DISCUSSION PAPER

Leibniz Institute of Agricultural Development in Transition Economies

Regional wheat price effects of extreme weather events and wheat export controls in Russia and Ukraine

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DISCUSSION PAPER NO. 154
2016

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ISSN 1438-2172

ABSTRACT

This paper further builds on the price transmission model framework of existing studies to identify domestic wheat price effects of wheat export controls. We explicitly take the fact into account that a harvest failure causes domestic price effects as well. 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. Contrasting, regional variation of export controls' domestic price effects in Ukraine is rather small.

JEL: C22, E30, Q11, Q17, Q18

Keywords: Export controls, international trade, agricultural trade policy, Russia, Ukraine, grain markets, food security, extreme weather events, climate change.

ZUSAMMENFASSUNG

REGIONALE WEIZENPREISEFFEKTE VON WETTEREXTREMEN UND WEIZENEXPORTKONTROLLEN IN RUSSLAND UND DER UKRAINE

Dieser Artikel entwickelt den Preistransmissionsansatz aus der Literatur weiter, um inländische Weizenpreiseffekte von Weizenexportkontrollen zu identifizieren. In unserem Ansatz findet speziell Berücksichtigung, dass auch Mißernten selbst Preiseffekte auslösen. Die Ergebnisse der Analyse auf regionaler Ebene weisen auf eine starke regionale Heterogenität bezüglich der Stärke der Preiseffekte während des Exportverbots 2010/11 in Russland hin. Der den Weizenpreis dämpfende Effekt ist in der Region mit direktem Zugang zum Weltmarkt am Stärksten und beläuft sich auf 67 %. Dieser Effekt wurde durch stark ansteigenden interregionalen Weizenhandel, zum Teil auch im Rahmen von Handelsumkehrung, in die übrigen Regionen übertragen. Im Unterschied zu Russland ist die Variation des inländischen Preiseffekts von Exportkontrollen in der Ukraine deutlich schwächer.

JEL: C22, E30, Q11, Q17, Q18

Schlüsselwörter: Exportkontrollen, internationaler Handel, Agrarhandel, Agrarhandelspolitik, Russland, Ukraine, Getreidemärkte, Ernährungssicherung, Extreme Wetterereignisse, Klimawandel.

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 measured in 2010 since the year 1500 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 % below average levels in the Ukraine in 2010/11 and 2012/13 in total. However, grain production was in excess of 60 % below average in some regions of Russia in 2010/11.

The literature intensively debates the link between the Russian heatwave in 2010 and climate change. COUMOU and RAHMSTORF (2012) are linking the heatwaves in Russia with the effects of global warming due to human influences upon the climate. They point out that climate change has increased the probability of such a weather event by a factor of three, whereas the extent of the heatwave in 2010 was rather natural[1].

Russia and Ukraine have a history of restricting grain exports to the world market. Export controls are justified by referring to 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 % of custom charges plus 7.5 Euro on February 1, 2015 which was removed in May 2015 (GÖTZ et al., 2015).

This paper investigates the effects of wheat export controls on the domestic wheat price to assess their effectiveness to dampen wheat prices in Russia and Ukraine. We are following a price transmission approach and supplement existing studies on export controls' domestic price effects in two respects: Firstly, we explicitly take into account in our price transmission model framework the question if export controls are implemented in the event of a 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, those 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. Instead of including prices observed when trade is freely possible in our data base, we select prices given free trade before the background of a pronounced production shortfall. 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 development 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 importance of these two aspects to correctly identify the export controls' domestic price effects is illustrated in the text.

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1 Contrasting, DOLE et al. (2011) instead see the Russian drought in 2010 as a natural event which is not related to anthropogenic climate change.

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 of domestic price effects in regional markets. The model framework, 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 are also investigated by BAYLIS et al. (2014), BAFFES et al. (2015) and IHLE et al. (2009) within 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. By contrast with this, 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). The study by GÖTZ et al. (2016) confirms 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. However, the challenges of regime classification of models with endogenous switch as the smooth transition cointegration (STC) model and the MSECM are discussed and compared to a regime-switching model with exogenous switch by GÖTZ et al. (2016). Accordingly, the STC performs signifycantly better than the MSECM, but only slightly better than the regime-switching 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. This would pose 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 this analysis.

In the above mentioned price transmission approaches followed by DJURIC et al. (2015), GÖTZ et al. (2013) and 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 the regime given trade is freely possible. However, export controls are often implemented when a harvest shortfall is observed on the domestic market, which also may influence domestic price developments. A harvest shortfall may counteract the influence of an export control and thus disregarding its influence in the modelling approaches, particularly if the harvest shortfall is pronounced, may lead to erroneous results.

An exception among the existing studies is BAFFES et al. (2015) which 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 in an error correction panel model framework. Accordingly, weather shocks have a strong short-run influence on domestic prices which is less pronounced in markets engaged in regional or international trade. Export bans exacerbate the effects of domestic weather disturbances in local markets by delaying the adjustment towards a long-run equilibrium with external markets. Results suggest that an export ban has a larger

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

influence on markets in the Northern zone compared to the Southern zone. Contrasting, IHLE et al. (2009) 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 within the partial equilibrium 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 exports in the respective scenarios. Also, they do not account for the regional effects of export controls.

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.

This paper adds to the few existing studies which explicitly take into account 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 a regional level.

3 REGIONAL WHEAT MARKETS, GRAIN PRODUCTION DEVELOPMENT AND EXPORT RESTRICTIONS IN RUSSIA AND UKRAINE

This section aims to provide background information on wheat markets in Russia and Ukraine that is essential to understand and interpret the results of our analysis of domestic price effects of export controls. We provide an overview of the major characteristics and differences of regional wheat markets in Russia and Ukraine. Particular attention is devoted to the regional distribution and concentration of wheat production and regional grain production development due to the fact that a harvest shortfall causes domestic price effects as well. 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 one country.

Russia

Wheat production in Russia is not concentrated in one region, but split between several separate grain production regions (Figure 1). North Caucasus accounts for an average (base: 2005-2013) of about 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, grain exports are supplied to the world market via ports in North Caucasus. The Volga and Black Earth regions are the primary grain production regions, alongside the North Caucasus, that supply wheat to the world wheat market. Therefore, grain flows from Volga and Black Earth towards the North Caucasus are observed when trade is freely possible and there is no harvest shortfall. 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 two regions which are several thousands of kilometres away from the world market, explaining why they are rarely engaged in international trade and mainly supply 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 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. Though, the export tax in Russia was only partially successful in dampening domestic wheat prices (Figure 2). In particular, early 2008 domestic prices increased beyond the world market price level in all of the 6 regions.

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 average, with regional production shortfalls of up to over 60 %, as illustrated above. The wheat export ban was cancelled in July 2011.

By contrast with this, exports remained freely possible during the 2012/13 marketing year, although total grain production was similarly 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). Similarly to 2007/8 and 2010/11, wheat exports to the world market ceased in 2012/13, but without any export restrictions (Figure 2).

Due to large distances, the production regions are affected by different climatic and weather conditions. This implies that favourable 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 2).

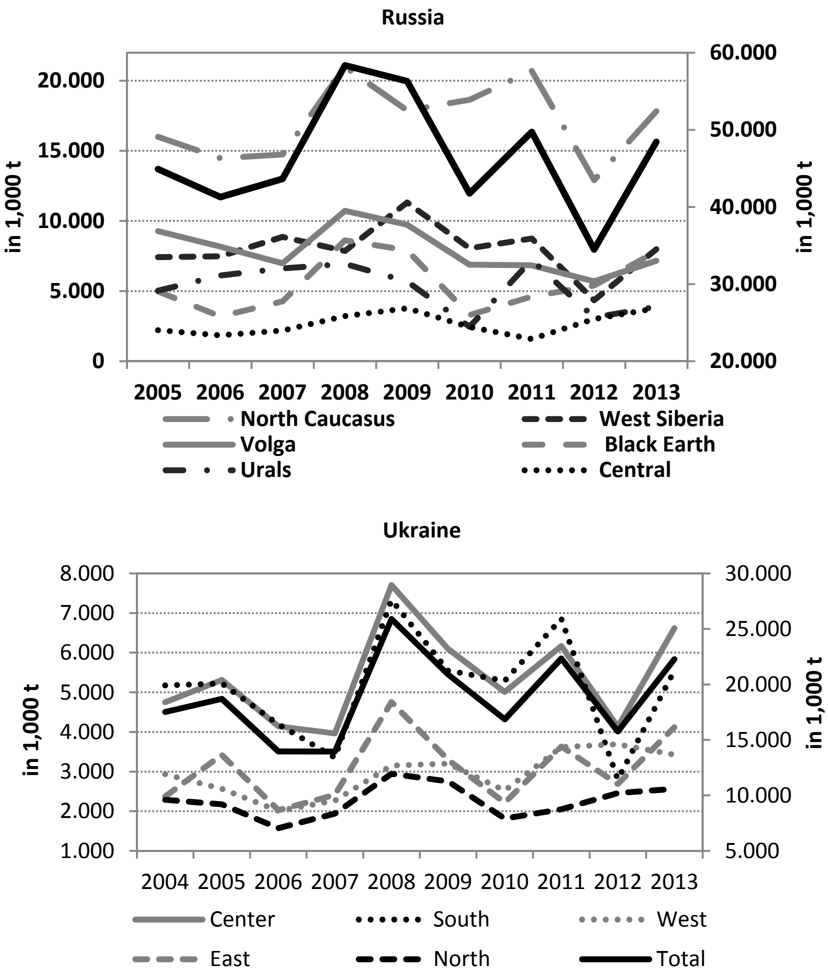
Table 1: Wheat export restrictions, grain production and wheat exports in Russia and Ukraine

	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

Sources: USDA (2015), UKRSTAT.

Notes: ** Average of the respective 3 previous years.

Figure 1: Regional grain production development Russia and Ukraine

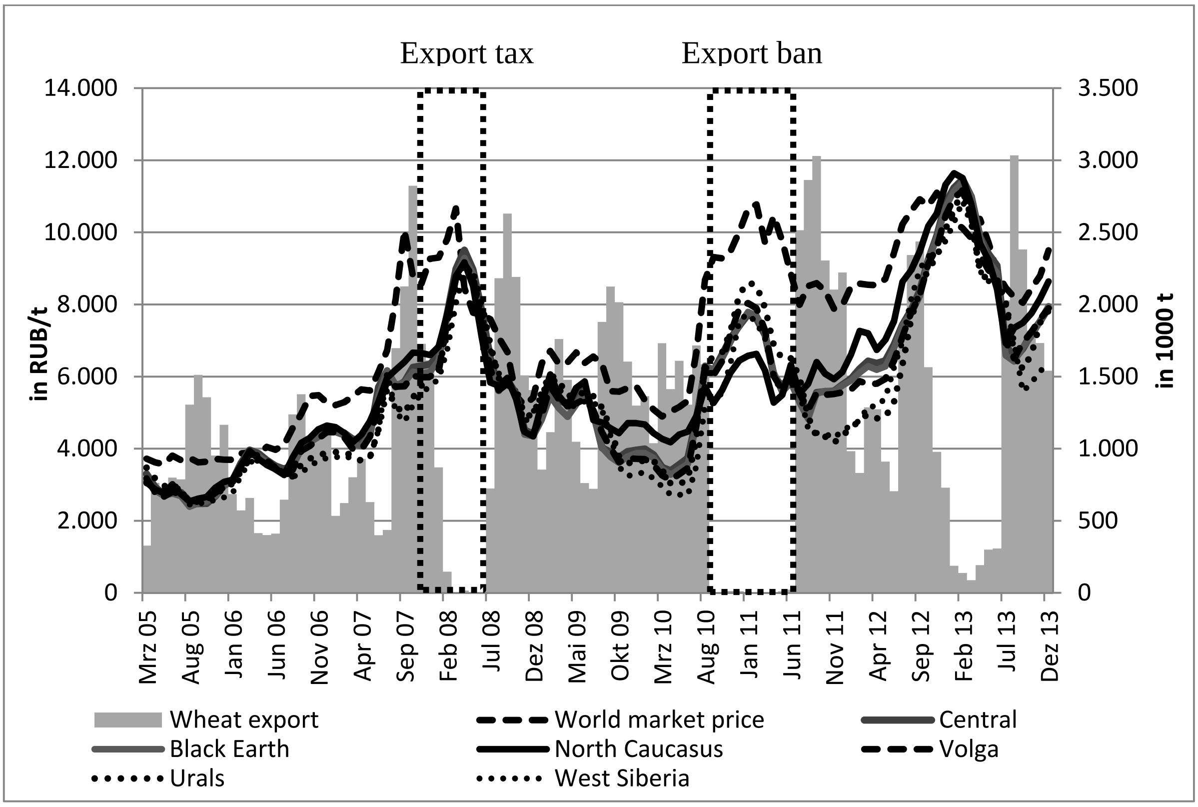


Sources: AGENCY OF STATISTICS OF THE REPUBLIC OF KAZAKHSTAN (2014), APK-INFORM (2014), ROSSTAT (2014), UKRSTAT (2014).

Notice: "Total" refers to secondary axis.

This explains why reversed trade flows were observed during the 2010/11 export ban. By way of an example, 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 a measure of grain trade within Russia during the export ban[3]. It becomes evident that North Caucasus and West Siberia were the only regions exporting grain during the export ban. In 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).

[3] It should be pointed out that in addition to rail transportation, grain is transported by truck particularly when the distances involved are rather low. Therefore, it can be assumed that the interregional grain export quantities were actually even higher, especially between neighbouring regions with lower distance separating them.

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).

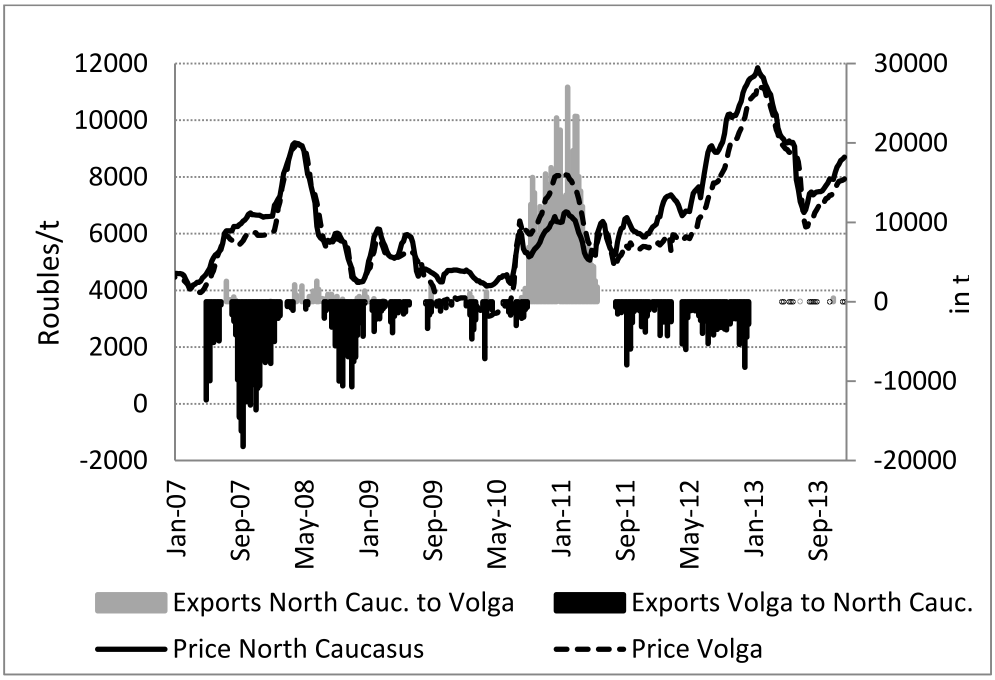
Table 3: Interregional grain trade quantities (in t) by train, Russia, August 2010-June 2011

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

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

Although grain production is distributed throughout the whole of Ukraine, the distance of the differrent production regions is rather small. Thus, as distinct to Russia, production regions are basically affected by similar climatic and weather conditions. This implies that in general a production shortage or an oversupply is observed in all production regions simultaneously. Also, the difference in the distance of the grain production regions of Ukraine to the Black Sea ports is rather low compared to Russia. In particular, the grain producing regions are about within 700 km distance to the Black Sea ports or about a day of traveling time. This explains the rather small difference in regional wheat prices. Figure 5 provides regional milling wheat prices for 11 regions of Ukraine (January 2008-May 2014). However, the development of wheat prices in Khmelnytskyi region represents an exception. In the case of the 2010/11 export quota, the 2011 export tax and after the harvest in 2012 prices in the Khmelnytskyi region were at a significantly higher level than in the other regions[4].

An export quota system was implemented in the Ukraine during both world market price peaks within a governmental licensing system. Export quotas varying between 3,000 tons and 1.2 million tons were in force from October 2006 to April 2007 and again from June 2007 until May 2008, as well as 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 specifies the amount of maximum grain exports for which trade remains open. If actual exports exceed this amount, trade will become 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 and was even 5 % higher in 2011/12. Nonetheless, exports were restricted in the 2010/11 and 2011/12 marketing year.

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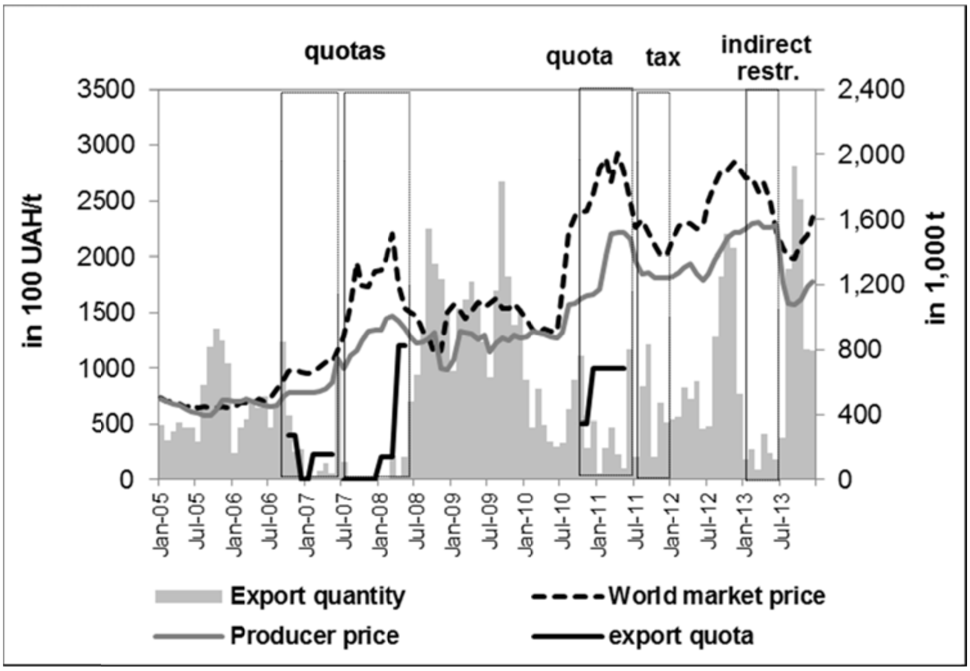
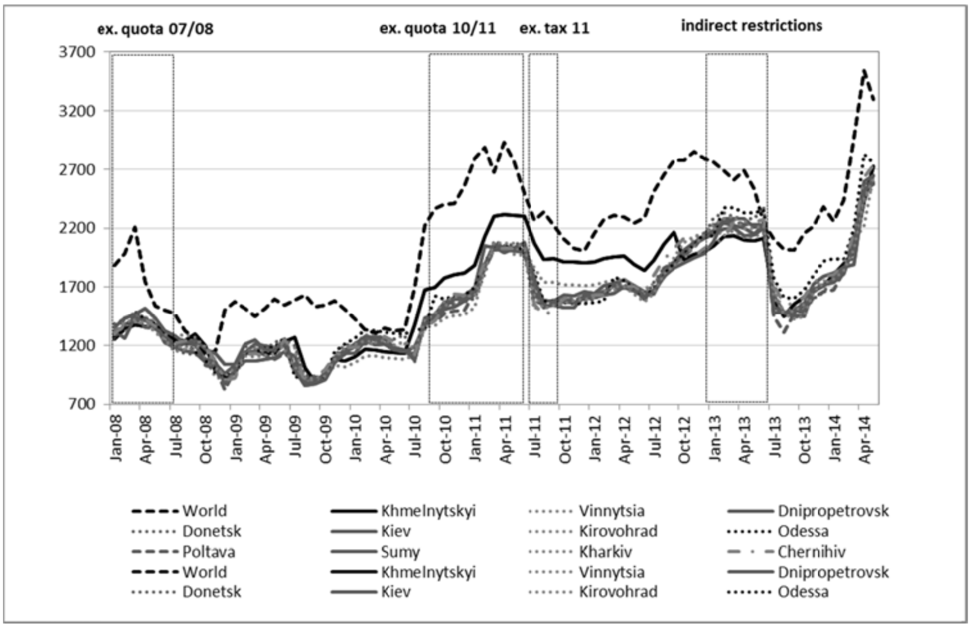
[4] The higher bread wheat prices for Khmelnytskyi region in 2010 through 2012 were driven by 2 key factors: 1) Khmelnytskyi region is a key supplier of high quality bread wheat for the western regions of Ukraine. In 2010 the wheat production shortfall in Khmelnytskyi region was even more pronounced 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 bakery purposes. Therefore, demand for the bread wheat of Khmelnytskyi region increased. These two factors induced further price increasing effects of the regional price of bread wheat in the Khmelnytskyi region.

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



Source: APK-INFORM (2014b).

Notice: Prices are averages of milling and bread wheat prices.

4 REGIONAL PRICE EFFECTS OF EXPORT CONTROLS AND HARVEST SHORTFALLS

In general, export restrictions aim to temporarily decrease the price level prevailing on the domestic market relative to the world market price. This price dampening effect is the result of two partial effects, the domestic supply effect and the 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. 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 the dampening effect on the domestic price becomes.

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. 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 of the domestic price relative to the world market price (compare GÖTZ et al., 2016).

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.

However, export restrictions are often implemented in the situation of a production shortfall which might be regionally limited. A harvest shortage decreases domestic supply regionally, inducing price increasing effects, which may raise domestic regional prices beyond world market prices. By catalysing trade flows from regions with supply surplus to regions experiencing a harvest shortfall, export controls exacerbate the price increasing effects of harvest shortfalls in the respective regions.

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:

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

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 value unity during times of export restrictions.

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, corresponding to the domestic supply effect, and by a smaller value of the slope parameter, reflecting the price insulating effect, compared to the free trade regime.

In this paper we take the fact into account 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, we limit our database to those prices only, which were observed when a production shortfall prevailed. Accordingly, in addition to prices observed when the export ban 2010/11 was implemented in the situation of a strong harvest shortfall, we select prices observed not only when trade was freely possible, but also when a harvest shortfall prevailed, 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".

A significant drop in production in one region decreases regional supply and increases the regional domestic price which might even lead to an overshooting of the domestic price to the world market price. 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, 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. Based on the parameter values estimated in (1), the domestic price dampening effect is calculated as follows:

$$\text{Price dampening effect} = \sum_{tf=1}^{n} \frac{p_{tf}^{wm} - e^{(\alpha+\beta * \ln(p_t^{wm}))}}{e^{(\alpha+\beta * \ln(p_t^{wm}))}} - \sum_{tr=1}^{m} \frac{p_{tr}^{wm} - e^{((\alpha+\gamma_\alpha)+(\beta+\gamma_\beta) * \ln(p_{tr}^{wm}))}}{e^{((\alpha+\gamma_\alpha)+(\beta+\gamma_\beta) * \ln(p_{tr}^{wm}))}} \quad (2)$$

which provides the % change in the domestic price proportionately to the world market price with tf = 1,…n and tr = 1,…m comprising all observations belonging to the "free trade" regime (f) and the "restricted trade" regime (r), respectively. 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 when compared to the "free trade" regime. This indicator informs us of the percentage by which the domestic price was decreased by the export controls relatively to the world market price.

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 is results from export controls.

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 to dampen the 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 milling wheat of class III (RUSSIAN GRAIN UNION, 2014) of the regions North Caucasus, Black Earth, Central, Volga, West Siberia and Urals (Figure 2). The price dampening effect is estimated for each region individually based on the parameters of the regimes "free trade under production shortage" and "restricted trade under production shortage". We use 26 region-specific price observations (January-June 2013) observed in times of domestic production shortage, but when trade remained open, as the basis for estimating parameters of the regime "free trade under production shortage"[5]. The parameters of the "restricted trade under production shortage" regime are estimated based on 47 region-specific price observations during the export ban 2010/11 against the backdrop of a production shortfall (August 2010-June 2011). In addition, we estimate the parameters of the "free trade" regime based on 360 observations when production levels were about average.

We follow a regional perspective to capture the domestic price effects of export restrictions in the Ukraine as well. As our data base for Ukraine we use monthly wheat ex warehouse price series (January 2008-May 2014) of milling wheat of class III (APK-Inform, 2014b) for 11 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 wheat of class III 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. This justifies the fact that we do not account for the influence of the wheat harvest shortage in the estimates for the Ukraine[8]. Therefore,

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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 even up to between 50% to 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).

8 In addition, our data set does not cover a period of production shortage when trade remained open. Please note that no formal export controls were implemented in Ukraine 2012/13; however, the MoU was in

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. 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.

To identify the effects of the different export control regimes for Ukraine individually, we additionally calculate our indicators based on national averages for weekly wheat ex warehouse prices of class III milling wheat 2005-2012 (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 (Appendix, Table S1) and all price pairs cointegrated with the world market price according to the results of Johansen trace test (Appendix, Table S2).

7 ESTIMATION APPROACH AND RESULTS

Results of the Granger-causality test (TODA and YAMAMOTO, 1995) procedure) allow rejecting the hypothesis that the world market price does not Granger-cause the regional price for all price pairs of Russia and Ukraine at the 5 % significance level (Appendix, Table S3). However, results do not allow rejecting that the regional price does not Granger-cause the world market price for all regions except the Black Earth region of Russia9. This motivates us to assume that the world market price is exogenous for all price pairs and to 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 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 conduct the Wald-test to check if the slope coefficient of each regime is equal to one, and if 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 a 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, we identify an intercept parameter which is lowest 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,

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place and traders reported on 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 highly 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).

amounting to 0.982, and the results of the Wald-test cannot disprove that it is equal to 1. By contrast with this, 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 comparing the parameters of 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 is detected in all 6 regions and a domestic supply effect for 5 out of the 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 is followed by 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 is alongside North Caucasus the only region exporting grains interregionally during the export ban. Since West Siberia usually does not export to the world market, it is not directly affect by the export ban, explaining why a domestic supply effect is not observed in this region.

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.

By way of a comparison, Table 4 also presents the estimates for the regional price insulating and the price dampening effect, if the influence of a harvest failure is not accounted for in the estimation approach. 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. Accordingly, 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. This confirms that to correctly identify the domestic price effects of export controls, it is decisive to account for a harvest failure in the estimation approach.

World wheat market integration of the regions of Ukraine is similarly to Russia rather strong when trade is freely possible, varying slightly between 0.752 in Sumy and 0.891 in Kirovohrad (Table 5). Even, the Wald-test does not allow rejecting 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. 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 the 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 regime "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 estimates for the price insulating effect during the export tax amounting to 9 % in 2011 is slightly puzzling, and appear too high compared to the other cases. At variance with this, 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**	**Dnipro-petrovsk**	**Donetsk**	**Kiev**	**Kirovohrad**	**Odessa**	**Poltava**	**Sumy**	**Kharkiv**	**Khmel-nytskyi**	**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 %

Source: Own calculations.

Notes: [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.

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 %	

Source: Own calculations.

Notes: [1] Compared to free trade regime; *** <1 %, **, 5 %, *10 % significance level.

8 Discussion and conclusions

This paper has investigated the domestic wheat price effects of export controls to assess their effectiveness at the regional level in Russia and Ukraine. By contrast with existing estimation frameworks (see literature review), we explicitly have taken the fact into account in our model framework that a wheat production shortage itself causes domestic wheat price effects as well. Therefore, we have modified the data base of the analysis of the export ban 2010/11 in Russia, when a harvest shortfall of 30 % on average and up to 60 % on 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 discovered 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 %, whereas the price dampening effect varies between 67 % and 35 %. 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 has proven superior to the conventional model approach in existing studies. Comparing results of the two estimation frameworks has made evident that disregarding the influence of a production shortage might imply that domestic price effects of export restrictions are erroneously identified.

Data on interregional grain trade flows by train shows that interregional grain trade within Russia had 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 within grain exports from North Caucasus to those regions. In particular, the 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 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 to the world market, primarily supplies its surplus supply to deficit regions within Russia, regardless of whether if 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 at by far the lowest levels 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 (compare SEREBRENNIKOV et al., 2014).

By contrast with this, 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 when trade remains open. 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 (compare Table 1).

At variance with this, our study finds 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 vary 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, exceeding even 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 harbour. 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 mere 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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APPENDIX

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

Source: Own calculation and illustration.

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.

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

Source: Own calculations.

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

Source: Own calculations.

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