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Impact of agricultural export restrictions on prices in importing countries

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IMPACT OF AGRICULTURAL EXPORT RESTRICTIONS ON PRICES IN IMPORTING COUNTRIES

Annelies Deuss, OECD

During the commodity price spikes in 2007-08 and 2010-11, several countries implemented temporary export restrictions on staple foods in an attempt to protect domestic consumers from rising and volatile prices. The impacts of these policies, however, are not limited to the countries that are instituting them; they can also influence consumer prices in their trading partners. This study analyses whether the impact of export restrictions was different in countries that were traditionally more dependent on imports from the restricting country than in countries that imported a smaller share. Four export bans are considered: the maize ban in Argentina, the rice bans in India and Viet Nam, and the wheat ban in the Russian Federation. Using an error correction model in a panel framework, the study identifies the long-run impacts of export bans by showing whether the introduction of these bans caused a structural break in the long-term relationship between prices in international markets and consumer prices in domestic markets. The analysis demonstrates that the effects of an export ban were more pronounced in the group of countries that traditionally imported a higher share from the restricting countries than in countries with a lower import dependency. The results show that, even though export bans are temporary in nature, they can have long lasting effects.

Keywords Food prices, export bans, price transmission, error correction model

JEL C23, F13, Q11, Q17, Q18

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EXECUTIVE SUMMARY

During the last decade, several large exporters temporarily restricted exports of staple foods in an attempt to shield their domestic consumers from rising and volatile prices. These policies, however, not only affect markets in the restricting countries, but can also influence prices in global markets and in their trading partners.

There are only a few studies that have examined how export restrictions impact the trading partners of the restricting country. But these studies concentrate on international price movements and thus implicitly assume equal impacts on all importers. They do not account for differences that may derive from variations in the dependency on imports from the restricting countries. The current study explicitly analyses whether the impact of export restrictions was different in countries that were traditionally more dependent on imports from the restricting country than in countries that imported a smaller share.

The study examines four specific export bans: the maize ban in Argentina, the rice bans in India and Viet Nam and the wheat ban in the Russian Federation. These bans were selected because they apply to major food crops and because they were implemented by large exporters. The focus is on export bans because they are the most extreme of all policies restricting exports.

For each importing country, its dependency on imports from the restricting country was determined by a Past Import Dependency (PID) indicator. This indicator is calculated as the average share of imports from the restricting country in total domestic supply in the three years before the export ban.

To examine the impact of the export bans, the study tests whether the introduction of a ban created a structural break in the long-term relationship between prices in international markets and consumer prices in the domestic markets. This relationship is measured via the long-run elasticity of price transmission, which indicates how much of a 1% change in the world price is transmitted to domestic prices in the long run. The existence of a structural break is then determined by testing whether long-term price transmission from the international to domestic markets on average decreased, increased or did not change following the introduction of the export ban in question, irrespective of whether that ban is subsequently rescinded.

There are multiple factors that can lead to a reduction in long-term price transmission, including increases in transaction costs and policy interventions. When a large exporter imposes a ban, the need for importing countries to find new foreign suppliers could affect the determinants of price transmission accordingly. For example, if a country obtains a large share of its imports from the country imposing an export ban, then transactions costs could rise by more than for a country with a diversified supplier base. Similarly, there may be more of an incentive for that country to apply policies that insulate the domestic market. Price transmission analysis cannot identify these underlying causes, but it can reveal the end result in terms of differential rates of price transmission according to whether countries obtain a high or low share of imports from the country imposing an export ban.

The results of the analysis point to significant policy implications. First, the analysis demonstrates that the effects of an export ban were more pronounced in the group of countries with a high PID than in countries with a low PID. In the group of countries with a high PID, long-run price transmission dropped following the introduction of all four bans. In the group of countries with a low PID, long-run price transmission decreased following the introduction of two of the four export ban cases. In particular, price transmission declined following the maize export ban in Argentina and the rice export ban in India, while it did not change after the rice export ban in Viet Nam or the wheat export ban in the Russian Federation.

The study establishes that when analysing the impact of export restrictions, it is important to account for countries' dependency on imports from the restricting country. These results are a stepping stone for policy discussions and further research that should focus on national and international strategies for addressing vulnerabilities associated with high import dependency. Future research could concentrate on specific case studies and investigate the drivers behind the changes in price transmission in the importing countries.

The study also shows that, even though export bans are temporary in nature, they can have long lasting effects. This analysis suggests that policymakers contemplating the imposition of export bans should recognise that they could induce a long-term reduction in demand from their traditional trading partners.

Introduction

During the food price crisis of 2007-08, several countries implemented temporary export restrictions on staple foods in an attempt to protect domestic consumers from rising and volatile prices. These policies, however, do not always achieve their objective of reducing price volatility in the country imposing the restriction (e.g. Baylis et al., 2014; Djuric et al., 2015; Götz et al., 2014; Porteus, 2012). Moreover, they can affect prices in the global markets and in their trading partners.

Most research so far has concentrated on analysing the impact of export restrictions on prices in the implementing countries and on global markets. There is little research that examines the effects of export restrictions on its trading partners. Any existing research that examines the impact on trading partners does so through an analysis of international prices and hence assumes an equal impact on all importing countries. However, countries vary in the extent to which they source their imports from different countries and countries that depend more on imports from the restricting countries could be affected differently than countries with a lower dependency.

The main objective of this study is to examine whether the impact of export restrictions was different in countries that traditionally imported a higher share from the restricting countries than in countries with a lower import dependency. In particular, the study tests whether the introduction of export restrictions created a structural break in the relationship between prices in international markets and consumer prices in the domestic markets.

A crucial part for the set-up of the study is the identification of the period before exports were restricted and the period after. We use the start date of the implementation of an export ban to distinguish between those two periods, and refer to them as the pre-implementation and post-implementation periods in the remainder of the paper. Export bans were selected because they are the most restrictive among all export restrictive policies. Rather than comparing the period before the export ban was implemented with the period during which the export ban was implemented, the study uses the start date of the export ban to identify the pre-implementation and post-implementation periods. This is because the exact period of the ban is not always clear-cut and because it takes time for exports to resume once the ban is lifted. Also, after the ban was lifted, several countries introduced other export restrictive policies, while others alternated between export bans and other export restrictions. This means that the introduction of an export ban can be considered as the beginning of a period where exports were restricted.

The study focuses on export bans implemented in the last decade by large exporters of three major food crops: maize, wheat and rice. It covers four export ban cases: the maize export ban of Argentina which started in 2006, the rice bans of India and Viet Nam, which were both introduced in 2007, and the wheat export ban of the Russian Federation, initiated in 2010.

The analysis is carried out in two steps. First, we compare price transmission between two periods: the period before export bans were implemented and the period after. In the second step, we analyse whether the effect was different in countries that traditionally imported a higher share from the restricting countries compared to those with lower import dependency.

The first part of the analysis assesses the impact of export bans on long-run price transmission regardless of import dependency. It tests for each of the four export ban cases whether the introduction of a ban created a structural break in the relationship between the international price and the consumer price in the importing countries. The purpose of this first step is to establish how price transmission changes following an export ban when we compare a weighted composition of prices in all importers with the world price. The results serve as a point of reference for the main analysis, where a distinction is made between countries with a high and low import dependency.

The second part of the study addresses the issue of import dependency. In particular, it examines whether export bans had different effects in countries which were historically more dependent on imports from the restricting countries than in countries with a lower import dependency. Also in this step, the impact of an export ban is examined by testing for a structural break in the long-run price transmission from the international to the domestic market. For each of the four export ban cases, the "Past Import Dependency (PID)" is calculated for all trading partners. This PID quantifies the dependency on imports from the restricting country in the period before the ban and is calculated as the average share of imports from the restricting country in total domestic supply in the three years before the export ban. The PID hence indicates the degree to which countries were dependent on imports from the restricting countries.

The influence of export bans is examined in a panel setting in order to exploit the variation across countries that are affected by the ban and those that are not. We use a panel vector Error Correction Model (ECM) to analyse the long-run dynamic relationship between domestic and international prices. We selected this model, which is commonly used to examine price transmission, because it has several advantages: i) it separates the long-run dynamic effects from the short-term effects, ii) it identifies whether there is a long-run relationship between the domestic price and the international price, and iii) if this relationship exists, the ECM framework allows estimating how quickly the domestic price adjusts to this long-run equilibrium relationship after a shock in the international price. We estimate the ECM with the pooled mean group (PMG) estimator, which accounts for heterogeneity in response due to the different PID among the importing countries.

The paper is organised as follows. The first section reviews the literature on the impact of export restrictions and the second section covers recent relevant work on price transmission analysis. The next section briefly explains the model. The fourth and fifth sections describe the data and the empirical strategy. The subsequent section presents the results of the estimations. The final sections discuss the results and conclude. The annex complements the paper with more information on the model and the results of the diagnostic and robustness tests.

Impact of export restrictions

There are several reasons why countries decide to restrict exports of agricultural commodities. During the commodity price spikes in 2007-08 and in 2010-11, the dominant rationale was to reduce domestic price volatility or avoid increases in domestic prices (Bouet and Laborde, 2010; Jones and Kwiecinski, 2010; Mitra and Josling, 2009; Nogués, 2008).

Numerous studies have examined whether countries imposing export restrictions during the past decade were successful at achieving these objectives. Depending on the scope, the set-up of the study, the country and the commodity, the results vary. Some studies find that certain countries using export restrictions were effective at reducing domestic price volatility (e.g. Abbott, 2011; Baffes et al., 2015). Other studies establish the opposite; namely that these trade measures increased domestic prices or amplified domestic price volatility (e.g. Baylis et al., 2014; Djuric et al., 2015; Porteus, 2012). Other analyses only find a limited or no effect (e.g. Götz et al., 2014).

Abbott (2011) compares changes in the prices of grains and rice in a large set of countries during 2007 and 2008 and shows that prices rose less in exporting countries which restricted trade than in exporting countries which did not. However, the effects depend on the commodity and on the country restricting exports: greater price stabilisation was achieved in Asian rice exporters than in the Latin American and Eastern European grain exporting countries. This result in Asian rice markets is confirmed by Dawe and Timmer (2012), who show that the People's Republic of China (hereafter "China"), India and Indonesia were successful at isolating their domestic rice markets from the global price volatility during 2007 and 2008. Baffes et al. (2015) examine the impact of the succession of export bans that were implemented in Tanzania between 2004 and 2011. The authors find that export bans exerted downward pressure on domestic maize prices.

On the other hand, there are also studies that show that export restrictions exacerbated domestic price volatility. Baylis et al. (2014) find that the export ban in India on wheat and rice increased domestic price volatility resulting from domestic supply shocks. The export bans hence could have raised domestic costs by reducing domestic market efficiency. Djuric et al. (2015) examine the impact of the export ban on wheat in Serbia on domestic prices. The authors show that the ban did not prevent domestic wheat prices from increasing above world market prices. The authors link this result to the fact that the government started accumulating stocks during the crisis and delayed the removal of the 30% import tariff. An examination of short term export bans on maize in East and Southern Africa suggests that these measures might have increased domestic prices and volatility (Porteus, 2012).

Besides studies demonstrating how export restrictions affected prices and price volatility in the implementing country, there is also research that shows that these export barriers were limited in their effectiveness. Götz et al. (2014) show that the export restrictions on wheat in Ukraine, Kazakhstan and the Russian Federation in 2007, 2008, 2010 and 2011 were not able to decouple domestic wheat prices from the world market prices.

Several researchers point out that, in addition to not being very effective at reducing domestic price volatility, export restrictions also exacerbated international price volatility since they created a domino effect. That is, when one country implemented a price insulating policy, it stimulated other countries to follow suit. However, when many countries apply the same measure, then the impact of each country's policy on reducing its domestic price volatility weakens while the combined impact of all the measures intensifies international price volatility (Anderson, 2012; Anderson and Nelgen, 2012; Anderson et al., 2013; Jones and Kwiecinski, 2010; Martin and Anderson, 2011).

Anderson et al. (2013) examine the impact of price insulating behaviour during the period 2006-08 in over 100 countries. In particular, the authors consider both export restrictions and reductions in import protection that were applied to wheat, maize, rice and edible oils and analyse their effect on domestic and international prices. The results indicate that even though it might seem that domestic prices rose less as a result of these insulating policies, the actual impact was much smaller since the collective implementation of these policies drove up international prices. In particular, the authors simulate that the combined effect of all the insulating policies explain 52% of the increase in the international price of rice, 18% of the increase in the world price of both maize and wheat, and 31% of the increase in edible oil prices.

The multiplier effect of insulating trade policies is confirmed by Giordani et al. (2014) for a large group of agricultural commodities. On average, a 1% increase in the share of trade affected by insulating policies (import promotion and export restriction) is associated with an increase between 0.4% and 1.2% of the international food staple prices. Rude and An (2015) focus their analysis on export restrictions that were applied to wheat, maize, rice and soybean in a large set of countries. Their estimations indicate that export restrictions implemented between 2006 and 2011 increased international price volatility for wheat and rice but not for maize and soybean.

The literature review shows that existing research finds varying effectiveness of export restrictions in stabilizing domestic prices or preventing domestic prices from rising. The review also indicates that export restrictions influence international prices. Several studies highlight the importance of an in-depth analysis on the impacts of these policies on importing countries, especially in light of the food security implications they might have in developing countries (Jean et al., 2011). However, no research so far has been done that examines explicitly how export restrictions affect their trading partners. The current study addresses this issue.

Price transmission

The study's objectives are examined through the analysis of long-run price transmission from the international market to the domestic markets in the importing countries. First, we test the impact of export bans by comparing price transmission between the pre- and post-implementation periods. Second, we test whether the impact is different between countries with a high PID and countries with a low PID.

Price transmission analysis gives important insights into the efficiency and integration of agricultural markets. High price transmission between markets is considered to be a sign of effective and competitive markets, while low price transmission is indicative of market failure. Countries where domestic prices establish a high co-movement with international prices are considered to be well-integrated and can hence rely on the international market to offset domestic supply or demand shocks. Higher market integration also means that shocks in international prices are transmitted to domestic markets.

The theoretical basis to examine price transmission is the law of one price (LOP) (Fackler and Goodwin, 2001). According to the LOP, the price of a homogenous commodity should be the same in the domestic market and the world market, once transaction costs are accounted for and assuming that there are no policy interventions. There are several factors that influence price transmission. Baquedano and Liefert (2013) group these into four groups: (1) price and border policies, (2) changes in exchange rate, (3) market structure and conditions and transaction costs; and (4) incomplete substitutability between domestic and foreign goods.

After the food price spikes in 2007-08 and 2011-12, several studies examined the transmission of high international food prices to domestic markets in developing countries. Minot (2011) uses a vector ECM model to examine price transmission of international maize, rice and wheat prices to domestic food markets in nine Sub-Saharan Africa countries. The econometric analysis indicates that only 13 of the 62 selected price series exhibit a long-term relationship with world prices and that African rice markets experience a higher price transmission from global markets than maize markets. Baquedano and Liefert (2013) also use the ECM framework to analyse price transmission, but extend their analysis to a larger group of countries. They show that developing countries' consumer markets for wheat, rice, maize and sorghum are cointegrated with international markets, but that the price transmission from the world to domestic markets is generally low.

The ECM approach is also used in studies that examine price transmission to one specific country. Halimi et al. (2015) examine how an export ban can disrupt the price linkage between two countries. Their results show that wheat and flour prices in Afghanistan were closely linked with prices in Pakistan before 2008, but that this link was broken after Pakistan banned wheat exports in January 2008. From then onwards, Afghan domestic wheat prices had a higher relation with prices in other Central Asian countries. Hatzenbuehler et al. (2016) find that rice prices in Nigerian urban markets are closely linked to world rice prices, while the prices of coarse grain (maize and sorghum) exhibit a low correspondence with international prices.

Baltzer (2013) summarizes the results of fourteen country-specific price transmission studies related to maize, rice and wheat. The author finds that there were large differences in price transmission across countries and commodities during the 2007-08 crisis. Whereas China and India shielded their domestic prices from international price shocks, grain markets in Brazil and South Africa were closely connected to the price fluctuations in the global markets. Isolated grain importing countries such as Ethiopia and Nigeria experienced domestic price shocks that were even larger than those in the global grain market.

Recent research shows that price transmission from international markets to domestic markets is incomplete and that the results vary by country and commodity. The current study does not intend to provide another set of price transmission results. Instead it uses price transmission analysis to examine the impact of export bans on prices in the importing countries. The next section describes in detail the empirical strategy and the tests that are used for this purpose.

Model

We use the ECM framework to assess price transmission from the international market to the domestic markets of the importing countries. The ECM was selected[1] because it adequately deals with the issues of non-stationarity and cointegration that are inherent to price time series. The estimated ECM takes the following general form:

1. Gravity models have been traditionally used to examine the determinants of bilateral trade flows and the impacts of trade policies. Since monthly bilateral trade flow data prior to 2011 are scarce and incomplete, gravity models could not be used for this study.

$$\Delta p_t^d = \alpha + \delta\left(p_{t-1}^d - \gamma p_{t-1}^w\right) + \theta \Delta p_t^w + \varepsilon_t \qquad (1)$$

where

- p_t^d is the logarithm of the domestic price of a specific commodity at time *t*, converted to real USD;
- p_t^w is the logarithm of the world price of that same commodity at time *t*, converted to real USD;
- Δ is the difference operator, hence $\Delta p_t^d = p_t^d - p_{t-1}^d$;
- α, δ, γ and θ are the estimated parameters; and
- ε_t is the error term.

In this study we are particularly interested in the following two parameters that examine the long-run effects:

- γ: the long-run (LR) elasticity of price transmission. If for example γ = 0.6, then in the long-run, a 100% increase in the world price leads to a 60% increase in the domestic price, in addition to any short-term effect.
- δ: the error correction term (ECT) or the speed of adjustment. It indicates the speed at which domestic prices return to their long-run equilibrium with international prices after a shock in the latter. δ is expected to be between -1 and 0 as it corrects (eliminates) divergences from the long-run equilibrium. The higher the absolute value of δ, the faster domestic prices return to the long-term equilibrium. Thus, if for example δ = -0.25, then 25% of the divergence from the long-run equilibrium is corrected each month.

Annex 1 provides more information about the ECM framework and the coefficients. Annex 2 presents the results of the diagnostic tests which confirm that the conditions to use the ECM are satisfied.

There are different ways to estimate the ECM in a panel framework. We use the pooled mean group (PMG) estimators developed by Pesaran and Smith (1995), which are computed by maximum likelihood. The PMG estimator was selected because it allows for short-run responses to vary across countries and distinguishes between the long-run (LR) and short-run (SR) relationships[2].

We prefer the PMG estimators over static panel methods (such as pooled OLS, fixed effects and random effects) and dynamic panel methods such as the generalized method of moments (GMM) estimators. Static panel methods ignore the dynamic relationship between the variables completely, while GMM methods only capture the short-run relationships. However, when examining price transmission, it is important to use a model that is able to differentiate between the SR and LR dynamics. Another issue with the static panel methods and GMM is that they impose homogeneity on the slope coefficients. However, Pesaran and Smith (1995) show that if the coefficients vary by country and the regressors are autocorrelated, then the assumption of homogeneous slope coefficients leads to biased and inconsistent estimators.

2. In addition to the PMG estimator, we also considered the Mean Group (MG) estimator which is also developed by Pesaran and Smith (1995). The PMG was chosen over the MG since the results of the Hausman test (see Annex 2 Diagnostic tests) indicated that the PMG estimator was most adapted to our data.

Data

We analyse the impact of export bans by comparing long-run price transmission in the period before and after the implementation of an export ban. We consider four different cases which correspond to the four export bans identified in the introduction section. These are the maize export ban in Argentina, the rice export bans in India and Viet Nam and the wheat export ban in the Russian Federation[3].

Since export bans were implemented at different points in time depending on the country and commodity, the data requirements varied according to the timing of these temporary export bans. Table 1 lists the start dates of the export bans in the countries that are considered in the study. The start dates of the ban are used to define the pre- and post-implementation periods.

Table 1. Start dates of temporary export bans of maize, rice and wheat considered in the analysis

Commodity	Country	Start date of export ban
Maize	Argentina	November 2006
Rice	India	October 2007
	Viet Nam	July 2007
Wheat	Russian Federation	August 2010

Source: AMIS Policy Database (2016).

Most bans started around 2007 which means that it was important to ensure that sufficient monthly price data were available for the pre-implementation period estimations. The period of estimation varies by country and commodity combination, but for all bans starting in 2006 or 2007 we verified that data series existed from 2005 onwards. When available, we used data starting as early as January 2000.

The international prices used in the analysis are the US No. 2 Yellow Maize, the Thai 100% B for rice and the US No. 2 Hard Red Winter wheat. GIEWS (2016) provides these data in USD per tonne from January 2000 onwards at monthly frequency. Figure 1, Figure 2 and Figure 3 illustrate the evolution of the international price as well as the start dates of the bans.

Monthly domestic price data were collected from GIEWS, the World Food Program (WFP), the European Commission and Ministries of Agriculture. Preference was given to consumer (retail) prices in capital cities. If no data for the capital city were available, national averages were used and, in absence of those, price data in the most populous city. The same source was used for each price series, i.e. we did not combine price information in order to extend series or fill gaps. We only considered price series that did not have more than 2 consecutive missing values and imputed missing data points using linear interpolation.

Domestic price data were converted from local currencies into USD per tonne using the monthly exchange rates from the International Monetary Fund (IMF, 2016) and then expressed in real values (2010 levels) using the countries' monthly domestic consumer price index (CPI) obtained from IMF. International prices were converted to real values using the monthly US CPI from IMF. The empirical analysis uses the natural logarithm of all prices.

Past Import Dependency (PID) in this study is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction. The period to calculate the PID hence differs by country and commodity. For example, since the rice export ban in Viet Nam started in July 2007, average PID is calculated for the years 2004 through 2006. Annual bilateral

3. We also considered the maize export ban in the Russian Federation and the wheat export ban in Argentina, but could not include these two cases in the analysis because of data availability issues.

trade flow data in volume terms were obtained from COMTRADE (2016), while annual domestic supply[4] data were downloaded from FAOSTAT (2016).

Table 2 lists the PID values, organized by restricting country and commodity, for those importing countries for which domestic price series are available. The three year averages in this table were also compared with two year averages (not shown). The list of countries with a PID of 5% and above and the list of countries with a PID below 5% is the same between the two year and three year averages. Some reshuffling of relative positions was observed around the 10% mark between the two and three year averages. This issue is addressed in the robustness checks.

Table 2 also indicates the average share of each of these exporters in global exports during the three years before their respective export bans. During the period 2003-05, Argentina accounted for 14.1% of global maize exports. India's and Viet Nam's average share in global rice exports during 2004-06 was 15.3% and 15.7%, respectively. The Russian Federation covered 10.7% of global wheat exports during 2007-09. The top exporter of wheat and maize during those periods was the United States, while Thailand was the top exporter of rice.

Table 2. Past Import Dependency (PID) by restricting country and commodity

Maize - Argentina 2003-05		Rice - India 2004-06		Rice - Viet Nam 2004-06		Wheat – Russian Federation 2007-09	
Share world exports: 14.1%		Share world exports: 15.3%		Share world exports: 15.7%		Share world exports: 10.7%	
Country	(%)	Country	(%)	Country	(%)	Country	(%)
Peru	38.6	South Africa	32.8	Cameroon	18.9	Armenia	58.5
Portugal	25.2	Niger	15.7	Senegal	18.5	Georgia	38.5
Cabo Verde	16.6	Senegal	10.4	Cote d'Ivoire	18.2	Azerbaijan	19.3
Spain	12.7	Cameroon	10.0	Niger	11.0	Bangladesh	16.7
Belgium	4.1	Italy	9.8	Philippines	10.9	Egypt	11.1
Mozambique	1.3	Togo	7.9	Russian Federation	10.9	Mongolia	8.5
Cote d'Ivoire	1.2	Mali	7.8	Mozambique	8.9	Greece	8.1
Dominican Republic	<1	Cote d'Ivoire	5.0	Mali	4.3	Peru	6.3
Panama	<1	Tunisia	4.7	Togo	1.6	Italy	3.1
Mali	<1	Benin	3.6	Benin	1.6	Indonesia	2.6
Greece	<1	Russian Federation	3.4	Brazil	<1	Israel	2.1
Cameroon	<1	Sri Lanka	2.9	Italy	<1	Pakistan	1.8
Italy	<1	Mozambique	2.7	South Africa	<1	India	1.4
Poland	<1	Mauritania	<1	Peru	<1	Lithuania	1.2
Benin	<1	Philippines	<1			Bulgaria	<1
Czech Republic	<1	Peru	<1			Moldova, Rep. of	<1
Slovenia	<1	Colombia	<1			Kyrgyzstan	<1
Togo	<1	Brazil	<1			Spain	<1
Germany	<1					Kazakhstan	<1

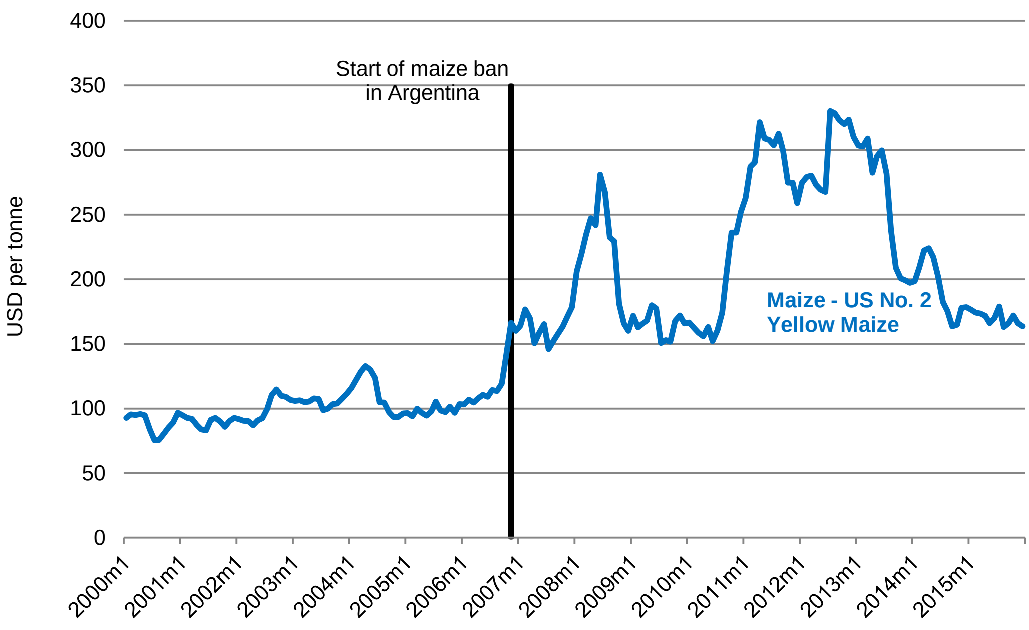
4. Domestic supply quantity = Production + imports - exports + changes in stocks (FAOSTAT, 2016).

Table 2. Past Import Dependency (PID) by restricting country and commodity (*cont.*)

Maize - Argentina		**Rice - India**		**Rice - Viet Nam**		**Wheat – Russian Federation**	
2003-05		**2004-06**		**2004-06**		**2007-09**	
Share world exports: 14.1%		Share world exports: 15.3%		Share world exports: 15.7%		Share world exports: 10.7%	
Country	(%)	Country	(%)	Country	(%)	Country	(%)
Philippines	<1					Ethiopia	<1
Austria	<1					Romania	<1
Kenya	<1					Belgium	<1
Slovakia	<1					Finland	<1
						Poland	<1
						United Kingdom	<1
						Germany	<1
						Czech Republic	<1
						Costa Rica	<1

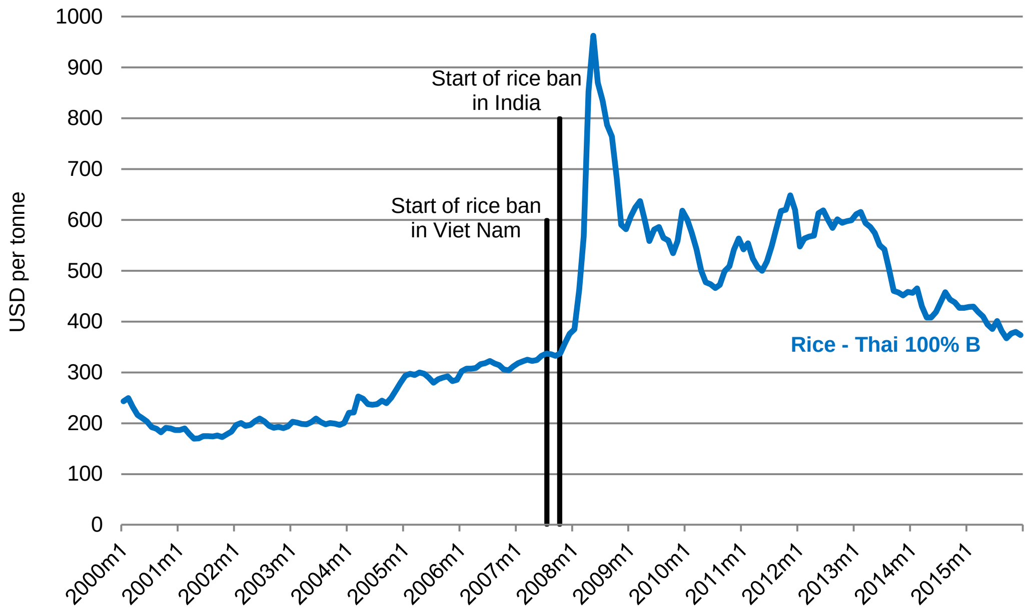
Notes: Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction. The table only lists countries for which domestic price data are available and for which the PID could be calculated.
Sources: COMTRADE (2016) for bilateral trade flows and FAOSTAT (2016) for domestic supply.

Figure 1. Evolution of international prices of maize and start of the export ban



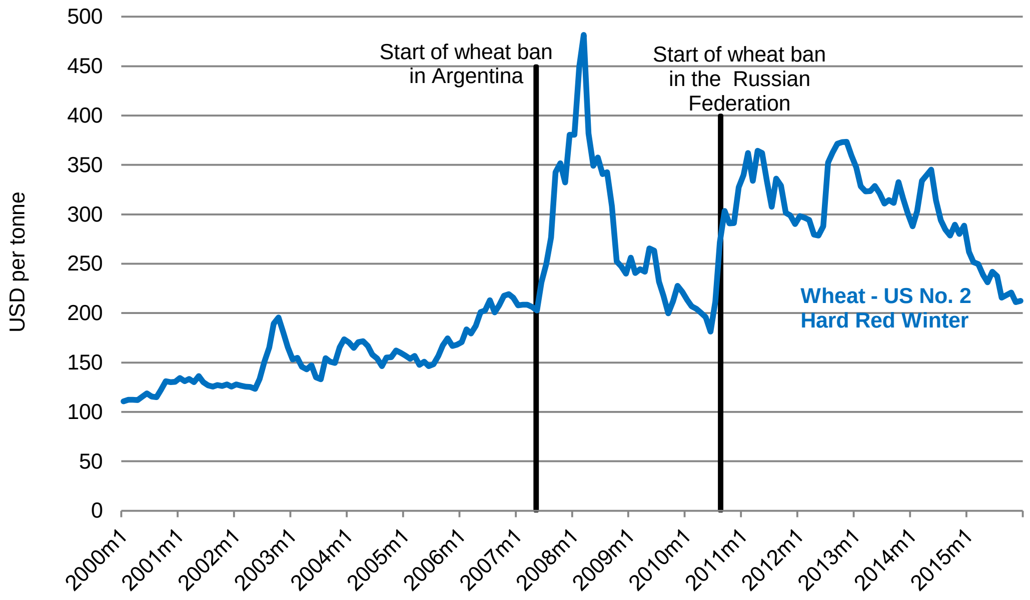
Source: GIEWS (2016) for prices, AMIS (2016) for timing of export bans.

Figure 2. Evolution of international prices of rice and start of the export bans



Source: GIEWS (2016) for prices, AMIS (2016) for timing of export bans.

Figure 3. Evolution of international prices of wheat and start of the export ban



Source: GIEWS (2016) for prices, AMIS (2016) for timing of export bans.

Empirical strategy

As mentioned in the introduction, the existing research on the impact of export restrictions on importing countries only examines international price movements. This approach ignores the fact that importing countries differ in their dependency on imports from the restricting countries. The current study explicitly analyses whether the impact of export restrictions was different in countries that traditionally imported a higher share from the restricting countries than in countries with a lower import dependency.

The study is organized around two questions:

- Did the introduction of an export ban lead to a structural break in the relationship between consumer prices and international prices?
- Was the impact of an export ban different in countries that traditionally imported a higher share from the restricting countries than in countries with a lower import dependency?

The first question does not account for import dependency and serves mainly as a point of reference for the main analysis, which is addressed in the second question.

The study focuses on export bans of wheat, maize and rice that were implemented by large exporters. We selected those three commodities because they are major food staples and we consider export bans because they are generally the most restrictive among all export restrictive policies.

Regarding the length of the post-implementation period, we consider the five-year period after the ban was introduced and not just the period during which the export ban was implemented. There are several reasons for doing this. First, the start and end dates of the ban might be well-defined on paper but they are not that clear-cut in practice. Second, in certain countries the export ban was not continuous. In India for example, the rice export ban was replaced by a minimum export price for a period of time and then reinstated. Third, in the period after the ban was lifted, several countries still continued to restrict their exports using other measures such as export taxes, minimum export prices, export quotas and licensing. The post-implementation period was set at five years (60 months) because this guarantees that we have a sufficient amount of data points to conduct the analysis. In the robustness tests, we check whether the results change if we consider a longer post-implementation period.

To examine the impact of export bans, we test whether the introduction of an export ban created a structural break in the relationship between prices in international markets and consumer prices in the domestic markets. In particular, we assess the degree to which international price signals have been transmitted to domestic commodity markets (the long-term price transmission) in the period before the export ban. Next, we examine price transmission in the period following the introduction of the ban and then we test whether the difference between the two periods is statistically significant.

In this paper, the objective is not to examine price transmission patterns per se, but rather to use price transmission analysis to investigate the impact of export bans. Given that the analysis is based on a panel, it is not meaningful to discuss the specific reasons for a change in price transmission following a ban. A change in price transmission can be a result of one or multiple factors (see section above on "Price transmission") and these vary by country. By first assessing the degree of price transmission in the period before the ban, we establish the average price transmission in the panel. An increase (decrease) in price transmission following an export ban indicates that the group of countries in the panel are on average more (less) integrated with the international market and rely more (less) on the international market than in the period before the export ban was introduced.

Practically, we test for each country-commodity pair whether the LR elasticity of price transmission, the speed of adjustment (ECT) and the median lag length are different between the pre-implementation and the post-implementation period. The country-commodity pairs refer to the large exporters and the commodity that they banned for exports, i.e. maize in Argentina, rice in India, rice in Viet Nam and wheat in the Russian Federation. The interpretation of the three parameters is as follows[5]:

- The **LR elasticity of price transmission** indicates how much of a 100% change in the world price is transmitted to domestic prices in the long run.
- The **ECT or speed of adjustment** measures how quickly domestic prices return to their long-run equilibrium with international prices after a shock in the latter.
- The **median lag length** shows how much time it takes for domestic prices to return to at least half of their LR equilibrium value after a shock in international prices.

The three abovementioned parameters each characterize different aspects of a long-run relationship between the international and domestic prices. Of course, it only makes sense to compare these parameters if it is certain that a long-run relationship actually exists between the international and domestic prices. Therefore, before we examine these three parameters, we first test for the existence of a LR cointegrating relationship by examining the statistical significances of the LR elasticity and the ECT. If both are statistically significant, then there is a LR cointegrating relationship and we can compare the parameters.

For the LR elasticity and ECT, we compare statistical significance levels between the two periods and also test the statistical significance of the difference. For the median lag length, we compare the value before the ban with the one after the ban was introduced. These tests not only indicate whether a structural break has occurred but also quantify the average effect as we can measure the levels of the LR elasticities, ECT, their difference and the median lag length.

To address the first question, we compare the three parameters between the pre-implementation and post-implementation period for the entire group of countries. To examine the second question, we compare the parameters between the two periods for two groups of countries: countries with a high PID and countries with a low PID. The initial cut-off used to identify countries with a high PID is 10%, i.e. countries which relied for at least 10%t of their domestic supply on imports from the restricting countries. The cut-off for countries to be included in the group of low PID is less than 1%. The 10% and 1% cut-off values were selected after inspecting the PID values as reported in Table 2.

Countries with a PID between 1% and 10% are not considered in the initial analysis because we want to be sure that the two groups are very different in their PID levels. As mentioned in the data section, the PID values can change depending on whether the reference period to calculate the PID is the two-year period or three year period before the ban. The sensitivity of the results to these cut-offs is tested in the robustness checks.

Results

The results are presented in two sections. The first section addresses the first question, namely whether long-run price transmission between the international market and domestic markets in importing countries changed after the implementation of an export ban. The second section takes on the second question and examines whether countries that relied more on imports from the restricting countries experienced a different impact from the export ban than the countries with a lower import dependency.

The results are organized by commodity and restricting country. For each of the four country-commodity pairs, we present a table with the PMG estimates. These tables show the LR elasticity of the world price, the ECT and median lag length in the pre-implementation period and the post-implementation period. In addition, the difference in the LR elasticities and ECT between the two periods is also calculated.

5. Refer to Annex 1 for a detailed explanation of these parameters.

The pre-implementation and post-implementation period differs by country-commodity pair (see Table 1 for the exact dates). The length of the pre-implementation period varies according to data availability, with the longest time series going back until January 2000. The length of the post-implementation period is fixed at five years (60 months) after the introduction of the ban. In the robustness checks, we show that the results remain consistent if a longer post-implementation period is used.

The results should be examined by commodity between the pre- and post-implementation period. It does not make sense to compare estimates of LR elasticity between commodities because of two reasons. First, the pre- and post-implementation periods are different for each case. Second, the commodity markets are very different. The international rice market, for example, is much more segmented by nature than the international wheat and maize markets. The set-up of the study requires choosing one specific international reference price; however this price cannot fully capture the different rice varieties and qualities that are traded. This explains why the values of the LR elasticities are on average lower for rice than for wheat and maize. Nevertheless, this is not an issue for the interpretation of the results as the study does not examine the specific value of the LR elasticities but examines the changes in the LR elasticity between the pre- and post-implementation period.

Question 1: Overall impact of an export ban

Table 3 presents the PMG estimates of the ECM for maize, rice and wheat organized by country-commodity pair. The countries included in the analysis are listed in Annex Table 7.

The parameters on the ECT and on the world price are significantly different from zero for all country-commodity pairs, both during the pre-implementation and post-implementation period. This indicates that there is a long-run cointegrating relationship between the international prices and domestic prices before and after the export bans are implemented, for all country-commodity pairs.

To examine how the export ban influenced this LR relationship, we compare the LR elasticity and ECT between the pre-implementation and post-implementation period. The values for the LR elasticity and ECT for the rice export ban in India and Viet Nam are relatively similar. This is not surprising since the export ban in Viet Nam preceded the one in India by only a few months and given that the panel for both is composed of the same group of 25 countries. In both cases, price transmission decreased slightly following the introduction of the ban. The decrease is only statistically significant for the rice export ban in India.

In the case of the maize export ban in Argentina, LR elasticity dropped significantly in the period after the introduction of the ban. Whereas in the pre-ban period international price changes were on average fully transmitted to domestic markets, only 26% of the change was on average transmitted in the post-ban period for the same group of countries. The significantly lower price transmission in the post-implementation period indicates that following the maize export ban, countries started to rely less on the international market for their maize supply. In the case of the wheat export ban, there is no significant change in price transmission following the ban.

The ECT measures how quickly domestic prices return to their LR relationship with international prices after a shock in the latter. A decrease in absolute terms of the ECT implies that it takes longer to recover from a shock in the world price in the period after the export ban compared to the pre-ban period. The ECT decreases in absolute terms for all country-commodity pairs, except in the case of the wheat export ban in the Russian Federation. The difference between the pre- and post-implementation period is not statistically significant for any of the export ban cases. This is also confirmed by the values for the median lag length, which at most change by one month between the two periods. In the case of the maize ban in Argentina, it takes on average one month more for the domestic price of maize to reach half of its equilibrium value after a price shock in the international price in the post-ban period compared to the pre-ban period. The median lag length also increased following the rice export ban in Viet Nam and decreased following the wheat export ban.

Table 3. Long run world to domestic price transmission elasticities before and after introduction of export bans for maize, rice and wheat

	Pre	Post	Difference
Maize - Argentina			
LR - World price	1.222***	0.258***	-0.964***
	(0.074)	(0.060)	(0.096)
ECT	-0.191***	-0.153***	0.037
	(0.023)	(0.023)	(0.034)
Median lag length	3	4	
N	1188	1920	
Countries	32	32	
Rice – India			
LR - World price	0.373***	0.242***	-0.131*
	(0.044)	(0.029)	(0.055)
ECT	-0.196***	-0.195***	0.001
	(0.049)	(0.023)	(0.057)
Median lag length	3	3	
N	1756	1497	
Countries	25	25	
Rice – Viet Nam			
LR - World price	0.340***	0.307***	-0.032
	(0.045)	(0.029)	(0.055)
ECT	-0.209***	-0.184***	0.025
	(0.052)	(0.023)	(0.059)
Median lag length	2	3	
N	1681	1500	
Countries	25	25	
Wheat – Russian Federation			
LR - World price	1.041***	1.139***	0.098
	(0.034)	(0.052)	(0.060)
ECT	-0.136***	-0.174***	-0.038
	(0.011)	(0.018)	(0.021)
Median lag length	4	3	
N	3131	2754	
Countries	48	48	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01. Pre- and post-implementation periods vary by country-commodity pair (Table 1). ECT stands for Error Correction Term.

The values of the LR elasticities are around 100% for maize in the pre-implementation period and for wheat in both periods and for both restricting countries. These values are higher than the long-run price transmission elasticities that are reported in other studies (Minot, 2011; Baquedano and Liefert, 2013). This is due to the fact that our study considers both developed and developing countries, while those other studies only include developing countries. Developed countries are on average more integrated with international markets than developing countries.

The above analysis confirms that there is a long-run cointegrating relationship between international prices and prices in domestic markets for maize, rice and wheat. However, the direction and nature of the change in price transmission after the introduction of an export ban is not clear. In the case of the maize export ban in Argentina and the rice export ban in India, price transmission decreased significantly following the introduction of the ban. In the other cases, no significant change is observed. These results reinforce the main objective of this study, namely that an analysis of the impact of export restrictions should account for the level of import dependency. The importance of import dependency is explicitly examined in the second part of the analysis.

Question 2: Impact of an export ban according to import dependency

The set of countries included in this part of the analysis is considerably smaller than in the previous section. This is because in addition to price data in the pre- and post-implementation period, we also need bilateral trade and domestic supply information to calculate the PID. Table 2 lists the countries for which data on prices, trade and domestic supply are available. The remaining sample sizes for maize-Argentina, rice-India, rice-Viet Nam and wheat-Russian Federation are 23, 18, 14, and 28 countries, respectively.

These countries are ranked according to their PID in Table 2. In the main analysis, we defined the high PID countries as countries with a PID of 10% or above while the low PID group contained countries with a PID below 1%. In the robustness checks, we examine how sensitive the results are to these cut-offs.

The focus of this section is to examine how the impact of an export ban was experienced in countries with a high PID and to compare it with the impact in countries with a low PID. The analysis in this section hence compares how our parameters of interest (LR elasticity, ECT and median lag length) vary in the pre-implementation and post-implementation period within and between the two PID groups.

Maize-Argentina

The maize export ban in Argentina had different impacts depending on the import dependency. The LR elasticity values of the world price in Table 4 illustrate that price transmission decreased significantly in the period following the ban for both the high and the low PID group. In the high PID group, however, there was no longer any significant price transmission in the post-implementation period, while in the low PID group, 21% of a change in international prices was transmitted on average to domestic prices in the long run in the period after the ban.

Domestic consumer prices in both groups responded much slower to a shock in global prices in the post-implementation period compared to the pre-implementation period. This decline in the speed of adjustment (ECT) was more pronounced in the high PID group. For the countries in this group, 26% of a shock in the international price was already transmitted in the first month during the pre-implementation period, but this dropped to 6.5% in the post-implementation period. This is also reflected in the median lag length, which increased from 2 to 10 months. In the low PID group, the speed of adjustment dropped on average from 23% to 11%.

Table 4. Long run world to domestic price transmission elasticities before and after the introduction of export bans for maize in Argentina, by PID group

	High PID (10% or above)			**Low PID (below 1%)**		
	Pre	Post	Difference	Pre	Post	Difference
LR - World price	0.735***	0.020	-0.715**	1.428***	0.214*	-1.214***
	(0.085)	(0.177)	(0.230)	(0.089)	(0.118)	(0.168)
ECT	-0.259***	-0.065***	0.194**	-0.226***	-0.112***	0.114***
	(0.084)	(0.004)	(0.068)	(0.034)	(0.014)	(0.032)
Median lag length	2	10		2	5	
N	156	240		573	960	
Countries	4	4		16	16	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; Post-implementation period is the five year period starting from November 2006; Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Rice-India

India's rice export ban had similar effects in the low and high PID groups. Before the ban, the two groups experienced similar price transmission levels of around 70%, which means that 70% of a change in international prices was transmitted to domestic markets in the long run. In the post-implementation period, price transmission dropped significantly for both groups to values around 20%. The ECT did not change significantly for neither group between the pre- and post-implementation period.

Table 5. Long run world to domestic price transmission elasticities before and after the introduction of export bans for rice in India, by PID group

	High PID (10% or above)			**Low PID (below 1%)**		
	Pre	Post	Difference	Pre	Post	Difference
LR - World price	0.672***	0.236***	-0.436***	0.702***	0.188*	-0.513**
	(0.084)	(0.088)	(0.123)	(0.148)	(0.102)	(0.195)
ECT	-0.173**	-0.184***	-0.011	-0.082**	-0.120***	-0.038
	(0.076)	(0.011)	(0.086)	(0.037)	(0.034)	(0.052)
Median lag length	3	3		8	5	
N	308	240		415	300	
Countries	4	4		5	5	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; Post-implementation period is the five year period starting from October 2007; Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Rice-Viet Nam

The effect of Viet Nam's rice export ban varied according to the level of import dependency. Following the ban, the LR elasticity decreased significantly between the pre- and post-implementation periods in the high PID. In the low PID group, there was no long-run cointegrating relationship between global prices and domestic prices in the pre-implementation period since the LR elasticity is not significantly different from zero. This changed in the post-implementation period, where there was a price transmission of 53% in the long-run. Prices in the high PID group experienced a cointegrating relationship with global prices in both periods.

Countries in the high PID group needed more time to adjust to a shock in global prices in the post-implementation period compared to the pre-implementation period. For this group, the ECT dropped in absolute terms from 0.31 to 0.19 and the median lag length tripled, from 1 to 3 months. The countries in the low PID group experienced the opposite effect as the median lag length decreased from 15 months in the pre-implementation period to six months in the post-implementation period.

Table 6. Long run world to domestic price transmission elasticities before and after the introduction of export bans for rice in Viet Nam, by PID group

	High PID (10% or above)			Low PID (below 1%)		
	Pre	Post	Difference	Pre	Post	Difference
LR - World price	0.654***	0.160**	-0.494***	0.148	0.528***	0.380
	(0.080)	(0.067)	(0.104)	(0.281)	(0.154)	(0.362)
ECT	-0.317*	-0.185***	0.132	-0.043***	-0.095**	-0.052
	(0.180)	(0.022)	(0.179)	(0.011)	(0.046)	(0.041)
Median lag length	1	3		15	6	
N	352	360		350	240	
Countries	6	6		4	4	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; Post-implementation period is the five year period starting from July 2007; Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Wheat-Russian Federation

After the Russian Federation imposed an export ban on wheat, domestic prices in the high PID group experienced on average a significantly lower price transmission from the international market. The LR elasticity decreased from 92% in the pre-implementation period to 66% in the post-implementation period. There was no change in price transmission in the low PID group between the two periods.

In both groups, domestic prices returned faster to a new equilibrium after a shock in global prices in the post-implementation period. The ECT increased in absolute levels for both groups and the median lag length became shorter.

Table 7. Long run world to domestic price transmission elasticities before and after the introduction of export bans for wheat in the Russian Federation, by PID group

	High PID (10% or above)			Low PID (below 1%)		
	Pre	Post	Difference	Pre	Post	Difference
LR - World price	0.921***	0.664***	-0.258*	1.165***	1.330***	0.166
	(0.063)	(0.080)	(0.101)	(0.075)	(0.080)	(0.110)
ECT	-0.152***	-0.317***	-0.165	-0.127***	-0.179***	-0.051
	(0.021)	(0.095)	(0.092)	(0.020)	(0.028)	(0.034)
Median lag length	4	1		5	3	
N	284	253		859	840	
Countries	5	5		14	14	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; Post-implementation period is the five year period starting from August 2010; Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Discussion of results

Previous studies that examine the impact of export restrictions through price transmission analysis have focused on the price effects in the restricting country. An export ban shields the restricting country from the international market, which could lower price transmission. In this study, the focus is on the importing countries. In a panel setting, price transmission analysis is used to examine whether the introduction of an export ban creates a structural break in the relationship between international and domestic consumer prices.

The study first tests for each of the four export bans whether long-term price transmission changed following the introduction of an export ban. This first part of the analysis does not account for the different levels of import dependency across the countries in the panel and is conducted to illustrate overall changes in price transmission patterns following each ban. In the next step, the study examines whether the impact of export bans is different in the group of countries which are more dependent on imports from the restricting country than in the group of countries with a lower dependency. By examining price transmission and export bans in a panel setting, we control for any country-specific factors that might have influenced price transmission patterns. Furthermore, the second part of the analysis also controls for global factors, such as price spikes, which affected both groups of countries.

The estimation results consistently show that there is a cointegrating relationship between the international prices of maize, rice and wheat and their domestic prices in importing countries. This confirms that international and domestic prices move together in the long-run and that deviations from their long-run equilibrium are only temporary. The existence of cointegration also supports the choice of the ECM, a model that incorporates cointegration in its design and distinguishes short-run effects from long-run effects.

Table 8 summarizes the results of the study. It shows for each of the questions how price transmission changed in the five-year period following the implementation of an export ban compared to the period before the introduction of the ban. A downward arrow indicates that price transmission significantly decreased between the two periods, while a horizontal line indicates that there was no statistical significant change in price transmission between the two periods. The robustness checks in the appendix show that these results remain valid if different cut-off values are used for the high and low PID groups and if a longer post-implementation period is considered.

Table 8. Schematic overview of the change in long run world to domestic price transmission before and after the introduction of the four export bans, for the full sample and by PID group

	Q1: Full sample	Q2: High PID (10% or above)	Q2: Low PID (below 1%)
Maize - Argentina	↓	↓	↓
Rice – India	↓	↓	↓
Rice – Viet Nam	–	↓	–
Wheat – Russian Federation	–	↓	–

Notes: A downward arrow indicates that price transmission significantly decreased between the pre- and post-implementation period. A horizontal line indicates that there was no statistical significant change in price transmission between the two periods.

Regarding the first objective, the estimation results demonstrate a significant decline in price transmission from world to domestic consumer markets following the maize export ban by Argentina and the rice export ban by Viet Nam. For the rice export ban by India and the wheat export ban by the Russian Federation, no significant change in price transmission patterns is observed following the ban. These inconclusive results motivate the second (main) part of the analysis, which specifically examines whether these results change when we compare the group of countries with a high import dependency on the restricting country with the group of countries with a low import dependency.

The second sets of results indicate that the high PID and low PID group experienced different changes in price transmission following an export ban. In particular, the price transmission decreased significantly between the two periods in the high PID group for all four export ban cases. For the countries in the low PID group, price transmission changes mirrored those in the full sample. In particular, price transmission decreased following two of the four export bans (maize export ban in Argentina and the rice export ban in India) while it remained unchanged for the other two export bans (rice export ban in Viet Nam and wheat export ban in the Russian Federation).

The international reference price for maize is the US No. 2 Yellow Maize and in the three years before the maize export ban in Argentina, the United States accounted for more than half of global maize exports, while Argentina was the second largest exporter covering 14% of maize exports. Following Argentina's export ban, countries in the high PID group and countries in the low PID group experienced a significant decrease in price transmission. Moreover, in the high PID group there was no longer any significant price transmission from the international markets to the domestic markets in the post-implementation period. These results indicate that following the ban the group of high PID countries were no longer integrated with the international markets whereas the group with low PID on average had a lower integration with the international market.

In the years before the rice export bans, Thailand was the largest exporter of rice, accounting for 28% of global rice exports in the period 2004-06. Viet Nam and India were respectively the second and third largest exporters, each covering around 15% of global rice exports. Viet Nam implemented a rice export ban in July 2007 and India followed a few months later, in October 2007. Whereas Viet Nam's export ban was officially lifted one year later, India continued rice bans on different varieties with the last ban expiring in September 2011.

In the period following India's rice export ban, price transmission from the international market dropped significantly in the group of countries with a high PID on India's rice. A similar evolution was observed in the group of countries with a high import dependency on Viet Nam's rice. The reduced integration with the international market in both high PID groups might be a result of the fact that India banned rice exports shortly after Viet Nam. As illustrated in Table 2, there is a considerable overlap in countries with a high PID on Viet Nam and India. Countries which depended highly on imports from both Viet Nam and India were first impacted by the ban in Viet Nam, which might have resulted in them relying more on imports from India. However, once India also banned rice exports, these countries might then have decided to that they no longer could rely on international markets.

After the rice export ban in India, price transmission also decreased in the low PID group, signalling that this group of countries relied less on the international market. The group of countries with a low PID on Viet Nam did not exhibit a change in price transmission following the rice export ban in Viet Nam.

The United States is traditionally the world's largest wheat exporter. In the period before the ban of the Russian Federation, i.e. 2007-09, the United States accounted for 21% of global wheat exports and the Russian Federation was the fourth largest wheat exporter, covering 11% of global wheat exports.

In the period after the Russian Federation implemented a wheat export ban, the high PID group became less integrated with the international market. This could be due to the timing of the wheat export bans: Argentina banned wheat exports in 2007 while the Russian Federation banned them in 2010. The countries that were highly dependent on wheat imports from the Russian Federation had already witnessed a previous export ban of wheat and its impact. As a result of this, they might have become less relying on the international market once they became more directly affected by the export ban by the Russian Federation a few years later. Countries which were less dependent on wheat imports from the Russian Federation were not directly impacted by the ban and this might explain why price transmission did not change for this group in the post-implementation period.

Data availability issues influenced the sample sizes and the results. To investigate the second objective, data on bilateral trade flows and domestic supply were needed in addition to domestic retail price data. This limited the set of countries in the panel analyses. Except for the low PID groups for the maize ban in

Argentina and the wheat ban in the Russian Federation, the panels are composed of less than ten countries. Still, the panel approach was preferred over an individual country approach in order to exploit the variation across countries that are affected by the ban and those that are not.

Conclusion

This study identifies the long run impacts of export bans by showing whether the introduction of these bans caused a structural break in the long-run price transmission from the world to domestic consumer markets. The results show that when analysing the impact of export restrictions, it is important to account for countries' dependency on imports from the restricting country. In particular, the group of countries with a high PID experienced more pronounced changes in long-run price transmission following the introduction of an export ban compared to the low PID group. As expected, the results depend on the commodity and on the restricting country, reflecting the different trading relations and market situations for each case.

In the group of countries with a high PID, long-run price transmission dropped following each of the four examined export ban cases. In the group of countries with a low PID, long-run price transmission decreased between the pre- and post-implementation period for two of the four export ban cases. In particular, price transmission dropped following the maize export ban in Argentina and the rice export ban in India, while it did not change after the rice export ban in Viet Nam and the wheat export ban in the Russian Federation.

The fact that the countries in the high PID group on average experienced lower levels of long-run price transmission following each of the bans illustrates that they rely less on international markets once they have been affected by an export ban. This implies that even though export bans are temporary in nature, they can have long lasting effects.

There are multiple factors that can cause lower price transmission from the international to the domestic markets, including changes in domestic and trade policies or increased transaction costs. Given the panel set-up in this paper, it is infeasible to explain which of the factors contributed to the changes in price transmission. Nevertheless, the results suggest that several countries lost their confidence in international markets and started to prioritize their domestic sectors. This is supported by the recent emergence of self-sufficiency policies and expansion of public stocks.

The results of this study have implications for policy discussions and future research. First, regarding the importing countries, the results show that policy analysis and advice should pay special attention to countries with a high PID as they are more affected by export restrictions. Future research could address some of the limitations in the current study by examining the factors that drive changes in price transmission. This type of research would need to be conducted in a bilateral and case study approach which controls for other country-specific variables that might have influenced price transmission.

A second implication concerns policy makers who contemplate the use of export restrictions. The significant decline in long-term price transmission in the countries with a high PID shows that implementing an export ban could reduce long-term demand from their traditional trading partners.

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Annex 1

Error Correction Model

Non-stationary variables drift randomly over time without returning to a common mean, contrary to stationary variables which have finite means and auto-covariances that do not change over time. When variables are non-stationary, standard regression techniques, such as ordinary least squares (OLS), can no longer be used. There are different ways to deal with non-stationary series and make them stationary. For example, if the series exhibit a long-term trend over time, then it is possible to make them stationary by de-trending.

Many economic series are stationary in first differences, which means that they can be made stationary by computing the differences between consecutive periods. If a series becomes stationary after calculating the first differences, i.e. the difference between one period and the next, then they are called first-difference stationary series. First-difference stationary series are also referred to as series that are integrated of order one, I(1), or unit root series. Series that need to be differenced *d* times to become stationary are called I(d). Stationary series are said to be integrated of order zero, I(0). When a non-stationary variable can be made stationary, standard regression techniques can be used.

However, when two or more time series in the analysis are I(1), then it is possible that they are cointegrated. Cointegrated variables move together in the long-run and any deviations from their long-run relationship are temporary. When variables are cointegrated, first-differencing the series is not advisable as it would remove the information contained in the long-run relationship between the series.

The ECM framework has several features which make it suitable to examine the relationship between price series. First, the ECM accommodates the existence of cointegrated variables and allows for testing for cointegration. In the case of price series, testing for cointegration in fact translates to testing for market integration (Rapsomanikis et al., 2004). Second, the ECM does not require that all variables are integrated of the same order, that is, it can be used regardless of whether the variables are I(0), I(1) or both. Third, the ECM separates the long-run from the short-run effects and thereby preserves the dynamic relationship between prices. Finally, if there is a long-run relationship between prices, then the ECM also provides an estimate of how quickly domestic prices adjust to their long-run relationship with the international price, after a shock in the international price (De Boef and Keele, 2008). However, the ECM can only be used if none of the variables are I(2) or above. This is tested in the next section.

To formulate the ECM, we start with a general model that formulates the relationship between the domestic price in country i with the world price:

$$p_{cit}^{d} = \alpha_0 + \sum_{j=1}^{p} \alpha_j p_{cit-j}^{d} + \sum_{j=0}^{q} \beta_j p_{ct-j}^{w} + \varepsilon_t \qquad \text{(A.1)}$$

where $\mathrm{p_{cit}^{d}}$ denotes the logarithm of the price of commodity *c* in country *i* at time *t*, converted to real USD and $\mathrm{p_{ct}^{w}}$ is the logarithm of the world price (in real USD) of commodity *c* at time *t*. By expressing the domestic price in USD, we account implicitly for the exchange rate. The model specification assumes that the international prices influence domestic prices in the importing countries, but not vice versa.

The model in (1) is an autoregressive distributed lag or ADL(p,q) model in levels with p lags for the domestic price and q lags for the international price. The advantages of this model are that it does not assume any particular lag length for either variable and that it can be consistently estimated using OLS (De Boef and Keele, 2008; Davidson and MacKinnon, 1993).

From this model, we can derive the ECM. For simplicity, we omit the country and commodity indices and set p=q=1. The ADL(1,1) in levels is hence:

$$p_t^d = \alpha_0 + \alpha_1 p_{t-1}^d + \beta_0 p_t^w + \beta_1 p_{t-1}^w + \varepsilon_t \quad \text{(A.2)}$$

By subtracting p_{t-1}^d from both sides, adding $(+\beta_0 p_{t-1}^w)$ and $(-\beta_0 p_{t-1}^w)$ to the right hand side, and then rearranging terms, we obtain the ADL(1,1) in differences:

$$\Delta p_t^d = \alpha_0 + (\alpha_1 - 1)p_{t-1}^d + \beta_0 \Delta p_t^w + (\beta_0 + \beta_1)p_{t-1}^w + \varepsilon_t \quad \text{(A.3)}$$

where $\Delta p_t = p_t - p_{t-1}$. The equation in (3) can then be written as the Generalized ECM, which illustrates the equivalence of the ADL and the ECM:

$$\Delta p_t^d = \alpha_0 + \delta\left(p_{t-1}^d - \gamma p_{t-1}^w\right) + \theta \Delta p_t^w + \varepsilon_t \quad \text{(A.4)}$$

with $\theta = \beta_0$, $\delta = (\alpha_1 - 1)$, and $\gamma = \frac{(\beta_0+\beta_1)}{(1-\alpha_1)}$.

Since all prices are expressed in logarithms, the coefficients are elasticities. The interpretations of the coefficients are as follows:

δ is the error correction term (ECT) or the speed of adjustment. It indicates the speed at which domestic prices return to their long-run equilibrium with international prices after a shock in the latter. δ is expected to be between -1 and 0 as it corrects (eliminates) divergences from the long-run equilibrium. The higher the absolute value of δ, the faster domestic prices return to the long-term equilibrium. Thus, if for example δ = -0.25, then 25% of the divergence from the long-run equilibrium is corrected each month.

γ is the long-run (LR) elasticity of price transmission. If for example γ = 0.6, then in the long-run, a 100% increase in the world price leads to a 60% increase in the domestic price, in addition to any short-term effect.

θ is the short-run (SR) elasticity. It measures the percentage adjustment of domestic prices to a change in the world price in the current period.

If δ = -1, then domestic prices will immediately return to their LR equilibrium relationship with world prices following a shock in the world price. However, if δ > -1, then it will take time for domestic prices to return to the LR equilibrium. Each period, a certain percentage of the gap between the domestic and international price will be corrected and these adjustments accumulate over time. To figure out how much time it takes for domestic prices to return to at least half of their LR equilibrium value after a shock in global markets, we calculate the median lag length, *m*, following De Boef and Keele (2008):

$$m = \frac{\sum_{r=0}^{R} \omega_r}{\sum_{r=0}^{\infty} \omega_r} \quad \text{(A.5)}$$

where *r* represents the number of periods (months in this study). The denominator is the LR transmission elasticity γ while the numerator calculates the effects through any number of time, R. Practically, to obtain the median lag length, we compute *m* for successive values of *r* and record *r* as soon as m ≥ 0.5.

This is best explained by an example. Suppose δ = -0.25 and γ = 0.6. This means that in the long-run, a 100% increase in the world price will lead to a 60% increase in the domestic price. However, since δ = -0.25, there will only be a 15% (=60%*0.25) increase in the immediate period (*r*=0) of the long run adjustment. At this point, *m* equals 15/60=0.25, which means that domestic prices only obtained 25% of their LR equilibrium in the immediate period. In the next period (*r*=1), domestic prices would increase by an additional 11.25% (=(60%-15%)*0.25), which leads to a total rise of 26.25%. As *m*=26.25/60 is still less than 0.5, we continue to the next period. When *r*=2, the additional increase in domestic prices will be 8.43%, which brings the total increase to 34.68. Now *m*=34.68/60 is greater than 0.5, hence we record the value of *r* and know that it will take two months for domestic prices to return to at least half of their LR equilibrium value after a shock in global markets.

Annex 2

Diagnostic tests

Unit root tests

One of the advantages of the ECM is that it can be applied regardless of whether the variables are I(0), I(1) or both. However, we need to make sure that none of the series are I(2) or above. We test the stationarity properties of all price series included in our study in two separate sets of tests. First, we perform unit root tests for the international prices. Second, we evaluate the order of integration of the domestic prices using panel unit root tests.

For the international prices of maize, rice and wheat, we employed the Augmented Dickey Fuller (ADF) and the Phillips-Perron (PP) tests both with and without trend to determine the order of integration. The null hypothesis for these tests is that the series contains a unit root, i.e. is integrated of order 1 or I(1). Annex Table 1 reports the results of the unit root tests, which all show that the international price series are non-stationary in levels but that their first-differences are stationary.

Annex Table 1. Unit root tests for international prices (p-values)

	Augmented Dickey Fuller				**Phillips-Perron**				max i(d)
	Without trend		With trend		Without trend		With trend		
	Level	Difference	Level	Difference	Level	Difference	Level	Difference	
Maize	0.303	0.000	0.814	0.000	0.354	0.000	0.883	0.000	I(1)
Rice	0.280	0.000	0.698	0.000	0.419	0.000	0.828	0.000	I(1)
Wheat	0.195	0.000	0.649	0.000	0.244	0.000	0.714	0.000	I(1)

Note: The choice of the number of lags for each unit root test is based on the Akaike information criteria (AIC). The 'max I(d)' column displays the highest level of integration among all tests.

The domestic price series include a country dimension in addition to the time dimension. Accordingly we utilize Fisher-style tests which conduct ADF and PP tests on each country panel individually and then combine the resulting p-values to produce an overall test. It assesses the null hypothesis that all panels are non-stationary against the alternative that one or more panels are stationary. As with the unit root test on the international price series, we performed the panel unit root tests with and without trend for each commodity. The results in Annex Table 2 indicate that domestic price series are at most integrated of order one.

Annex Table 2. Panel unit root tests for domestic prices (p-values)

	Fisher-style Augmented Dickey Fuller				**Fisher-style Phillips-Perron**				max I(d)
	Without trend		With trend		Without trend		with Trend		
	Level	Difference	Level	Difference	Level	Difference	Level	Difference	
Maize	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	I(0)
Rice	0.284	0.000	0.700	0.000	0.049	0.000	0.392	0.000	I(1)
Wheat	0.000	0.000	0.253	0.000	0.000	0.000	0.015	0.000	I(1)

Note: The choice of the number of lags for each unit root test is based on the Akaike information criteria (AIC). The 'max I(d)' column displays the highest level of integration among all tests.

Model selection

To estimate the ECM we considered two estimators: the mean group (MG) estimator and the pooled mean group (PMG) estimator. The MG estimator assumes heterogeneity of all parameters (the short-run coefficients, the long-run coefficients, the error correction term and the error variances) across countries, whereas the PMG estimator allows for heterogeneous short-term effects but assumes that the long-run elasticity is the same across all countries. We empirically test which of the two estimators is preferred using the Hausman test.

Annex Table 3 lists the MG and PMG estimates of the ECM models for maize, rice and wheat. The MG and PMG estimates are computed in Stata using the *xtpmg* command. Both estimators give similar values and the same statistical significance levels for the LR elasticity of the world price and the ECT. The median lag lengths are slightly larger for the PMG compared to the MG. In all cases, the ECT have a negative sign, which is expected as the ECT measures the speed for domestic prices to return to the long-run equilibrium. Furthermore, the ECT are also all statistically significant, which provides strong evidence for the long-run impact of world prices on domestic prices and confirms that the ECM is the valid model for estimating this relationship.

The Hausman test was performed for each commodity to determine which estimator should be used. For all commodities, the p-value is above 0.05 which indicates that the PMG estimators are preferable to the MG estimators. Based on these results, we use the PMG estimators for all ECM estimations in this paper.

The estimates in Annex Table 3 indicate that there is a long-run cointegrating relationship between world prices and domestic prices, which is characterized by relatively high price transmission but slow adjustment of domestic prices to world price shocks. In the case of maize, the LR elasticity of the world price is 0.5, which means that in the long run a 1% increase in the world price of maize leads to a 0.5% increase in domestic prices. The ECT shows that this impact is not immediate and that only 10% of this change is adjusted in the current period. Rice prices experience a similar LR elasticity while this value is higher for wheat. All commodities demonstrate a similar slow speed of adjustment, which is around 10%. The countries included in the analysis are listed in Annex Table 7.

Annex Table 3. MG and PMG estimates of the ECM for maize, rice and wheat

	Maize		**Rice**		**Wheat**	
	MG	PMG	MG	PMG	MG	PMG
LR - World price	0.472***	0.473***	0.520***	0.557***	1.039***	1.005***
	(0.05)	(0.04)	(0.06)	(0.02)	(0.13)	(0.03)
ECT	-0.124***	-0.106***	-0.122***	-0.095***	-0.179***	-0.133***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
N	4600	4600	4120	4120	6100	6100
countries	32	32	25	25	48	48
Median lag length	5	6	5	6	3	4
Hausman test: chi-square	0.00		0.45		0.07	
p-value	[0.954]		[0.504]		[0.790]	

Notes: Estimates are obtained using Stata's xtpmg command. Robust standard errors in parentheses; p-values in brackets;
* p<0.1, ** p<0.05, *** p<0.01. The Hausman test indicates that the PMG estimator is consistent and efficient and is preferred over the MG estimator. LR stands for long-run, ECT stands for Error Correction Term.

Annex 3

Robustness tests

We conducted two sets of robustness checks to test the sensitivity of our results. First, we varied the cut-off values for the high PID and low PID groups. Second, we extended the post-implementation period. The rationale behind these robustness tests and the results are described below.

Robustness tests 1: Different cut-off levels for PID groups

In the main analysis, we defined the high PID countries as countries with a PID of 10% or above while the low PID group contained countries with a PID below 1%. We now vary both cut-off levels. First, we increase the cut-off level of the high PID group and then we vary the cut-off level of the low PID group. This set of robustness tests only applies to the second part of the study given that the first objective relates to the overall impact of an export ban and does not consider the past import dependency levels.

When increasing the cut-off level for the high PID group from 10% to 15%, the sample size decreases for most country-commodity pairs. The countries that are included in the sample can be easily identified by referring to Table 2, which ranks the importing countries by PID for each country-commodity pair. Annex Table 4 shows the results of the main analysis for the 10% and 15% cut-off levels for the high PID group. The values of the parameters only change slightly between the two groups of high PID and the statistical significance levels remain the same for almost all parameters. Hence, restricting the high PID group to only countries with a PID of 15% or above does not alter any of the conclusions reached in the main analysis. Since the sample size is larger when considering the 10% cut-off value, this cut-off value is preferred over the more restrictive 15%.

Annex Table 5 compares the results of the main analysis with the 1% cut-off value for the low PID group with the two alternative cut-off levels of 5% and 10%. In this case, the sample sizes are increased under the robustness checks. We observe mostly the same trends when comparing pre- and post-implementation values and the statistical significance levels are also comparable with the original 1% cut-off. This shows that the results remain robust regardless of which cut-off is used for the low PID group.

Robustness tests 2: Longer post-implementation period

The pre-implementation and post-implementation periods vary according to the start date of the export ban. As explained in the data section, for the export bans starting in 2006 or 2007, we guarantee that price data exist from 2005 onwards. When available, we consider price data series starting as early as January 2000. The post-implementation period is defined as the five years (60 months) after the introduction of the ban.

In the second set of robustness checks, we extend the post-implementation period to 7 years (84 months). For example, in the case of India, the post-implementation period in the initial analysis was from October 2007 until September 2012. Under this robustness check, the post-implementation period extends from October 2007 until September 2014. In the case of the Russian Federation, the post-implementation period is extended by only a few months because of data availability issues. Whereas the original post-implementation period was from August 2010 to September 2015, the post-implementation period under the robustness check ends in December 2015. A longer post-implementation period is considered for both parts of the study, i.e. the overall impact of the export ban and the impact according to PID.

Annex Table 6 shows the results of this robustness test. The values of the pre-implementation period are the same as in the main analysis. To test the robustness of the results related to the first objective, we compare the first three columns of data in the

Annex Table 6 with the table in section 1 of the results chapter, i.e. Table 3. Consequently, the last six columns of Annex Table 6 should be compared with the tables in Section 2 of the results chapter, i.e. Table 4 through to Table 7.

The second set of robustness tests show that the results remain consistent when we consider a longer post-implementation period. In particular, for the maize export ban in Argentina and the rice export ban in India, price transmission dropped significantly for all groups (full sample, high PID and low PID) in the period following the ban. In the case of the rice export ban in Viet Nam and the wheat export ban in the Russian Federation, price transmission decreased significantly for the high PID group but did not change in the low PID group and the full sample.

Annex Table 4. Robustness check: Alternative high PID

	High PID (10% or above)			**High PID (15% or above)**		
	Pre	Post	Difference	Pre	Post	Difference
Maize - Argentina						
LR - World price	0.735***	0.020	-0.715**	0.671***	0.052	-0.619*
	(0.085)	(0.177)	(0.230)	(0.163)	(0.178)	(0.254)
ECT	-0.259***	-0.065***	0.194**	-0.227**	-0.065***	0.162
	(0.084)	(0.004)	(0.068)	(0.105)	(0.005)	(0.087)
Median lag length	2	10		2	10	
N	156	240		123	180	
Countries	4	4		3	3	
Rice - India						
LR - World price	0.672***	0.236***	-0.436***	0.655***	0.300**	-0.355*
	(0.084)	(0.088)	(0.123)	(0.089)	(0.124)	(0.148)
ECT	-0.173**	-0.184***	-0.011	-0.155	-0.182***	-0.028
	(0.076)	(0.011)	(0.086)	(0.132)	(0.023)	(0.164)
Median lag length	3	3		4	3	
N	308	240		184	120	
Countries	4	4		2	2	
Rice – Viet Nam						
LR - World price	0.654***	0.160**	-0.494***	0.517**	0.159	-0.357
	(0.080)	(0.067)	(0.104)	(0.214)	(0.104)	(0.224)
ECT	-0.317*	-0.185***	0.132	-0.518	-0.213***	0.305
	(0.180)	(0.022)	(0.179)	(0.349)	(0.035)	(0.315)
Median lag length	1	3		0	2	
N	352	360		145	180	
Countries	6	6		3	3	
Wheat – Russian Federation						
LR - World price	0.921***	0.664***	-0.258*	0.934***	0.675***	-0.259*
	(0.063)	(0.080)	(0.101)	(0.065)	(0.081)	(0.103)
ECT	-0.152***	-0.317***	-0.165	-0.141***	-0.223***	-0.082*
	(0.021)	(0.095)	(0.092)	(0.024)	(0.032)	(0.040)
Median lag length	4	1		4	2	
N	284	253		254	240	
Countries	5	5		4	4	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; pre- and post-implementation periods vary by country-commodity pair (see Table 1); Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Annex Table 5. Robustness check: Alternative low PID

	Low PID (below 1%)			**Low PID (below 5%)**			**Low PID (below 10%)**		
	Pre	***Post***	***Diffe-rence***	***Pre***	***Post***	***Diffe-rence***	***Pre***	***Post***	***Diffe-rence***
Maize - Argentina									
LR - World price	1.428***	0.214*	-1.214***	1.366***	0.262***	-1.105***	1.366***	0.262***	-1.105***
	(0.089)	(0.118)	(0.168)	(0.078)	(0.094)	(0.134)	(0.078)	(0.094)	(0.134)
ECT	-0.226***	-0.112***	0.114***	-0.235***	-0.138***	0.097*	-0.235***	-0.138***	0.097*
	(0.034)	(0.014)	(0.032)	(0.031)	(0.028)	(0.043)	(0.031)	(0.028)	(0.043)
Median lag length	2	5		2	4		2	4	
N	573	960		708	1140		708	1140	
Countries	16	16		19	19		19	19	
Rice - India									
LR - World price	0.702***	0.188*	-0.513**	0.412***	0.097*	-0.315***	0.346***	0.106**	-0.239**
	(0.148)	(0.102)	(0.195)	(0.072)	(0.053)	(0.093)	(0.052)	(0.051)	(0.073)
ECT	-0.082**	-0.120***	-0.038	-0.182*	-0.179***	0.003	-0.195**	-0.193***	0.001
	(0.037)	(0.034)	(0.052)	(0.095)	(0.029)	(0.108)	(0.076)	(0.035)	(0.090)
Median lag length	8	5		3	3		3	3	
N	415	300		797	658		1019	838	
Countries	5	5		11	11		14	14	
Rice – Viet Nam									
LR - World price	0.148	0.528***	0.380	0.264***	0.206***	-0.059	0.282***	0.236***	-0.046
	(0.281)	(0.154)	(0.362)	(0.075)	(0.079)	(0.110)	(0.073)	(0.073)	(0.105)
ECT	-0.043***	-0.095**	-0.052	-0.152***	-0.185***	-0.033	-0.144***	-0.184***	-0.040
	(0.011)	(0.046)	(0.041)	(0.053)	(0.055)	(0.078)	(0.047)	(0.049)	(0.069)
Median lag length	15	6		4	3		4	3	
N	350	240		569	420		658	480	
Countries	4	4		7	7		8	8	
Wheat – Russian Federation									
LR - World price	1.165***	1.330***	0.166	1.173***	1.343***	0.169	1.148***	1.360***	0.213*
	(0.075)	(0.080)	(0.110)	(0.061)	(0.071)	(0.093)	(0.056)	(0.070)	(0.089)
ECT	-0.127***	-0.179***	-0.051	-0.118***	-0.161***	-0.043	-0.117***	-0.150***	-0.033
	(0.020)	(0.028)	(0.034)	(0.017)	(0.025)	(0.030)	(0.016)	(0.023)	(0.028)
Median lag length	5	3		5	3		5	4	
N	859	840		1312	1200		1558	1380	
Countries	14	14		20	20		23	23	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; pre- and post-implementation periods vary by country-commodity pair (see Table 1); Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Annex Table 6. Robustness check: Longer post-implementation period (7 years)

	Full sample			**High PID (10% or above)**			**Low PID (below 1%)**		
	Pre	***Post***	***Diffe-rence***	***Pre***	***Post***	***Diffe-rence***	***Pre***	***Post***	***Diffe-rence***
Maize - Argentina									
LR - World price	1.222***	0.297***	-0.925***	0.735***	0.107	-0.628*	1.428***	0.207**	-1.221***
	(0.074)	(0.051)	(0.091)	(0.085)	(0.169)	(0.255)	(0.089)	(0.086)	(0.144)
ECT	-0.191***	-0.143***	0.047	-0.259***	-0.064***	0.195***	-0.226***	-0.109***	0.117***
	(0.023)	(0.019)	(0.032)	(0.084)	(0.009)	(0.059)	(0.034)	(0.012)	(0.029)
Median lag length	3	4		2	10		2	6	
N	1188	2687		156	335		573	1344	
Countries	32	32		4	4		16	16	
Rice - India									
LR - World price	0.373***	0.219***	-0.154**	0.672***	0.367***	-0.305*	0.702***	0.234**	-0.468**
	(0.044)	(0.028)	(0.051)	(0.084)	(0.088)	(0.122)	(0.148)	(0.100)	(0.178)
ECT	-0.196***	-0.173***	0.023	-0.173**	-0.173***	-0.001	-0.082**	-0.097**	-0.016
	(0.049)	(0.023)	(0.052)	(0.076)	(0.042)	(0.085)	(0.037)	(0.040)	(0.055)
Median lag length	3	3		3	3		8	6	
N	1756	2049		308	336		415	420	
Countries	25	25		4	4		5	5	
Rice – Viet Nam									
LR - World price	0.340***	0.275***	-0.065	0.654***	0.158**	-0.497***	0.148	0.575***	0.427
	(0.045)	(0.029)	(0.052)	(0.080)	(0.064)	(0.102)	(0.281)	(0.142)	(0.319)
ECT	-0.209***	-0.165***	0.044	-0.317*	-0.169***	0.148	-0.043***	-0.085**	-0.042
	(0.052)	(0.022)	(0.053)	(0.180)	(0.036)	(0.156)	(0.011)	(0.043)	(0.044)
Median lag length	2	3		1	3		15	7	
N	1681	2055		352	504		350	336	
Countries	25	25		6	6		4	4	
Wheat – Russian Federation									
LR - World price	1.041***	1.067***	0.026	0.921***	0.697***	-0.225*	1.165***	1.193***	0.028
	(0.034)	(0.041)	(0.052)	(0.063)	(0.066)	(0.092)	(0.075)	(0.065)	(0.099)
ECT	-0.136***	-0.170***	-0.035	-0.152***	-0.308***	-0.156	-0.127***	-0.176***	-0.049
	(0.011)	(0.019)	(0.022)	(0.021)	(0.097)	(0.098)	(0.020)	(0.024)	(0.032)
Median lag length	4	3		4	1		5	3	
N	3131	2969		284	273		859	910	
Countries	48	48		5	5		14	14	

Notes: Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01; pre- and post-implementation periods vary by country-commodity pair (see Table 1); Past import dependency (PID) is defined as the average share of imports from the restricting country in total domestic supply in the three years before the export restriction; ECT stands for Error Correction Term.

Annex 4

List of countries with domestic price data

Annex Table 7. List of countries with domestic price data, organized by commodity

Maize	Rice	Wheat
Austria	Benin	Afghanistan
Belgium	Brazil	Armenia
Benin	Cameroon	Austria
Burkina Faso	Central African Republic	Azerbaijan
Burundi	Chad	Bangladesh
Cabo Verde	Colombia	Belgium
Cameroon	Costa Rica	Brazil
Central African Republic	Cote d'Ivoire	Bulgaria
Chad	Guatemala	Burundi
Cote d'Ivoire	Haiti	Cabo Verde
Czech Republic	Italy	Cameroon
Dominican Republic	Lao People's Democratic Republic	Central African Republic
Gambia	Mali	Costa Rica
Germany	Mauritania	Czech Republic
Greece	Mozambique	Djibouti
Haiti	Nepal	Egypt
Italy	Niger	Estonia
Kenya	Peru	Ethiopia
Malawi	Philippines	Finland
Mali	Russian Federation	Gabon
Mozambique	Senegal	Georgia
Niger	South Africa	Germany
Panama	Sri Lanka	Greece
Peru	Togo	Guinea-Bissau
Philippines	Tunisia	Haiti
Poland		India
Portugal		Indonesia
Slovakia		Israel
Slovenia		Italy
Spain		Kazakhstan
Togo		Kyrgyzstan
Zambia		Latvia
		Lithuania
		Mauritania
		Mongolia
		Nepal
		Pakistan
		Peru

Annex Table 7. List of countries with domestic price data, organized by commodity (*cont.*)

Maize	Rice	Wheat
		Poland
		Republic of Moldova
		Romania
		Slovakia
		Slovenia
		Spain
		Sri Lanka
		Swaziland
		Tajikistan
		United Kingdom

Note: List of countries included in the analysis related to question 1.