes to the domestic wheat producer price, whereas the transmission of price increases on the world market was reduced 15%-20% by the export tax in Russia and 30% by the export quota in Ukraine. However, considering the feedback price effects of price-insulating behavior worldwide during the 2007/08 commodity price peak that increased the world wheat-market price by about 20%-30%, the wheat-export controls in the KRU countries did not successfully curb domestic wheat-price increases (Anderson and Nelgen, 2012; Martin and Anderson, 2012). From a global point of view, the domestic wheat price in the KRU countries would have increased to about the same degree without any price-insulating behavior from 2006 to 2008 (Götz *et al.*, 2012). Export controls also seem to be ineffective when stabilizing domestic wheat prices. Rather, analyzing the development of price volatility showed that the export-quota system in Ukraine substantially increased domestic-price risk and created additional price variations.

Decreased domestic wheat prices, foregone export revenues, and increased domestic price risks all create economic losses and additional costs to farmers and traders, and thus reduce incentives for investments in grain production. This is particularly problematic since the KRU countries bear high additional grain-production potential and could play a significant role in heightened global grain production and trade, assuming they make substantial investments in grain production (Petrick and Oshakbaev, Chapter 2, this volume). The EBRD estimates that investments of USD 1000/ha to USD 2000/ha are required to fully mobilize the grain production potential in Ukraine (Harmgart, 2011).

Furthermore, wheat-export restrictions do not seem to be an appropriate means to achieve a reduction in domestic food-price inflation. In all three KRU countries, the intermediate milling industry did not transmit the price-reducing effects from the wheat price to the flour price. Rather, large industrial mills increased flour prices during the export-control regime against the background of higher wheat spot-market prices. Also relevant for the large milling industry was the generally low wheat prices that prevailed during the previous harvest. Ultimately, the increased flour costs forced bakeries in the KRU countries to increase bread prices.

Thus, the effectiveness of export controls as an instrument of protection against high food prices is highly questionable, particularly in the case of wheat which is transformed to an end-consumer product in a complex supply chain with several intermediaries. Considering their far-reaching global consequences, the WTO should mandate that export restrictions be regulated at a multilateral level. Instead of aiming to insulate domestic agricultural prices, governments should allow domestic prices to increase and help lower income consumers cope with high food prices. Consumer-oriented crisis measures, food subsidies, food vouchers, and direct income transfers can be better targeted and are more effective.

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3.3 Impact on Domestic Wheat Prices in Importing Countries

Integration of South Caucasian wheat markets with world wheat markets: Evidence from Armenia, Azerbaijan and Georgia, SVANIDZE, M., L. GÖTZ, I. DJURIC, J. ILYASOV AND T. GLAUBEN, Contributed Paper, IAAE Inter-Conference Symposium *"Agricultural Transitions along the Silk Road: Restructuring, Resources and Trade in the Central Asia Region"*, April 4-6, 2016, Almaty, Kazakhstan.

South Caucasian and Central Asian wheat markets integration in the world wheat markets – Evidence from Armenia, Azerbaijan, Georgia and Kyrgyzstan

Miranda Svanidze [a], Linde Götz [a], Ivan Djuric [a], Jarilkasin Ilyasov [b] and Thomas Glauben [a]

[a] Leibniz Institute of Agricultural Development in Transition Economies (IAMO),

[b] International Food Policy Research Institute (IFPRI)

Abstract

Efficient functioning of grain markets is a very important component of food security in South Caucasian and Central Asian regions as wheat provides almost half of total daily calories in those countries. In this study we examine the degree of South Caucasian and Central Asian wheat markets integration in the world wheat markets. We employ linear and threshold cointegration models to study price transmission from world to domestic markets over 2006-2014 and investigate the influence of transaction costs on market integration. Estimation results indicate that markets in South Caucasus region function more efficiently and the reduction of trade costs is a critical concern for the Central Asian region in order to improve the functioning of wheat markets and alleviate food insecurity for vulnerable population.

Key Words: price transmission, trade costs, wheat, Central Asia, South Caucasus

1 Introduction

Recent increases in global food prices and its pronounced volatility in 2007/08 and 2010/11 renewed research interest in analyzing pattern and magnitude of price transmission form world to domestic agricultural commodity markets. Despite stable development of world commodity prices over the last three years, concern still exists that global markets will again witness several episodes of high and volatile prices in the future as income and population growth on the demand side persistently outpaces productivity growth on the supply side (McCorriston, 2015).

Local wheat markets in Central Asian and South Caucasian regions also become subject to frequent global wheat market shocks that took place several times during the last decade. Wheat is an important product generating around 40%-50% of total daily calories in those food-insecure and import-depended countries, which cover most of its total wheat demand by import from Black Sea region countries (Kazakhstan, Russia and Ukraine).

Given the background story, our research is oriented to analyze the extent to which the wheat price dynamics on relevant export markets in the world are spatially transmitted to domestic wheat prices in South Caucasus and Central Asian regions. Furthermore, within the study we examine the role of trade costs in the integration of South Caucasian and Central Asian wheat markets in the world wheat markets. In the end, we draw implications for food security in South Caucasian and Central Asian countries.

Usually, markets are referred to be integrated if they exercise strong price co-movement in the long-run, while disequilibrium deviations are allowed in the short-run. Notion of spatial market integration relies on the concept of the 'Law of One Price' (LOP), which states that the price of a homogeneous good across spatially separated markets, expressed in the same unit of currency, would equalize net of transaction costs (Fackler & Goodwin, 2001). If price difference exceeds trade costs, profiting opportunities will arise and arbitrage mechanism will bring diverging prices back to the equilibrium. LOP is empirically tested in the framework of cointegration models, while arbitrage opportunities are studied in the framework of error correction models. Both approaches together form the price transmission analysis from the long-run and short-run perspectives.

Enforcement of LOP indicates strong integration and efficient functioning of markets. Since South Caucasian countries trade in Black Sea region at a large extent and Central Asian countries almost exclusively import wheat from Kazakhstan, in the event of undistorted markets, full price transmission and thus, strong market integration between those markets is expected. However, LOP is scarcely observed in empirical applications. There exist many factors that might hinder full price transmission from the international to the domestic wheat markets. Significant transportation and other marketing costs, trade barriers, underdeveloped infrastructure, government interventions, local currency dynamics and market structure could diminish pass through of one price on another. South Caucasian and Central Asian countries are familiar with many of those factors, which could weaken the degree of integration and lead to the inhomogeneous pattern of price transmission in the regions. Unluckily, existing literature on the functioning of South Caucasian and Central Asian wheat markets is very scarce that took us more effort to learn specifics of those markets.

In order to conduct research on market integration, we use linear and threshold error correction models (Engle & Granger, 1987; Goodwin and Piggott, 2001) that are widely applied methods of studying price transmission from long-run and short-run perspectives. We make a choice of the models based on the results of different linear and threshold cointegration tests (Engle and Granger 1987; Johansen 1988; Hansen and Seo 2002; Larsen 2012).

In our study we use monthly producer prices for domestic markets in South Caucasus and Central Asia and export prices for world wheat markets over 2006-2014. Since most of the wheat demand in those regions is covered by import, primarily (more than 90%) coming from Black Sea region countries, we refer to those markets in our study as the world wheat markets of main interest and in addition, we also include two reference markets in France and USA.

The paper is organized as follows: section 2 provides a general overview of wheat markets in the regions. Section 3 introduces the model framework and research question, while section 4 presents literature review. Section 5 discusses data and empirical results and in section 6 conclusions and policy recommendations are presented.

2 Wheat trade in South Caucasus and Central Asia

After the breakdown of the Soviet Union in early 90s its ex-member countries followed a transition path from centrally planned to market economies. Despite the high share of agriculture in total employment (around 40%-50%) and the time passed after the breakdown, those nations still maintain the status of net food importers (FAOSTAT, 2014). In addition, a large portion of income in those regions is spent on food and non-alcoholic beverages. Namely, a household in South Caucasus region spends on average 40% of their total income on food, while this number amounts to 45% in Central Asian countries (EUROSTAT, 2014; USDA, 2015). Among other food items, wheat, mainly in the form of bread, comprises an essential component of daily food intake in those countries. In particular, the portion of consumed wheat in any nutritional form varies in the range of 30% and 60% in both regions (FAOSTAT, 2014).

Food insecurity is chronical in Central Asia and critical in South Caucasus region. Prevalence of stunting in children under five is 22% and 17% in Central Asia and South Caucasus, respectively. Share of underweighted children under five in those regions is still critical (6% in Central Asia and 4% in South Caucasus). Moreover, malnutrition in all age groups prevails in 13% of the population in Central Asia and in 6% of total population in South Caucasus. Since wheat accounts for the large share of total daily food energy intake in those regions, well-functioning of wheat markets is an essential component in alleviating food insecurity.

2.1 Wheat imports

Domestic wheat production cannot suffice local consumption in none of the regions. Most of the wheat demand is covered by imports. Share of import in total wheat consumption accounts for 63% in South Caucasus and 33% in Central Asia (USDA, 2015). As illustrated in Figure 1, wheat import in South Caucasus and Central Asian regions mainly comes from Black Sea region countries. In particular, Russian, Kazakh and partly Ukrainian wheat dominates on South Caucasian wheat markets, whereas almost all imported wheat in Central Asian countries exclusively comes only from Kazakhstan.

Figure 1: Share of Black Sea region in total wheat import in South Caucasus and Central Asia (excluding Kazakhstan), 2006-2013

Source: Trade Map, own illustration.

Therefore, contrary to South Caucasian markets, only one country from regional wheat exporters provides wheat to the domestic markets in Central Asia. Disadvantage of strong dependence on few geographically close markets is the risk of importing output volatility when unfavorable conditions prevail on those markets. Farshbaf (2012) studied effect of international trade diversification on output volatility. As he figured out, equally diversified trade reduces the risk of output volatility. In addition, he also showed that greater stability of the trading partner is associated with lower output fluctuations. Looking at the recent past, Black Sea region countries implemented various export control systems over the periods of high and volatile prices (Götz et al., 2013). As a result, South Caucasian and Central Asian wheat importers started searching for alternative distant exporting markets paying additional transportation and marketing costs to ensure that enough wheat is supplied to domestic wheat markets.[1]

2.2 Trade costs and routes

Central Asian countries, compared to South Caucasus region, have a landlocked location and difficult access to Black Sea region markets except Kazakhstan (Figure A1 in the annex). Wheat transportation here mainly occurs by train or truck, though railway route is more intensively utilized. Kazakh wheat could be directly delivered to Kyrgyzstan and Uzbekistan, from where wheat is then transited to Tajikistan and Turkmenistan. Transportation costs are relatively higher in Central Asia. For instance, despite the fact that Kyrgyzstan borders to its main wheat supplier country Kazakhstan, wheat trade costs still range between 50 and 90 US dollars per tonnes.

Map of South Caucasian wheat trade routes is given on Figure A2 in the annex. Out of three South Caucasian countries, only Georgia has an access to Black Sea ports, where it receives wheat from Russian and Ukrainian harbors. Armenia utilizes a section of Georgian railway route to transfer wheat from Georgian Black Sea ports to their borders. Concerning Azerbaijan, it mainly uses railway wagons to import wheat from Black Sea region markets. Azerbaijan receives Ukrainian and Kazakh wheat through crossing the territory of Russia. Kazakh wheat which is imported in Georgia is delivered through the Azerbaijani railway route. Armenia cannot utilize this cost-efficient way to import Kazakh wheat since it has military conflicts and closed border with Azerbaijan.

Compared to the Kazakhstan, delivery of Russian and Ukrainian wheat to South Caucasus region is relatively cheaper. As the table A1 in the annex shows, freight costs from Russia and Ukraine to Georgia Black Sea ports are as high as $15-$30 per tonnes of wheat, while railway transportation, including loading and unloading, from Black Sea ports to the borders of Armenia costs around additional $20-$25 per tonnes. Railway tariffs to import wheat from Russia directly to Azerbaijan, varies between $30 and $35 per tonnes of wheat. Compared to other Black Sea countries, wheat transportation from Kazakhstan to South Caucasian countries costs almost double. As estimated, railway transportation cost is about $80-$85 per tonnes of wheat until Azerbaijan and then adds around $25-$30 to reach the Georgian border. While

[1] During Russian wheat export ban in 2010, South Caucasian countries imported part of wheat from various distant markets, such as Iran, Uzbekistan and also some European countries, while traders from Central Asian countries approached to the seashores of Russia and Ukraine when Kazakhstan banned its wheat export in 2008.

Russian Federation has better logistics to provide wheat to its southern neighbour countries in South Caucasus region, Kazakhstan inherited faulty infrastructure from Soviet Union (Pertick et al. 2014). In order to encourage wheat trade towards European direction Kazakh government in 2010 initiated transportation subsidies ($40/tonne) on exported wheat to compete with Russia, which, due to high budgetary costs, lasted only until 2012 (Zharmagambetova & Flake, 2012).

2.3 Characteristics of wheat trade environment

In order to provide more insight about local situation on South Caucasian and Central Asian wheat markets, in the subsequent part we discuss and compare 'trading across border' component from Doing Business parameter[2] and corruption perception index averaged separately for South Caucasus and Central Asian regions. Based on those indicators, Central Asia experiences much more difficulties in regard with trade procedures than South Caucasian countries.

Table 1: Characteristics of wheat trade in South Caucasus and Central Asia, 2010

Attributes / Country	time to import (day)	documents to import (number)	cost to import (deflated $/container)	Domestic transport cost per distance ($/km)	Corruption perception index (rank/178)[3]
South Caucasus	28	8	2280	1.7	108
Central Asia	82	9	4130	2.9	166

Source: http://www.doingbusiness.org and http://www.transparency.org, own illustration.

As table 1 shows, Central Asian countries, compared to South Caucasus, have higher import costs and need much more time, as well as documents, to import a product. Concerning domestic transportation costs per distance, it costs 2.9 USD/km to transport a product in Central Asia, whereas this number comprises 1.7 USD/km for South Caucasus region. In addition, bribe-taking (especially, in Central Asia) also makes transportation and marketing costs higher in those countries.

2 Indicators are calculated for the following product 'parts and accessories of motor vehicles (HS 8708)' imported from Russia (in case of Armenia, Azerbaijan and Uzbekistan), China (in case of Kyrgyzstan and Tajikistan) and Germany (in case of Georgia).

3 '0'=highly corrupt and '10'=very clean. Survey includes 178 countries in total.

3 Model framework and research hypothesis

We employ Engle and Granger (1987) two-step Ordinary Least Square approach to conduct cointegration and linear error correction analysis. Given wheat markets in importing and exporting countries, M_1 and M_2, respectively, long-run cointegration relationship between prices on those markets can be expressed in the following way:

$$\varepsilon_t = P_{1,t} - \alpha - \beta P_{2,t} \qquad [1]$$

Where P_t denotes natural logarithm of prices and ε_t is a stationary disturbance term; α and β are interpreted as intercept and long-run price transmission elasticity, respectively, characterizing equilibrium relationship of wheat prices.

Given that price series are cointegrated and residuals from [1] are stationary, a linear error correction model[4] can be estimated to analyze short-run market dynamics as a next stage.

Following equation provides linear error correction representation:

$$\Delta P_{1,t} = \gamma \varepsilon_{t-1} + \sum_{i=1}^{k} \delta_i \Delta P_{1,t-i} + \sum_{i=1}^{l} \theta_i \Delta P_{2,t-i} + \omega_t \qquad [2]$$

Where γ denotes the speed of adjustment, at which deviations from the long-run equilibrium are corrected. For instance, when equilibrium is squeezed, higher price is forced to move up and lower price is forced to move down to restore equilibrium between markets. ε_{t-1} represents error correction term $[P_{1,t-1} - \alpha - \beta P_{2,t-1}]$, i.e. lagged residuals from equation [1], δ_i and θ_i contain dynamic short-run parameters and ω_t is a conventional disturbance term with $\omega_t \sim N(0, \sigma^2)$.

Linear error correction models rests on the assumption that any, even slightest, deviation from the long-run equilibrium relationship, that is subject to correction and magnitude of price adjustment, is identical irrespective of the direction of deviation. Thus, Engle and Granger's method assume symmetric adjustment mechanism, which will lead to inconsistent results if the error correction process is indeed asymmetric. As spatial trade arbitrage theory postulates, price transmission between two spatially separated markets will take place if price difference exceeds transaction costs (Goodwin & Piggott, 2001).

4 In this study we use error correction rather than vector error correction model approach, since South Caucasian and Central Asian countries exclusively are wheat importers and there is only uni-directional trade going from Black Sea region to those countries. Thus, we employ small, open country assumption and estimate only one-way equation with domestic prices as a dependent variable.

Heckscher (1916) was the first who developed an idea of ‘band of inaction’, in which small deviations from the LOP are not corrected, because the price difference (potential earning) is less than the transaction costs. This process is not captured by the linear error correction model. In order to overcome this deficiency and examine impact of transaction costs on price behaviour, threshold cointegration models were designed, which implicitly capture trade costs by estimating threshold value and splitting adjustment process above and below it to characterize trade arbitrage in both cases. The model generally includes, but is not restricted to, three regimes that are separated by two thresholds. Thresholds describe transaction costs in one and the other direction of trade flows. Since we observe only unidirectional trade and no trade flow reversals for domestic wheat markets, we propose usage of threshold error correction models with one threshold and two regimes. In threshold error correction model, threshold variable and corresponding threshold parameter determine the state of regime. Usually, stronger spatial arbitrage takes place in the ‘upper’ regime where price difference exceeds the transaction costs and it is very weak (or does not occur at all) in the ‘lower’ regime where prices move independently of one another. The model equation looks as it follows:

$$\Delta P_{1t} = \begin{cases} \gamma_1 \varepsilon_{t-1} + \sum_{i=1}^{k} \delta_i \Delta P_{1t-i} + \sum_{i=1}^{l} \theta_i \Delta P_{2t-i} + \omega_t, & \varepsilon_{t-1} \leq \tau \quad \text{'lower' regime} \\ \gamma_2 \varepsilon_{t-1} + \sum_{i=1}^{k} \delta_i \Delta P_{1t-i} + \sum_{i=1}^{l} \theta_i \Delta P_{2t-i} + \omega_t, & \varepsilon_{t-1} > \tau \quad \text{'upper' regime} \end{cases} \qquad [2']$$

Where τ denotes threshold value and ε_{t-1}, error correction term, serves as a threshold variable, as well.

To obtain model parameters, we apply regularized Bayesian estimator recently developed by Greb et al. (2013) instead of commonly used Profile Likelihood estimator (Hansen and Seo, 2002; Lo and Zivot, 2001). The latter one is superior due to its better small sample properties and avoidance of arbitrary trimming parameter to generate threshold estimates. Contrary to Profile Likelihood estimator, Bayesian threshold estimates are well-defined over the whole domain of threshold parameter.

In order to make a proper choice between linear and threshold error correction models, we apply linear and threshold cointegration tests. We perform two linear cointegration tests (Engle and Granger, 1987; Johansen 1988), with the null hypothesis of no cointegration against an alternative of linear cointegration and two threshold cointegration tests (Hansen and Seo, 2002;

Larsen, 2012) with the null hypothesis of linear cointegration against an alternative of threshold cointegration. Hansen and Seo's test examines threshold cointegration models with one threshold and Larsen's test is applicable for model setups with two thresholds.

4 Literature review

Engel & Granger (1987) and Johansen (1988) were among those pioneers who established linear estimation procedures for cointegration and error correction analysis to evaluate magnitude and speed of price transmission. Linear models would be misspecified if trade costs, which are having a strong impact on price transmission between spatially separated markets, are not taken into account. In order to overcome such deficiencies, further advancements were made to develop nonlinear regime switching models, among which threshold vector error correction models have found a wide application in analyzing spatial integration of agricultural commodity markets.

Balke and Fomby (1997) introduced threshold cointegration model to address the theory of the term structure of interest rates. Later, First Goodwin and Holt (1999) introduced threshold vector error correction model in a vertical price transmission setting and later Goodwin and Piggott (2001) proposed it for the spatial price transmission analysis on agricultural commodity markets. They confirmed importance of transaction costs in price transmission analysis and found that value of threshold is positively associated with the distance between markets. Furthermore, they showed that if price differential exceeds the transaction costs, faster price adjustment will be observed.

In the recent literature, linear error correction models are mainly found in cross-country comparison studies due to its simplistic and automatized estimation approach. For instance, recent work by Zorya et al. (2015) employed linear models to demonstrate price transmission patterns from international to local markets in developing countries for different types of cereals (maize, rice and wheat). As their findings indicate, average long-run price transmission elasticity in total sample equals to 0.75 and short-run speed of adjustment varies between 0.09 and 0.11. In their study, maize markets have tendency to be more cointegrated, whereas rice market account for the lowest percentage share of cointegrated market pairs. Concerning wheat markets, they show that after price spikes in international commodities markets in 2007 average magnitude of price transmission increased from 0.58 to 1.01, albeit its speed of adjustment significantly reduced from 0.68 to 0.21.

Paper by Minot (2011) is another demonstration of application of linear vector error correction model, which analyzes price transmission from international to domestic markets in nine countries of Sub-Saharan Africa over the period of recent food price crises for the following types of cereals: maize, rice, sorghum and wheat. He shows that domestic wheat markets, in general, are not well-integrated in the world commodities markets as only 13 out of 62 domestic markets indicated cointegration relationship with international prices. Furthermore, compared to rice, maize markets in Sub-Saharan Africa are more isolated from the international market dynamics.

In the empirical studies on wheat market integration, there is a lack of comprehensive research which will consider bunch of many countries around the world and draw broader conclusions on the role of trade costs in the integration of domestic wheat markets in the international counterparts. Such an analysis already exists for rice markets. Jamora (2014) investigated thresholds in the international rice markets covering 223 domestic markets in 47 countries.[5] She found threshold cointegration in 61% of total sample (137 out of 223 markets). In order to account for possible structural breaks during global food price crises, she splits the sample before-2007 and after-2007 periods. As estimation results indicated, trade costs increased and speed of adjustment decreased after 2007. Jamora (2014) attributes such difference to the increase of oil prices and reinforcement of tariff and non-tariff barriers to trade. In addition, her findings also provide an evidence of higher thresholds for remotely located and more regulated markets and greater speed of adjustment for import-depended countries.

In our paper we will study wheat market integration from the perspective of net-importer countries. Valdes et al. (2011) is among those authors who employed linear error correction models to estimate market integration between small net-importer (Chile) and large exporter countries (Argentina and the USA) over 1986-2007. Their findings indicate that Chilean prices do adjust to the shocks arising on the world wheat markets. Namely, long-run price transmission elasticity and short-run speed of adjustment comprised to the values of 0.80-0.90 and 0.049-0.04, respectively.

Another study by Bakucs (2015) investigates spatial integration of wheat markets between net-importer country Slovenia and net-exporter country Hungary, which are two small neighbouring countries located in the Central and Eastern parts of Europe. As they find, Hungarian wheat export prices determine producer prices in Slovenia, but not vice versa.

[5] However, link between international export and domestic producer prices is still missing, because Jamora (2014) considers price transmission from international to either wholesale or retail prices on domestic markets.

However, degree of long-run market integration is rather restricted, suggesting only 55% of Hungarian wheat price changes are transmitted to the Slovenian wheat market. Markets are diagnosed to function competitively, as error correcting mechanism is symmetric and quite fast (36% of any disequilibrium is corrected in each month). They conclude that despite of local changes in socio-economic environment and recent global disturbances on commodities market, integration of Hungarian and Slovenian wheat markets stayed rather unaffected over the years of 2000-2011.

5 Data and empirical results

5.1 Data

Our data base comprises monthly domestic prices of wheat for Armenia, Azerbaijan and Georgia in South Caucasus region and Kyrgyzstan in Central Asian region, as well as wheat export prices for Kazakhstan, Russia and Ukraine in Black Sea region and France and USA as international reference markets.[6] Table 2 gives information on the price series used in the empirical analysis and the data is depicted in Figure A3 in the annex. The underlying time period of our data base is October, 2006 to August, 2014 with 95 observations for each price series.

It should be pointed out that producer price data for countries of the South Caucasus and Central Asia is not publicly available and personal contacts to unions and private companies had to be established to get access. As a result, our dataset is complete for South Caucasian countries. Nonetheless, for Central Asian region, we do have price data available only for Kyrgyzstan, which serves as a representative country in our study for the whole region[7].

Table 2: Data description

Product	Region	Country	Price	Data Source
Wheat (Domestic)	South Caucasus	Armenia	Producer prices, monthly, AMD/t	National statistics office
		Azerbaijan	Producer prices, monthly, AZN/t	Ag. Ministry
		Georgia	CIF, monthly, GEL/t	National statistics office
	Central Asia	Kyrgyzstan	Producer prices, monthly, KGS/t	National statistics office

6 We select USA and France for three reasons: first, those markets did not experience export controls during recent years of high food prices; second, they have international commodities exchange, based on which local traders in South Caucasus and Central Asia negotiate prices with Black Sea region markets; third, France and USA are large wheat exporters throughout the world and their role in world wheat price formation is significant as they provide quite solid amount of wheat to the world.

7 This is justified since Central Asian countries overall have similar difficulties in terms of wheat trade and food security.

Wheat (International)	Black Sea	Kazakhstan	FOB, monthly, USD/t	APK-Inform
		Russia	FOB, monthly, USD/t	APK-Inform
		Ukraine	FOB, monthly, USD/t	APK-Inform
	Reference markets	France	FOB, monthly, USD/t	HGCA
		USA	FOB, monthly, USD/t	USDA

Source: Own illustration.

Due to the export restrictions, our price data from Russia and Ukraine contains missing values for some time periods. In particular, as a result of prohibitive export tax in 2008 and export ban in 2010/2011, 14 observations (15.5%) are missing from Russian price data. Similarly, in case of Ukrainian prices, 16 data points (16.8%) are missing as a consequence of binding export quotas in 2006/2007 and 2007/2008. Nevertheless, local traders reported that despite existing trade embargoes, there was still a spread of information about prices between markets, which shaped their expectations and influenced their price setting rules in local markets. Therefore, rather than losing this information, we opted for updating missing values in Russian and Ukrainian price series. In particular, we imputed them by linear regression techniques, i.e. we regressed each of those price series with missing values on the average of Kazakh, Russian and Ukrainian wheat prices[8] and updated missing observations based on the predicted values from the estimation regression. Since transactions on wheat trade are usually conducted in US dollar, we transform local wheat prices to the US Dollars using exchange rates from the websites of local national banks' offices.

We applied various unit root tests to confirm relevance of data for our estimation analysis. Results of different univariate unit root tests, applied to each separate price series, are summarized in table A2 in the Annex. With conventional ADF test (Dickey, 1981) we find that all wheat prices contain a unit root at the 5% level of significance, while KPSS test (Kwiatkowski et al. 1992), on the contrary, reports that all price series are stationary both in level and first differences. Due to the mismatch of those two test results, we additionally employed ADF test with structural breaks (Perron and Vogelsang, 1992) to make final conclusion on unit root processes. Results from the breakpoint ADF test indicated that all price series contain unit root at the 10% level of significance. We accept the results from latter test and proceed to cointegration analysis.

8 Correlation coefficient of Russian and Ukrainian prices with the average of Black Sea region price is 0.96 in both cases.

5.2 Tests on linear and threshold cointegration

We follow the Engle and Granger (1987) and Johansen (1988) approach to test for linear cointegration between domestic and world wheat prices. As table 3 shows, both of the tests confirm linear cointegration for all price pairs in South Caucasus region at 5% level of significance, however, Johansen test fails to confirm linear cointegration of Kyrgyz prices with Russia, Ukraine, France and USA. The existence of a long-run equilibrium for the Kyrgyz price series can only be verified for Kazakh wheat prices.

Furthermore, we also tested for the presence of threshold effects to validate the use of threshold error correction models. Results from the threshold cointegration tests are summarized in table 4. Hansen and Seo test (with one threshold) failed to reject the null hypothesis of linear against an alternative of threshold cointegration for all price pairs in South Caucasus region, whereas Larsen test (with two thresholds) supports threshold cointegration only in case of Armenia-Ukraine price pairs. Concerning Kyrgyz wheat prices, again, there is no strong support of threshold cointegration with the world wheat prices, except for Kazakhstan. With this latter one, both of the tests strongly confirmed the existence of threshold cointegration.

Table 3. Tests of linear cointegration

price series	Engle & Granger test[a]			Johansen's test[b]					
	ADF test[a] specification	Test statistic	5 % critical value	number of cointegrating vectors H₀	H₁	specification	rank test	5 % critical value	p-value
$\ln p_t^{arm} - \ln p_t^{kaz}$	0 lag, none	-4.051	-1.944	0	1	1 lag, constant	24.643	20.262	0.012
				1	2		6.215	9.165	0.175
$\ln p_t^{arm} - \ln p_t^{rus}$	0 lag, none	-3.723	-1.944	0	1	1 lag, constant	29.773	20.262	0.002
				1	2		7.289	9.165	0.112
$\ln p_t^{arm} - \ln p_t^{ukr}$	0 lag, none	-3.614	-1.944	0	1	1 lag, constant	32.876	20.262	0.001
				1	2		5.761	9.165	0.210
$\ln p_t^{arm} - \ln p_t^{frn}$	0 lag, none	-3.545	-1.944	0	1	1 lag, constant	24.958	20.262	0.010
				1	2		4.350	9.165	0.363
$\ln p_t^{arm} - \ln p_t^{usa}$	0 lag, none	-3.800	-1.944	0	1	1 lag, constant	31.320	20.262	0.001
				1	2		6.998	9.165	0.127
$\ln p_t^{azn} - \ln p_t^{kaz}$	0 lag, none	-3.050	-1.944	0	1	1 lag, constant	28.058	20.262	0.003
				1	2		7.068	9.165	0.123
$\ln p_t^{azn} - \ln p_t^{rus}$	0 lag, none	-2.731	-1.944	0	1	1 lag, constant	27.880	20.262	0.004
				1	2		9.061	9.165	0.052
$\ln p_t^{azn} - \ln p_t^{ukr}$	0 lag, none	-2.429	-1.944	0	1	1 lag, constant	27.447	20.262	0.004
				1	2		7.094	9.165	0.122
$\ln p_t^{azn} - \ln p_t^{frn}$	0 lag, none	-2.674	-1.944	0	1	1 lag, constant	28.029	20.262	0.003
				1	2		9.036	9.165	0.053
$\ln p_t^{azn} - \ln p_t^{usa}$	0 lag, none	-2.775	-1.944	0	1	1 lag, constant	21.705	20.262	0.001
				1	2		0.010	9.165	0.935
$\ln p_t^{geo} - \ln p_t^{kaz}$	0 lag, none	-4.783	-1.944	0	1	1 lag, constant	26.361	20.262	0.006
				1	2		8.026	9.165	0.082
$\ln p_t^{geo} - \ln p_t^{rus}$	0 lag, none	-4.123	-1.944	0	1	1 lag, constant	26.721	20.262	0.006
				1	2		7.960	9.165	0.084
$\ln p_t^{geo} - \ln p_t^{ukr}$	0 lag, none	-4.739	-1.944	0	1	1 lag, constant	30.796	20.262	0.001
				1	2		7.155	9.165	0.119
$\ln p_t^{geo} - \ln p_t^{frn}$	0 lag, none	-3.729	-1.944	0	1	1 lag, constant	29.630	20.262	0.002
				1	2		6.705	9.165	0.143

$\ln p_t^{geo}$ - $\ln p_t^{usa}$	0 lag, none	-3.601	-1.944	0	1	1 lag, constant	29.151	20.262	0.002
				1	2		6.436	9.165	0.160
$\ln p_t^{kyr}$ - $\ln p_t^{kaz}$	0 lag, none	-5.399	-1.944	0	1	1 lag, constant	38.789	20.262	0.001
				1	2		5.909	9.165	0.198
$\ln p_t^{kyr}$ - $\ln p_t^{rus}$	0 lag, none	-2.476	-1.944	0	1	2 lags, constant	32.408	20.262	0.001
				1	2		13.065	9.165	0.009
$\ln p_t^{kyr}$ - $\ln p_t^{ukr}$	0 lag, none	-2.235	-1.944	0	1	1 lag, constant	22.841	20.262	0.022
				1	2		9.914	9.165	0.036
$\ln p_t^{kyr}$ - $\ln p_t^{frn}$	0 lag, none	-3.276	-1.944	0	1	1 lag, constant	24.650	20.262	0.012
				1	2		9.016	9.165	0.053
$\ln p_t^{kyr}$ - $\ln p_t^{usa}$	0 lag, none	-3.117	-1.944	0	1	2 lags, constant	25.181	20.262	0.010
				1	2		9.008	9.165	0.053

Note: Sample runs from 2006M10 to 2014M08 (95 obs.) [a]: H_0: no cointegration | H_1: linear cointegration. Test is applied to the regression residuals from corresponding cointegration equations. One-sided p-values are from MacKinnon (1996). Lag length selection is based on Schwarz Information Criterion. [b]: Johansen's rank test is based on Trace statistic. P-values are from MacKinnon, Haug and Michelis (1999).

Source: Own calculations.

Table 4: Tests of threshold cointegration

price series	Lags	Hansen and Seo (1 threshold)[a]	Larsen (2 thresholds)[a]
		p-value	p-value
$\ln p_t^{arm} - \ln p_t^{kaz}$	1	*0.610*	*0.881*
$\ln p_t^{arm} - \ln p_t^{rus}$	1	*0.138*	*0.226*
$\ln p_t^{arm} - \ln p_t^{ukr}$	1	*0.128*	**0.090**
$\ln p_t^{arm} - \ln p_t^{frn}$	1	*0.138*	*0.108*
$\ln p_t^{arm} - \ln p_t^{usa}$	1	*0.257*	*0.643*
$\ln p_t^{azn} - \ln p_t^{kaz}$	1	*0.109*	*0.427*
$\ln p_t^{azn} - \ln p_t^{rus}$	1	*0.116*	*0.500*
$\ln p_t^{azn} - \ln p_t^{ukr}$	1	*0.796*	*0.498*
$\ln p_t^{azn} - \ln p_t^{frn}$	1	*0.804*	*0.898*
$\ln p_t^{azn} - \ln p_t^{usa}$	1	*0.772*	*0.904*
$\ln p_t^{geo} - \ln p_t^{kaz}$	1	*0.750*	*0.903*
$\ln p_t^{geo} - \ln p_t^{rus}$	1	*0.568*	*0.725*
$\ln p_t^{geo} - \ln p_t^{ukr}$	1	*0.810*	*0.668*
$\ln p_t^{geo} - \ln p_t^{frn}$	1	*0.676*	*0.642*
$\ln p_t^{geo} - \ln p_t^{usa}$	1	*0.566*	*0.542*
$\ln p_t^{kyr} - \ln p_t^{kaz}$	1	**0.069**	**0.010**
$\ln p_t^{kyr} - \ln p_t^{rus}$	2	*0.558*	*0.744*
$\ln p_t^{kyr} - \ln p_t^{ukr}$	1	*0.153*	**0.051**
$\ln p_t^{kyr} - \ln p_t^{frn}$	1	*0.373*	*0.283*
$\ln p_t^{kyr} - \ln p_t^{usa}$	1	**0.083**	*0.227*

Note: Sample runs from 2006M10 to 2014M08 (95 obs.). Trimming parameter is equal to 0.05; number of bootstrap replications is set to 1000; fixed regressor bootstrap method. [a] H_0: linear cointegration| H_1: threshold cointegration.

Source: own calculations.

5.3 Summary of estimation results and discussion

Relying on results from linear and threshold cointegration tests, we justify use of linear error correction model for South Caucasus region and threshold error correction model for Kyrgyzstan.

In general, South Caucasian wheat markets are better integrated in world wheat markets compared to Central Asia. They have easier access to the world wheat markets in contrast to Central Asia, which is landlocked region and has remote geographical location with the world grain markets. For this reason, Central Asian countries largely depend on one particular country (Kazakhstan) in the world wheat import. On the contrary, South Caucasian wheat markets could diversify their wheat trade with different countries of Black Sea region markets.

All results of econometrical analysis are summarized in table 5. First, we interpret long-run price transmission elasticities. Estimation results indicate that Kyrgyz market lacks cointegration with all world wheat markets in Russia, Ukraine, France and USA and is only integrated with Kazakhstan. In contrast, cointegration tests identified long-run equilibrium relationship between South Caucasian and all selected world wheat markets. The range of international wheat price transmission elasticity for South Caucasus region varies between 0.55 and 0.79, meaning that on average 55%-79% of any international export price change is transmitted to the South Caucasian wheat markets in the long-run. From the short-run perspective, linear error Correction models estimated that price shocks which originate on the world wheat markets are corrected by South Caucasian wheat prices at a speed of 15% - 40% per month.

Furthermore, the results also suggest that information transfer is as equally important for South Caucasian wheat markets as direct wheat trade flows. Estimation results indicate that price transmission form French and US wheat markets is as high (sometimes, even higher) as price transmission from Black Sea region markets, given that there is no direct trade of wheat from France and USA to South Caucasus. In the literature, there are several studies (Jensen, 2007; Fackler and Tastan, 2008; Ihle and Amikuzuno, 2009; Stephens et al., 2012) which show that information exchange could lead to price transmission and market integration between the markets that are not even directly linked by trade flows. The fact that such link obviously exists for South Caucasian wheat markets was assuredly reported by the local wheat traders in the region, who claimed that they usually observe tendencies on CBOT[9] and MATIF[10] exchange markets to form their expectations and set orientation prices on Black Sea region markets.

Table 5: Estimation results from cointegration equation and linear/threshold error correction models

	Price transmission elasticity (β)				Speed of adjustment (γ)			
World market \ Domestic market	Armenia*	Azerbaijan*	Georgia*	Kyrgyzstan**	Armenia*	Azerbaijan*	Georgia*	Kyrgyzstan**
Kazakhstan	0.55	0.55	0.62	0.79	-0.26	-0.20	-0.28	-0.53/-0.66
Russia	0.63	0.49	0.74	-	-0.31	-0.16	-0.36	-
Ukraine	0.71	0.62	0.77	-	-0.39	-0.19	-0.38	-
France	0.62	0.51	0.75	-	-0.28	-0.15	-0.36	-
USA	0.71	0.60	0.79	-	-0.28	-0.17	-0.29	-

Note: All parameters are significant at 1%. - = no cointegration relationship was detected for the respective price pairs. *Parameters are received from cointegration and linear error correction model. **Parameters are received from cointegration and threshold error correction model. First and second estimates refer to the 'lower' and 'upper' regime, respectively. Threshold value is τ=0.183, 78 observations fall in 'lower' regime and 15 observations fall in 'above' regime.

Source: own calculations.

Our results confirmed the importance of transaction costs in the integration of Kyrgyz wheat market with Kazakhstan, its trade partner in wheat import. While South Caucasian countries have lower costs of wheat trade with Black Sea region, transaction costs are of critical importance in Central Asian countries. Respectively, our models do not identify thresholds for South Caucasian grain markets, whereas threshold cointegration is confirmed for Central Asian (Kyrgyz) wheat markets. Moreover, Figure A4 in the annex shows that from the perspective of domestic markets wheat price volatility is more pronounced in Kyrgyzstan and from the perspective of world wheat markets it is more evident in Kazakhstan. To summarize, unstable nature of Central Asian wheat markets aggravated by the higher trade costs put even higher pressure on the food-insecure population in this region.

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9 Chicago Board of Trade (CBOT) is agricultural commodities exchange located in USA.
10 Marché à Terme International de France (MATIF) is agricultural commodities exchange located in France.

6 Conclusions and policy recommendations

In this paper we analyze wheat market integration of import-depended and food-insecure countries of South Caucasia and Central Asia in the Black Sea region and selected reference export markets. In particular, the study used linear and threshold cointegration models to investigate the development of domestic wheat prices in connection with the world wheat markets over the period of 2006-2014.

As the overview of wheat markets shows, Black Sea region countries are important partners of South Caucasus and Central Asian regions in the wheat trade. More than 95% of total wheat import in those regions comes from Black Sea wheat markets. South Caucasus region has easier access to the world markets than countries in Central Asia and grain markets in this region function also more efficiently. While South Caucasian countries diversified their sources of wheat import, Central Asian countries have to almost exclusively rely on wheat import from Kazakhstan.

Moreover, we conclude that not only physical trade but also information spread contributes to the transmission of price signals between domestic and world wheat markets. We find an evidence for integration of South Caucasian wheat markets with France and USA, whereas South Caucasian countries are not engaged in wheat trade with them.

Our results do not provide evidence for a strong influence of trade costs on price transmission between South Caucasus and international wheat markets. Contrasting, wheat trade in Central Asia is characterized by higher transaction costs and strong price volatility, which negatively affects food security in Central Asia.

Given the study outcomes, we argue that wheat markets in South Caucasus region function more efficiently, while the reduction of trade costs in Central Asia is critical to improve the functioning of grain markets. Local governments in Central Asia should invest in trade infrastructure, i.e. transportation systems and storage facilities in order to alleviate barriers of trade and strengthen the integration of local markets in the world wheat markets.

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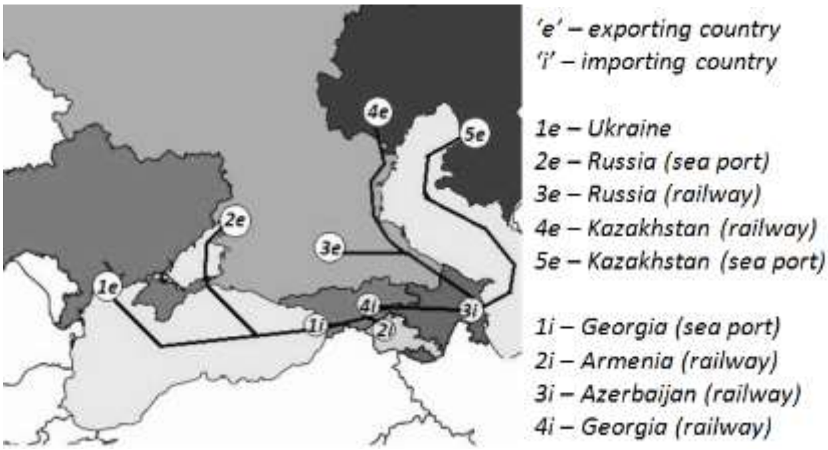
Annex

Figure A1: Map of South Caucasus, Central Asia and Black Sea region countries

Source: Own illustration.

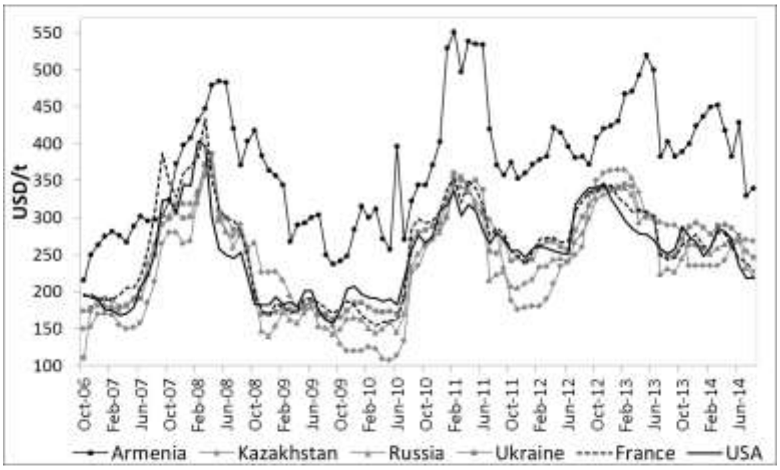
Figure A2: Map of well-established wheat trade routes from Black Sea to South Caucasian markets



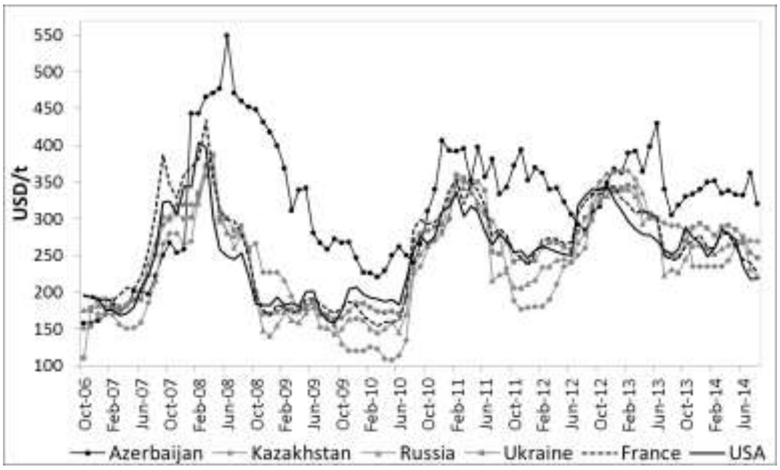
Source: Own illustration.

Figure A3: Domestic and export wheat prices, 2006-2014

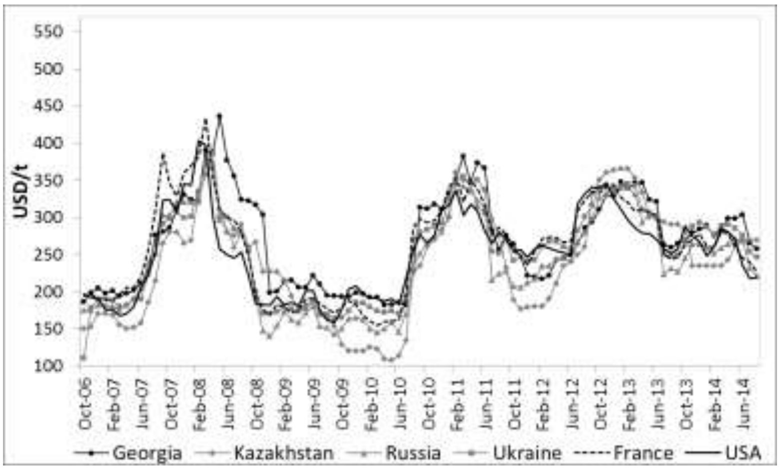
a) Armenia and world wheat export markets



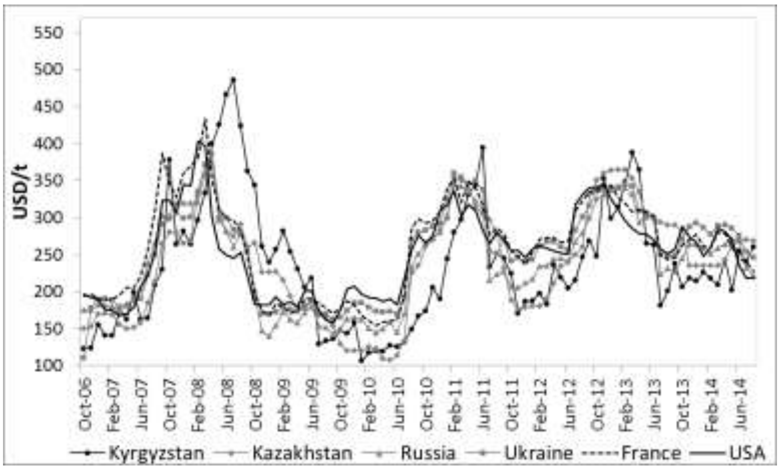
b) Azerbaijan and world wheat export markets



c) Georgia and world wheat export markets

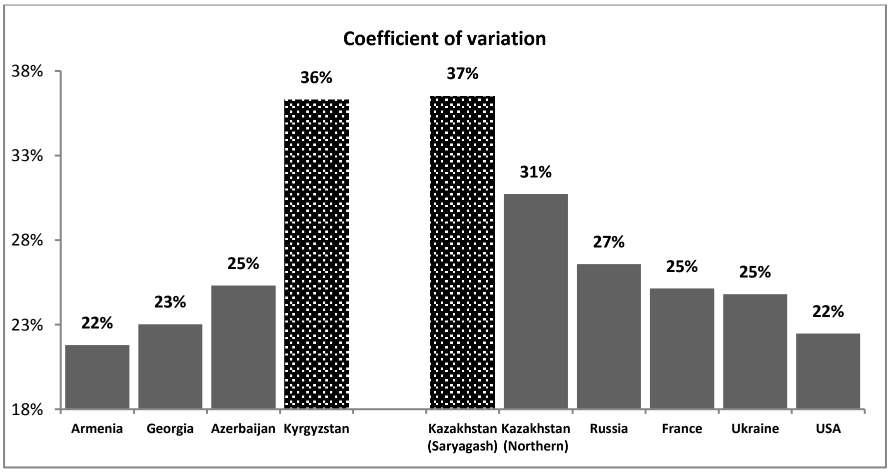


d) Kyrgyzstan and world wheat export markets



Source: APK-Inform, national statistics offices and ministry of agriculture in Azerbaijan, own illustrations.

Figure A4: Coefficient of variation on domestic and the world wheat markets



Source: own calculation and own illustration.

Table A1: Wheat transportation costs from Black Sea wheat markets to the borders of Armenia, Azerbaijan and Georgia and Kyrgyzstan, 2014

from	**Kazakhstan**				**Russia**				**Ukraine**			
to	**Armenia**	**Azerbaijan***	**Georgia***	**Kyrgyzstan**	**Armenia**	**Azerbaijan**	**Georgia**	**Kyrgyzstan**	**Armenia**	**Azerbaijan**	**Georgia**	**Kyrgyzstan**
Ship transportation rates	−	−	−	−	15-30	−	15-30	−	15-30	10-15	15-30	−
Rail transportation rates	−	80-85	110	50-90	20-25	30-35	−	−	25	30-35	−	−
Total transportation rates ($/t)	−	**80-85**	**110**	**50-90**	**35-55**	**30-35**	**15-30**	−	**40-55**	**40-50**	**15-30**	−

Source: International Seaborne Market and personal interviews with traders and field experts, own illustration.

Note: * tariff rates excludes transportation subsidy $40 per tonnes during 2010-2012 years, which was introduced by Kazakh government to make wheat trade more competitive towards western directions. Transportation costs are approximate and average estimates; they might vary in time, by capacity (t) and total distance travelled. Thus, the numbers must be considered with caution. − =Not applicable.

Table A2: Unit root and stationarity tests

Price series	Unit Root Tests: Augmented Dickey-Fuller test: test statistic	specification	5 % critical value	Augmented Dickey-Fuller test with break: test statistic	Specification	break	Break date	5 % critical value	Stationarity Test: KPSS test: test statistic	specification	5 % critical value
$\ln p_t^{arm}$	-2.597	1 lag, constant	-2.893	-3.317	0 lag, constant, trend	Intercept	2010M07	-4.860	0.065	6 lags, constant and linear trend	0.146
$\Delta \ln p_t^{arm}$	-8.137	0 lag, none	-1.944	-8.842	0 lag, constant	Intercept		-4.444	0.146	2 lags, constant	0.463
$\ln p_t^{azn}$	-2.639	0 lag, constant	-2.893	-2.790	0 lag, constant	Intercept	2010M08	-4.444	0.086	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{azn}$	-8.938	0 lag, none	-1.944	-11.505	0 lag, constant	Intercept		-4.444	0.211	3 lags, constant	0.463
$\ln p_t^{geo}$	-2.509	1 lag, constant	-2.893	-2.964	1 lag, constant	Intercept	2010M07	-4.444	0.059	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{geo}$	-7.878	0 lag, none	-1.944	-9.262	0 lag, constant	Intercept		-4.444	0.085	3 lags, constant	0.463
$\ln p_t^{kyr}$	-2.640	0 lag, constant	-2.893	-3.245	2 lags, constant, trend	Intercept	2009M02	-4.860	0.100	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{kyr}$	-11.769	0 lag, none	-1.944	-8.695	0 lag, constant	intercept		-4.444	0.094	1 lag, constant	0.463
$\ln p_t^{kaz}$	-2.549	1 lag, constant	-2.893	-5.610	6 lags, constant, trend	Intercept, trend	2010M07	-5.176	0.075	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{kaz}$	-6.016	0 lag, none	-1.944	-7.668	0 lag, constant	Intercept		-4.444	0.061	4 lags, constant	0.463
$\ln p_t^{rus}$	-2.478	1 lag, constant	-2.893	-3.661	1 lag, constant, trend	Intercept	2010M06	-4.860	0.088	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{rus}$	-7.111	0 lag, none	-1.944	-7.801	0 lag, constant	Intercept		-4.444	0.074	3 lags, constant	0.463
$\ln p_t^{ukr}$	-2.137	1 lag, constant	-2.893	-3.389	1 lag, constant, trend	Intercept	2010M06	-4.860	0.071	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{ukr}$	-8.568	0 lag, none	-1.944	-9.949	0 lag, constant	Intercept		-4.444	0.186	3 lags, constant	0.463

$\ln p_t^{frn}$	-2.531	1 lag, constant	-2.893	-3.846	1 lag, constant, trend	Intercept	2010M06	-4.860	0.083	7 lags, constant and linear trend	0.146
$\Delta \ln p_t^{frn}$	-6.423	0 lag, none	-1.944	-7.660	0 lag, constant	Intercept		-4.444	0.088	3 lags, constant	0.463
$\ln p_t^{usa}$	-2.683	1 lag, constant	-2.893	-3.698	1 lag, constant, trend	Intercept	2010M06	-4.860	0.077	6 lags, constant and linear trend	0.146
$\Delta \ln p_t^{usa}$	-6.876	0 lag, none	-1.944	-7.614	0 lag, constant	Intercept		-4.444	0.117	0 lags, constant	0.463

Note: Sample runs from 2006M10 to 2014M08 (95 obs.) ADF lag length selection is based on Schwarz Information Criterion. One-sided p-values for ADF test are from MacKinnon (1996). KPSS test bandwidth selection is based on Newey-West method. P-values for KPSS test are from Kwiatkowski, Phillips, Schmidt and Shin (1992, Table 1). In ADF test with break, break selection is based on minimizing Dickey-Fuller t-statistic. Lag length is defined based on Schwarz Information Criterion. Break type follows to Innovational Outlier model. Break date is unknown and estimated from data. Break variables are defined as follows: Intercept=1(t ≥ T_b) and Trend=1(t = T_b). T_b is specified break date. Asymptotic one-sided p-values are from Vogelsang (1993).

Source: own calculations.

Erklärung an Eides statt

Hiermit erkläre ich an Eides statt, dass ich meine Habilitationsschrift “Trade Policy Interventions on Agricultural Markets in Countries of the Former Soviet Union and the Balkans” selbständig und ohne fremde Hilfe verfasst habe, keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe und die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe.

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