A Global VAR Model for the Analysis of Wheat Export Prices

Luciano Gutierrez

Dipartimento di Agraria, University of Sassari, Italy *

Francesco Piras

Dipartimento di Agraria, University of Sassari, Italy.

Abstract

Reasonable limited volatility is a common feature of agricultural markets, particularly in international markets. However, occasionally, more pronounced and even extreme upward or downward price spikes have been recently registered. Food commodity prices fluctuations has important impacts on poverty and food insecurity across the world. Conventional models have not provided a complete picture of recent price spikes in agricultural commodity markets, while there is an urgent need for appropriate policy responses. Perhaps new approaches are needed in order to better understand international spill-overs, the feedback between the real and the financial sectors and also the link between food and energy prices. In this paper, we present results from a new worldwide dynamic model that provides short and long-run impulse responses of wheat international price to various real and financial shocks. The results show that stocks, oil price and US dollar depreciation affect worldwide wheat prices.

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*Corresponding author: Telephone: +39.079.229.056, Fax: +39.079.229.356, E-mail address: lgutierr@uniss.it.

1 Introduction

During the food crisis of 2006-2008 and 2010-2011 the world observed large increases in the prices of wheat, rice and maize on international markets. The surges in prices on international markets led to substantial increases in domestic prices. According to FAO [1] by July 2008, domestic wheat, rice, and maize prices where each, on average among countries, about 40% higher (adjusted for inflation) than they were in January 2007. Although, in recent years numerous factors have been proposed in the literature as explaining recent commodity price movements, there is no general consensus on the relative weight that should be attributed to each of them. Many authors have stressed that more consideration should be given to the effects of growing food demand in developing countries, especially in China and India, and also to the lower production growth rate as being among the causes of the recent food price spike (see for example Trostle, 2008; Von Braun, 2007; Dewbre et al. 2008, and Krugman, 2011). Other studies have argued that biofuel programs in the United States and European Union are behind the run-up in food prices. These programs provide subsidies for biofuels leading to greater use of corn and vegetable oil and resulting in price increases for these commodities (see Mitchell, 2008 and Headey and Fan, 2008). On the other hand Baffes and Haniotis (2010) suggested that the link between food prices and energy prices is the main factor in recent commodity price movements. Energy prices affect food commodity prices by influencing the cost of inputs, such as nitrogen fertilizer, and the cost of transport. The use of agricultural commodities to produce biofuels is also an additional reason for a possible link between energy and food commodity prices. Besides the above mentioned factors, the list of possible causes analysed in the recent literature includes the decline of commodity stocks (Abbot, Hurt and Tyner, 2008; Piesse and Thirtle 2009), a weak U.S. dollar (Abbot, Hurt and Tyner, 2008; Mitchell, 2008), panic buying (Timmer, 2009), bans on exports (Dollive, 2008; Headey, 2011) and speculation (Irwin, Sanders and Merrin, 2010; Cooke and Robles 2009; Sanders, Irwin and Merrin, 2010; Gilbert, 2010a; 2010b; Gutierrez, 2013).

The aim of the paper is to model the impacts of the main factors behind the wheat export price dynamics. In details, the research provides a worldwide dynamic model for the analyses of short and long-run impulse responses of wheat commodity prices to various real and financial shocks. Specifically, we propose a GLObal Wheat Market Model (GLOWMM) to study the dynamic of wheat export prices. The model is specified by using the Global Vector AutoRegressive (GVAR) model proposed by Pesaran et al. (2004) and Dees et al. (2007). The methodology allows the analysis of wheat export prices for the six main export countries, USA, Argentina, Australia, Canada, Russia and EU. Specifically, single country wheat export prices are modelled as persistence processes that reverts to a time-varying mean determined by both country-specific and foreign-specific variables plus the effect of global variables, as the oil price. These single country models are then aggregated into a global model by using export weighting matrices. Thus we can evaluate the first and second round inflationary effects on wheat export prices of various shocks as a reduction of the wheat stock to utilization ratio, an increase in the oil price and a US currency devaluation relative to the main competitor's currencies.

The paper is organized as follows. Section 2 provides the motivation for this study and describes the econometric model. In Section 3 data and empirical results are discussed. Section 4 concludes.

2 Motivation and methodology

Amid the recent food commodity prices turmoil, policy makers have become increasingly concerned on what happened (and why) on world food markets in recent years. As shown in Figure 1 which reports the FAO Food Price Index, food prices have increased abruptly since 2002 and especially since late 2006 leading to unprecedented highs between 2006 and 2008. In the second half of 2008 prices declined again but market turbulence returned in late 2010 recalling back the negative memories of 2008 crises (Tangermann, 2011; Serra and Gil, 2012).

A wide strand of different explanations for recent food prices increased volatility has been proposed in the literature. The identification of the main factors is still under debate. Obviously it is not an easy task to depict a clear picture of food price crisis because it is a global phenomenon that involves a large number of distinct events. Many authors have considered some explanations more reliable than others.

Figure 1 about here

[1] FAO Global information and Early a Warning System

Unfavourable weather condition in major producing countries have been viewed as one important factors according to OECD report (2008), Tangermann (2011) and OECD-FAO (2011). Despite of this, Headey and Fan (2008) suggest that production shortfalls are a normal occurrence in agricultural and low production in several countries were offset by large crop in other regions. Macroeconomic conditions such as strong GDP growth and subsequent stronger demand for food in some developing countries have also been considered as a permanent factor behind the recent prices spike (see Von Braun, 2007; Trosle, 2008; Carter et al., 2011; Krugman, 2011). Other studies have argued that low level of real interest rates and growing money supply diverted investments away from financial assets towards physical assets, including commodities. This excess of liquidity in the global economy, with a depreciation of US dollar, resulted in inflation and in its turn, in rising commodity prices and an increased commodities demand for importing countries (see Calvo, 2008; Abbot et al. 2008; Mitchell, 2008; Timmer, 2009; Gilbert, 2010a; Tangermann 2011).

The excess of liquidity fostered financial investments in commodity future markets convincing some authors that speculation and not fundamentals were behind the commodities price boom and bust (Baffes and Haniotis, 2010; Masters, 2008; Soros ,2008; Calvo, 2008). Cooke and Robles (2009), Gilbert (2010b) and Gutierrez (2013) found evidences that financial activities in future markets may be of use in explaining the change in food price. However, a large strand of literature challenged the arguments proposed by the bubble proponents through logical inconsistencies, conceptual errors and empirical evidences showing that speculation did not have a significant role in rising commodities food prices (see Krugman, 2009; Wolf, 2008; Wright, 2009; Irwin et al., 2009; Sanders and Irwin, 2010; Baffes and Haniotis, 2010). Other possible causes analysed in literature include the decline of commodity stocks, the rising of crude oil price, biofuels production and finally panic buying, ban and export restrictions.

The competitive storage model explains how commodity stocks can play a main role in buffering price volatility (see the pioneering work of Gustafson 1958; but also Samuelson 1971; Wright and Williams 1982; Scheinkman and Schechtman 1983; Williams and Wright 1991 and Deaton and Laroque 1992). Starting on the years 1999-2000, the global stock level for major cereals has been declined reaching its historical low level in 2007 (Dawe, 2009; Wright, 2011; Tangermann, 2011). Therefore, it is not surprising that literature has identified the reduction of commodity stocks as one of the main factors in recent food price spike (Piesse and Thirtle, 2009; Trostle, 2008; Dawe, 2009). Empirical evidence have been provided by Kim and Chavas (2002), Balcombe (2011), Carter et al. (2011), Hochman et al. (2011), Serra and Gil (2012). The oil price represents a permanent factor in food price formation and some authors have highlighted its possible importance as major factor in the recent prices boom (see Baffes, 2007; Baffes and Haniotis, 2010; Balcombe, 2011, among others). Moreover, as oil price increases, biofuels becomes more competitive. Mitchell (2008), Baffes (2007), OCSE-FAO (2011) and Tangermann (2011) suggest that biofuels contributed to the price crisis in 2006-2008. Hochman et al. (2011) provide a complete literature about quantitative estimates of biofuels impact on food commodity price index.

In the paper, we focus on wheat market for two reasons. First rising food prices mainly affects lower income consumers, especially in poor countries where households spend a great part of their income on food. This is particular true for cereals and especially wheat. It represents the most relevant source of food in developing countries. Second, market assumptions for the analysis of wheat are deeply changed during the last decades evolving from an oligopoly between US and Canada with the latter as a price leader (McCalla, 1966) to a tripoly including also Australia (Alouze et al. 1978) and hence to a price leadership model with US price leader (Oleson 1979; Wilson, 1986). However, Westcott and Hoffman (1999) recognize that although US is the largest word wheat exporter its market share is not enough to be considered a price leader anymore. In essence, wheat market is nowadays characterized by a relative small number of wheat producing and exporting countries that sell to a relative large group of importers, mostly developing countries. While new market assumptions can be introduced for example in general equilibrium models, more flexible models can be provided and used for the analysis of worldwide commodity markets.

To this end, in this paper we introduce and evaluate an innovative econometric methodology represented by the Global Vector Autoregressive model. The GVAR approach is particular appealing for the analysis of the worldwide wheat market for two reasons. First, it is specifically designed to model fluctuations and interactions between countries. This is a crucial asset given the features of world wheat market and the global dimension of the food prices crisis that cannot be downsized to one country, rather involves a large number of countries. Secondly, the GVAR allows to model the dynamic of wheat export prices as results of the effects exerted by the country-specific and by foreign-specific variables. The foreign-specific variables are defined as weighted average of wheat export prices, the stock to utilization ratio and the effective exchange rate fluctuations in all competitor countries. Thus both country-specific and foreign-specific effects can be jointly modelled. Finally the GVAR model combines a number of atheoretic relationships. Unlike structural models, as for example general equilibrium models, the approach does not attempt to make restrictions, for example on the basis of economic theory. Causal relationships are analyzed by means of the impulse response functions that, built from the GVAR estimates, allow to highlight how shocks on wheat stocks and demand, exchange rates, input prices or global oil price propagate at domestic and global level.

2.1 The analytical framework

Before presenting the GVAR methodology, it is useful to introduce a simple model which may account for the main relationships among the dynamics of export prices, cost prices, stock and demand factors and exchange rates. For each country the export price equation can be derived for example within a mark-up framework. Oligopolist behaviour in wheat international market has been largely analyzed in many study as McCalla(1966), Alouze et al. (1978), Oleson (1979), Wilson, (1986), Arnade and Pick (1997) and more recently Arnade and Vocke (2013). Setting-up the model, we assume that the log of export prices expressed in US dollar in country i for $i = 0, ..., N$ and at time t for $t = 1, ..., T$, px_{it}, is set as mark-up mk_{it} on the marginal production cost, cp_{it} (expressed in log)

$$px_{it} = (1 + mk_{it}) + cp_{it} + \varepsilon_{it}. \tag{1}$$

Using a pricing to market strategic behaviour (Krugman, 1987; Knetter, 1992; Athukorala and Menon, 1994 among others), the mark-up in each country i is hypothesised to depend on the competitive pressure in the world market and stock and demand pressures in both the home and world market. These effects can be modelled by the following equations

$$mk_{it} = mk\left[\left(\sum_{j\neq i} w_j\left(px^l_{jt} - e_{jt}\right)\right) - \left(px^l_{it} - e_{it}\right)\right] \tag{2}$$

$$px^l_{it} = px^l\left(z_{it}, S_{it}\right). \tag{3}$$

In equation (2) the mark-up depends on the ratio between the price of competitors given by the average of competitors' prices weighted by the share, w_j, that each country has in the world export market, and the home price. In order to include the effects of exchange rates, the export price px_{it} is defined as ratio of the home price expressed in local currency, px^l_{it}, and the log of the bilateral exchange rate of local currency in country i per unit of US dollar. Finally, in equation (3)the home price is assumed for each country i to depend on the supply and demand effects synthesised in the stock to utilization ratio variable, z_{it}, an other variables which may affect home prices defined by the variables S_{it}. Substituting (2) and (3) in (1) and assuming a linear relationship among the log variables, it easily to see that the export price equation can be expressed as

$$px_{it} = \alpha + \beta_1 cp_{it} + \beta_2 e_{it} + \beta_3 z_{it} + \beta_4 S_{it} + \beta_5 e^*_t + \beta_6 z^*_t + \beta_7 S^*_t + \varepsilon_{it}. \tag{4}$$

where $e^*_t = \sum_{j\neq i} w_j e_{jt}$, $z^*_t = \sum_{j\neq i} w_j z_{jt}$ and $S^*_t = \sum_{j\neq i} w_j S_{jt}$. From (4) emerges that export prices are influenced by a set of home variables and a set foreign variables computed as average of the exchange rates, e^*_t, the average stock to use ratio, z^*_t and other variables S^*_t which all account for the effects of external competitors' factors on the dynamics of countries export prices. Similar equation can be derived for the stock to use variable z_{it}. The original feature of the GVAR modelling approach lies in the ability to estimate models expressed in the form (4). Specifically, the GVAR model is basically composed of a number of countries modelled individually and estimated as a vector autoregression and the dynamics of home variables are linked each others by including foreign-specific and global variables related to the international export patterns of each country. The specification of the GVAR model proceeds in two stages. In the first stage, i.e. the estimation stage, the reduced form vector autoregression VAR model, augmented with the exogenous, X, variables, labelled VARX(p, q), is estimated for each country i, and in the second stage all individual country VARX models are stacked and linked using weight matrices.

Specifically, modelling each country i as a VARX(p, q),

$$\Phi_i (L, p_i) y_{it} = a_{i0} + \Lambda_i (L, q_i) y^*_{it} + \Psi_i (L, q_i) d_t + \epsilon_{it} \tag{5}$$

where the indexes $i = 1, ..., N;\ t = 1, ..., T$, a_{i0} is a $(k_i \times 1)$ vector of deterministic intercepts, y_{it} is a $(k_i \times 1)$ vector of country-specific (domestic) variables and corresponding $(k_i \times k_i)$ matrices of lagged coefficients, denoted by $\Phi_i (L, p_i) = I - \sum_{p=1}^{p_i} \Phi_i L^i$, where L is the lag operator; y^*_{it} is a $(k_i \times 1)$ vector of trade-weighted foreign variables and corresponding $(k_i \times k^*_i)$ matrix of lag polynomial denoted by $\Lambda_i (L, q_i)$; $\Psi_i (L, q_i)$ is a matrix lag polynomial associated to the global exogenous variables d_t. Finally ϵ_{it} is a $(k_i \times 1)$ vector of zero mean, idiosyncratic country-specific shocks, assumed to be serially uncorrelated and with time invariant covariance matrix $\sum_{ii}$, i.e $\epsilon_{it} \sim iid(0, \sum_{ii})$. The GVAR model assumes the weak exogeneity of y^*_{it}, i.e. the models rules out long-run feedbacks from y_{it} to y^*_{it}.

The first step of the analysis is to fix the order of the matrices polynomial $\Phi_i (L, p_i)$, $\Lambda_i (L, q_i)$ and $\Psi_i (L, q_i)$. We use the Akaike information criterion (AIC). We allow at maximum for a VARX(3, 1), the maximum p_i allowed is $p_i = 3$ and q_i is $q_i = 1$ in order to reduce the number of estimated parameters and avoid degrees of freedom problems. In the second stage of the GVAR methodology, we cast the country-specic models into their global representation. To show how the GVAR model is constructed, consider a generic country i in (5) with $p_i = 2$ and $q_i = 2$ and assume that $\Psi_i (L, q_i) = 0$

$$y_{it} = a_{i0} + \Phi_{i1} y_{it-1} + \Phi_{i2} y_{it-2} + \Lambda_{i0} y^*_{it} + \Lambda_{i1} y^*_{it-1} + \Lambda_{i2} y^*_{it-2} + \varepsilon_{it}. \tag{6}$$

First, for each country we group both the domestic and foreign variables as

$$\mathbf{z}_{it} = \begin{pmatrix} y_{it} \\ y^*_{it} \end{pmatrix}, \tag{7}$$

Therefore each country VARX model (6) becomes

$$\mathbf{A}_i \mathbf{z}_{it} = a_{i0} + \mathbf{B}_{i1} \mathbf{z}_{it-1} + \mathbf{B}_{i2} \mathbf{z}_{it-2} + \varepsilon_{it} \tag{8}$$

where

$$\mathbf{A}_i = (I_{k_i}, -\Lambda_{i0}),\ \mathbf{B}_{i1} = (\Phi_{i1,}, \Lambda_{i1}), \mathbf{B}_{i2} = (\Phi_{i2,}, \Lambda_{i2}). \tag{9}$$

The next step we create a vector of variables

$$y_t = \begin{pmatrix} y_{0t} \\ y_{1t} \\ \vdots \\ y_{Nt} \end{pmatrix}, \tag{10}$$

and using the weight matrix $\mathbf{W}_i$ constructed as the export weights of each country relative to the export of all competitor's countries, we obtain the following identity

$$\mathbf{z}_{it} = \mathbf{W}_i y_t \quad \forall i = 0, 1, ..., N. \tag{11}$$

The previous relationship allows each country model to be written in terms of the global vector y_t , thus it is the fundamental device through which each country wheat market is linked to the global GVAR model. Using now the identity (11) in each country VARX model (9) we obtain

$$\mathbf{A}_i \mathbf{W}_i y_{it} = a_{i0} + \mathbf{B}_{i1} \mathbf{W}_i y_{it-1} + \mathbf{B}_{i2} \mathbf{W} y_{it-2} + \varepsilon_{it}. \tag{12}$$

Finally by stacking each country-specific model in (12), we end with the Global VAR for all endogenous variables in the system y_t,

$$\mathbf{G} y_{it} = a_{i0} + \mathbf{H}_1 y_{it-1} + \mathbf{H}_2 y_{it-2} + \varepsilon_t \tag{13}$$

where

$$\mathbf{G} = \begin{pmatrix} \mathbf{A}_0 \mathbf{W}_0 \\ \mathbf{A}_1 \mathbf{W}_1 \\ \vdots \\ \mathbf{A}_N \mathbf{W}_N \end{pmatrix},\ \mathbf{H}_1 = \begin{pmatrix} \mathbf{B}_{01} \mathbf{W}_0 \\ \mathbf{B}_{11} \mathbf{W}_1 \\ \vdots \\ \mathbf{B}_{N1} \mathbf{W}_N \end{pmatrix},\ \mathbf{H}_2 = \begin{pmatrix} \mathbf{B}_{02} \mathbf{W}_0 \\ \mathbf{B}_{12} \mathbf{W}_1 \\ \vdots \\ \mathbf{B}_{N2} \mathbf{W}_N \end{pmatrix},\ \mathrm{a}_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ \vdots \\ a_{N0} \end{pmatrix},\ \varepsilon_t = \begin{pmatrix} \varepsilon_{0t} \\ \varepsilon_{1t} \\ \vdots \\ \varepsilon_{Nt} \end{pmatrix}.$$

If the $\mathbf{G}$ matrix is non singular, it can be inverted obtaining the Global VAR model in its reduced form, i.e

$$y_t = b_0 + \mathbf{F}_1 y_{t-1} + \mathbf{F}_2 y_{t-2} + v_t \tag{14}$$

where

$$\mathbf{F}_1 = \mathbf{G}^{-1}\mathbf{H}_1,\ \mathbf{F}_2 = \mathbf{G}^{-1}\mathbf{H}_2,\ \mathrm{b}_0 = \mathbf{G}^{-1}a_0,\ v_t = \mathbf{G}^{-1}\varepsilon_t.$$

3 The empirical results

In the application, we employ data for the main six wheat export countries: Argentina, Australia, Canada, Russia, EU and USA at monthly frequency for the period July 2000 to January 2012. The GVAR model includes five variables for each country-specific VARX model: the wheat export prices p_{it}^e, expressed in US dollars, the home wheat stock to utilization ratio z_{it}, the fertilizer price p_{it}^f expressed in US dollars. We first build the indexes of all variables using the period (July/2000-June/2001)=100 as the base year.

The fluctuation of the exchange rate influences the dynamic of export prices. As previously introduced the GVAR model accounts for the effects of country-specific and foreign-specific variables.

Thus the foreign-specific variables are constructed as (geometric) average of the single country variables using as weights the export-country shares. The weights are presented in Table 1. The choice of weights based on exports is undertaken with the rationale that exogenous shocks, as a wheat stock reductions or and exchange rate devaluation, could pass-through on export prices in all countries through the trade channel. We use fixed weights over time computed as average of the years 2008-2010. Data are from the International Grain Council. Thus, both country-specific and foreign-specific variables will affect the system. As for the exchange rate, wheat export prices in a specific country will be influenced by home variables as the stock to utilization ratio, the deflated exchange rate, the dynamics of fertilizer input prices and by the foreign-specific variables given by the average wheat stocks to utilization ratio, z_{it}^*, the rer_{it}^* variable, the average wheat foreign prices p_{it}^{e*}.

Table 1 about here

Finally, the home wheat export prices will be also influenced by global variables, i.e. variables common to all countries, as the oil price p_t^o. All variables, with the exception of the stock to utilization ratio, are log transformed. In the Data Appendix we present the data sources and the key steps used for their analysis.

The first step in the analysis is to test the nonstationary properties of our series.[2] The results are presented in Table (2). Given that the majority of the series are $I(1)$, the cointegrating VARX country models are estimated subject to the reduced rank restriction (Johansen, 1992 and 1995).

Table 2 about here

To this end we employ the *trace* and *maximum eigenvalue* statistics. Both tests are conducted at the 95% significance level when a restricted intercept is included in the model. The rank statistics are reported in Table (3), while the number of cointegrating relationships for each VARX country model and the VARX autoregressive orders p, q are reported in table (4). The VARX orders are estimated using the Akaike criterion. For all country models, with the exception of Australia, the rank tests suggest one cointegration relation. For Australia, both tests indicate the presence of two cointegrating relations. Thus, each country model has been estimated using its Vector Error Cointegration (VEC) form or, in other words, each country model is estimated subject to reduced rank restriction.

Table 3 about here

Table 4 about here

The estimation of the cointegrating VEC models gives the opportunity to analyze the effects of foreign variables on their home counterparts. Specifically, the model allows for the analysis of the impact on the home variables of a 1% change of the corresponding foreign-specific variables. These impacts have been labelled as *impact elasticities* and permit the analysis of the co-movements among

[2]All the procedures for the analysis of the GVAR model have been written using GAUSS 11.

the home and foreign variables. In table (5), we present the impact elasticities and their t-statistics. Looking at wheat export prices, we find that all the estimates are positive and significant, with the exception of Russia estimate that it is not significant at the 5% significance level. Moreover, USA, Canada and Australia show an impact elasticity close to one. Positive but mainly non significant co-movements are evidenced by the real exchange rate variable. EU is the only region that shows a positive an significant estimate. Finally the stock-to utilization ratio variable presents both positive and negative co-movements. Argentina reports a negative and significant correlation, the elasticity for Russia is negative but not significant. However, the elasticities are positive and significant for the remaining countries.

Table 5 about here

The GVAR model requires to account for the hypothesis of weak exogeneity for both the foreign and global variables. We use the exogeneity test proposed by Johansen (1992). For each country-specific model, the following regression is performed

$$\Delta y_{it,l} = \mu_{il} + \sum_{j=1}^{r_i} \gamma_{ij,l} ECM^j_{i,t-1} + \sum_{k=1}^{p_i} \phi_{ik,l} \Delta y_{i,t-k} + \sum_{m=1}^{q_i} \theta_{ik,l} \Delta \tilde{y}_{i,t-m} + \epsilon_{it,l} \tag{15}$$

where the $\Delta y_{i,t-k}$ is the group of home variables expressed in differences, with $k = 1, ..., p_i$ and p_i is the lag order of the home component for each of i^{th} country model, $\Delta \tilde{y}_{i,t-m}$ is the set of foreign-specific and global variables in differences, with $m = 1, ..., q$ and q is the lag order of the foreign-specific and global components for each of i^{th} country model, and finally $ECM^j_{i,t-1}$ is the estimated error correction term, with $j = 1, ..., r_i$, and r_i is the number of cointegrating relations, i.e. the rank, found in the i^{th} country model. The procedure consists in testing by means of an F the joint hypothesis that $\gamma_{ij,l} = 0$ for each $j = 1, ..., r_i$. Results of Table 6 indicate that the hypothesis of weak exogeneity cannot be rejected.

Table 6 about here

4 Generalized Impulse Response Analysis

In the absence of strong a priori information to identify the short-run dynamics of our system, we use the generalised impulse response function (GIRF) approach proposed in Koop, Pesaran and Potter (1996) and further developed in Pesaran and Shin (1996). The GIRF has the nice property of being invariant to the ordering of the variables and of the countries. This is of particular importance in our system where there is not a clear economic *a priori* knowledge which can establish a reasonable ordering. To assess the dynamic properties of the GVAR model and the time profile of the effects of shocks to home foreign variables, we analyze the implications of five different external shocks:

- A one standard error negative shock to US stock to utilization ratio
- A one standard error negative shock to global stock to utilization ratio
- A one standard error positive shock to oil price
- A one standard error negative shock to real effective exchange rate
- A one standard error positive shock to fertilizer price

Due to space limitation we only present the GIRF impulse responses of the wheat export prices for the various countries analyzed and we focus on the first two years following the shock.

The first shock we consider is a negative shock to the USA stock to utilization ratio. In this case a one-standard deviation shock corresponds to a decrease of 0.11% of the value of the variable.[3] In Figure 2, we show the effect of this shock on the wheat export prices with the solid line, while the 90% bootstrapped confidence intervals are represented by the thinner lines [4]. Unsurprisingly, a negative shock to US stock to utilization ratio raises the export prices in all countries. In US the response

[3] During the period of analysis, the average value of the variable is 0.511.
[4] The confidence interval is calculated using the sieve bootstrap method with 1000 replications.

impact is +1.6%, after three months the wheat export price reaches the maximum of +4.9%. Similar shapes are evidenced by other countries. Argentina, Australia, Canada show similar impacts after the stock to utilization ratio shock, while Russia and EU present minor impact with long-run increase of wheat export prices of +2.0%.

Figure 2 about here

The second shock we analyze is what can be labelled *the perfect storm* of the stock to utilization ratio variable. We simulate a decrease of this variable in all countries, i.e. we assume a general reduction in stock detained by the main export countries. The one-standard deviation shock corresponds in this case to an average decrease of 0.14%[5]. The impact on export prices is shown in Figure 3. As expected, the contemporaneous effect on wheat export prices is relevant. The export prices raise from the minimum value of +1.3% in Argentina to the maximum value of +3.0% in USA. Second-round effects are also relevant. Export prices in the first rapidly increase reaching values that ranges from +6.6% in Canada to +13.1% in Russia before reducing in the following months.

Figure 3 about here

The devaluation of the US exchange rate has been ascribed as one of the main factors behind the commodity prices upsurge during the period 2007-2008. For this reason we simulate the effect of reduction on the rer_{it}^* variable that can be interpreted as a global (real) devaluation of the US exchange rate. A one standard error shock in this case is equivalent to a fall of around 15% of the US dollar against the competitors' currencies. Interestingly, the shock is accompanied by a raise of wheat export prices of the same entity. Thus, with the exception of Argentina and Australia that show a lower impact, on average we note an unitary elasticity of wheat export prices to a devaluation.

Figure 4 about here

In Figure 5 are presented the impulse responses of a one standard error shock on the fertilizer price. In this case the one standard error shock means a raise of fertilizer price of 19.4%. This increase is associated with an increase in wheat export prices of 1.4%. The full effect after 24 months is differentiated. Russia and EU show the same long-run impact +7%, the long-run impact for USA remains at a baseline of 4% and for the other countries the magnitude of the rate of growth of wheat prices remains limited between 1% and 2%.

Figure 5 about here

We finally analyze the effect of a global oil price shock to the dynamics of the export prices. The results are reported in Figure 6. A positive standard error unit shock to nominal oil prices corresponds to an increase of about 8.6 percent of the oil price index in one month. The impact of wheat export prices vary significantly among countries. For US and EU area the impact is quite similar and equal to 1.0%. Australia is the country that seems to suffer more for an oil shock with an impact on wheat export price close to 1.5%.

Figure 6 about here

5 Concluding Remarks

In this paper, we have employed the Global Vector Autoregressive (GVAR) methodology for the analysis of short and long-run response of wheat export prices to both different country-specific and common shocks. Impulse response analysis reveals that a decrease of wheat stocks with respect to the level of consumption, and increase of oil prices and real exchange rate devaluation have all inflationary effects on wheat export prices although their impacts are different among the main export countries. Unfortunately by construction the model is nonstructural. Structural interpretations of VAR models require additional identifying assumptions that must be motivated mainly on institutional knowledge, economic theory, or other constraints on the model responses. Only after having identified the model we can assess the causal effects of all previous shocks on the model variables. However this work can be done using the approach proposed by Dees et al. (2007), and we leave this for future research.

[5]This value has been obtained as using single countries export shares

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Data Appendix

In this appendix we describe our data sources and key steps in the analysis of our data.
Wheat Export Prices:
- Source: International Grain Council. Index : 2000.7 - 2001.6 = 100.
Stock to utilization ratio
- Source: USDA, Grain World Markets and Trade
- Ratio of Predicted Ending Stocks on Predicted Consumption
Nominal Exchange rate
- Source : IMF Financial Statistics and Financial Statistics of the Federal Reserve Board.
- Real exchange rate : Ration of Nominal exchange rate of each country over wheat export prices of the same country. Index : 2000.7 - 2001.6 = 100.
Fertilizer prices
- Source: World Bank Commodity Price Data (Pink Sheet)
- DAP (Diammonium Phosphate) price. Nominal US dollar. Index : 2000.7 - 2001.6 = 100.
Oil price
- Source: World Bank Commodity Price Data (Pink Sheet)
- Crude oil price. Nominal US dollar. Index : 2000.7 - 2001.6 = 100.

Table 1: Trade Weights Based on Wheat Export Statistics

Variables	Argentina	Australia	Canada	Russia	EU	USA
Argentina	0.00000	0.12179	0.16149	0.32007	0.18444	0.21220
Australia	0.04941	0.00000	0.17480	0.34646	0.19965	0.22969
Canada	0.05163	0.13775	0.00000	0.36201	0.20861	0.24000
Russia	0.06291	0.16786	0.22257	0.00000	0.25420	0.29246
EU	0.05300	0.14142	0.18752	0.37166	0.00000	0.24640
USA	0.05477	0.14613	0.19376	0.38404	0.22130	0.00000

Notes: International Grain Council. Trade weights are computed as averages of shares of exports over the period 2008-2010. They are displayed in row by country. Each row, but not column, sums to 1

Table 2: Augmented Dickey-Fuller unit root statistics for Home and Foreign Variables

Variables	Argentina	Australia	Canada	Russia	EU	USA
p_{it}^{e}	-1.610	-2.530	-1.735	-1.484	-1.339	-1.901
z_{it}	-1.100	-3.088	-2.959	-2.411	-1.489	-1.953
rer_{it}^{d}	-2.800	-1.669	-0.500	-0.500	-1.539	-
p_{t}^{f}	-1.190	-1.190	-1.190	-1.190	-1.190	-1.190
p_{it}^{e*}	-1.370	-1.324	-1.367	-1.386	-1.787	-1.510
z_{it}^{*}	-2.006	-2.363	-1.822	-2.243	-2.857	-2.827
rer_{it}^{*}	-1.574	-1.640	-1.380	-2.623	-1.323	-1.576
p_{t}^{o*}	-1.109	-1.109	-1.109	-1.109	-1.109	-1.109

Notes: The ADF statistics are based on univariate $AR(p)$ models in the levels with p chosen according to Ng and Perron (2001) procedure. The regressions for all variables include an intercept. The 95% critical value of the ADF statistics for regressions without trend is -2.59.

Table 3: Cointegration Rank Statistics

Country	Trace				Maximum Eigenvalue			
	H_0	H_1	Statistics	95% Cr. Values	H_0	H_1	Statistics	95% Cr. Values
Argentina	$r = 0$	$r > 1$	96.24	90.60	$r = 0$	$r = 1$	44.87	40.19
	$r < 1$	$r \geq 2$	51.37	63.10	$r < 1$	$r = 2$	28.01	34.15
	$r \leq 0$	$r \geq 3$	23.36	39.94	$r \leq 2$	$r = 3$	13.17	27.82
	$r \leq 0$	$r \geq 4$	10.20	20.63	$r \leq 3$	$r = 4$	10.20	20.63
Australia	$r = 0$	$r > 1$	127.91	90.60	$r = 0$	$r = 1$	51.39	40.19
	$r < 1$	$r \geq 2$	76.52	63.10	$r < 1$	$r = 2$	39.04	34.15
	$r \leq 0$	$r \geq 3$	37.48	39.94	$r \leq 2$	$r = 3$	20.14	27.82
	$r \leq 0$	$r \geq 4$	17.34	20.63	$r \leq 3$	$r = 4$	17.34	20.63
Canada	$r = 0$	$r > 1$	124.43	90.60	$r = 0$	$r = 1$	48.74	40.19
	$r < 1$	$r \geq 2$	75.59	63.10	$r < 1$	$r = 2$	33.18	34.15
	$r \leq 0$	$r \geq 3$	42.40	39.94	$r \leq 2$	$r = 3$	27.93	27.82
	$r \leq 0$	$r \geq 4$	14.47	20.63	$r \leq 3$	$r = 4$	14.47	20.63
Russia	$r = 0$	$r > 1$	99.37	90.60	$r = 0$	$r = 1$	45.04	40.19
	$r < 1$	$r \geq 2$	54.33	63.10	$r < 1$	$r = 2$	21.79	34.15
	$r \leq 0$	$r \geq 3$	32.54	39.94	$r \leq 2$	$r = 3$	20.89	27.82
	$r \leq 0$	$r \geq 4$	11.65	20.63	$r \leq 3$	$r = 4$	11.65	20.63
EU	$r = 0$	$r > 1$	102.52	90.60	$r = 0$	$r = 1$	40.53	40.19
	$r < 1$	$r \geq 2$	61.99	63.10	$r < 1$	$r = 2$	36.06	34.15
	$r \leq 0$	$r \geq 3$	25.93	39.94	$r \leq 2$	$r = 3$	15.28	27.82
	$r \leq 0$	$r \geq 4$	10.65	20.63	$r \leq 3$	$r = 4$	10.65	20.63
USA	$r = 0$	$r > 1$	64.15	90.60	$r = 0$	$r = 1$	37.41	40.19
	$r < 1$	$r \geq 2$	26.75	63.10	$r < 1$	$r = 2$	22.07	34.15
	$r \leq 0$	$r \geq 3$	4.67	39.94	$r \leq 2$	$r = 3$	4.67	27.82

Notes: The null hypothesis (H_0) indicates r cointegration vectors against the alternative hyphotesis (H_1) of (at most) $r+1$ cointegration vectors for the maximum eigenvalue (trace) test. r is chosen as the first non significant statistics, undertaking sequentially the test starting from $r = 0$.

Table 4: VARX Order and Number of Cointegrating Relationship

Country	p_i	q_i	Cointegrating Relationship
Argentina	1	1	1
Australia	3	1	2
Canada	1	1	1
Russia	3	1	1
EU	1	1	1
USA	3	1	1

Notes: Rank orders are derived using Johansen's trace statistics at the 95% critical value level.

Table 5: Contemporaneous Effects of Foreign variables on Home-Specific Counterparts

Country	p^{e*}_{it}	z^*_{it}	rer^*_{it}
Argentina	0.323	−0.534	0.763
	(3.013)	(−8.369)	(0.109)
Australia	0.995	0.872	0.402
	(4.426)	(7.666)	(1.727)
Canada	1.191	0.629	−0.134
	(3.817)	(8.172)	(−0.368)
Russia	0.311	−0.119	0.672
	(0.647)	(−0.905)	(1.412)
EU	0.729	0.088	0.89
	(4.495)	(6.269)	(3.814)
USA	0.980	0.214	−−
	(7.754)	(2.928)	(−−)

Table 6: F Statistics for Testing the Weak Exogeneity of Country-specific Foreign and Global Variables

Country		p^{e*}_{it}	z^*_{it}	rer^*_{it}	p^o_{it}
Argentina	F(1,127)	1.673	0.657	2.684	0.682
		(0.194)	(0.419)	(0.104)	(0.410)
Australia	F(2,116)	0.729	1.248	1.016	0.756
		(0.485)	(0.291)	(0.365)	(0.472)
Canada	F(1,127)	0.222	0.203	0.628	1.558
		(0.638)	(0.653)	(0.429)	(0.214)
Russia	F(1,117)	0.195	0.257	0.359	0.007
		(0.660)	(0.613)	(0.550)	(0.782)
EU	F(1,127)	3.041	2.792	1.669	0.529
		(0.084)	(0.097)	(0.199)	(0.468)
USA	F(1,121)	1.101	0.154	−−	0.601
		(0.296)	(0.695)	(−−)	(0.440)

Notes: In parentheses the p-values

Figure 1: FAO Food and Cereals prices indexes (logarithms) 1990.1 - 2013.3

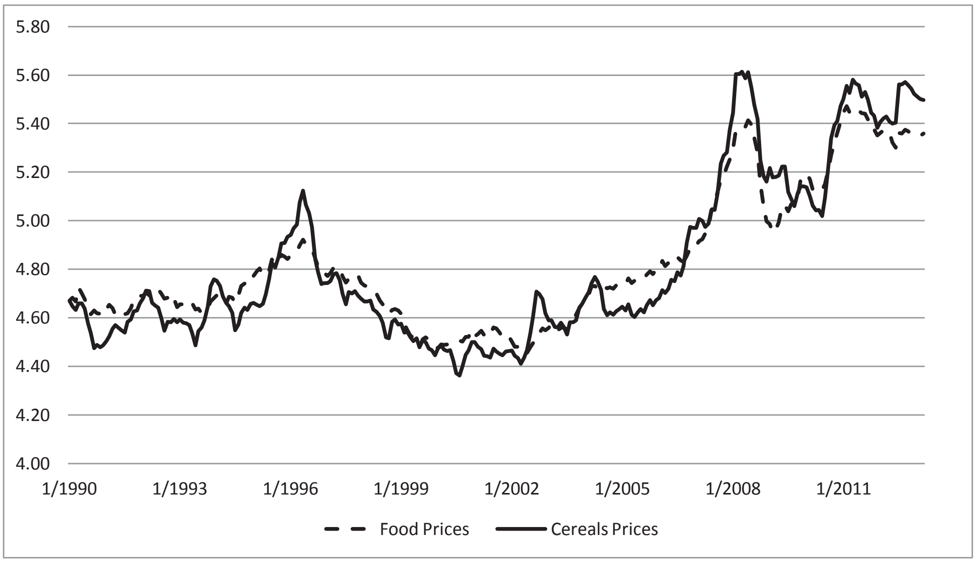
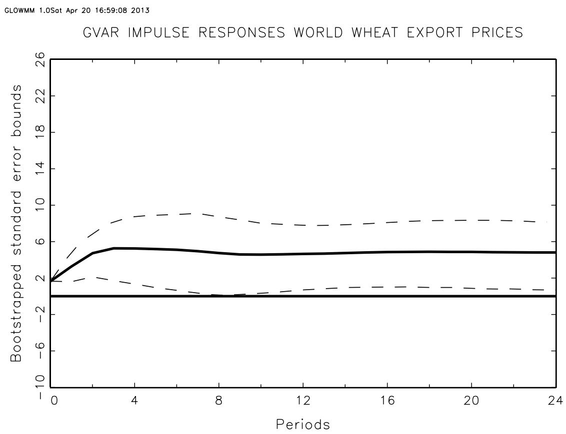
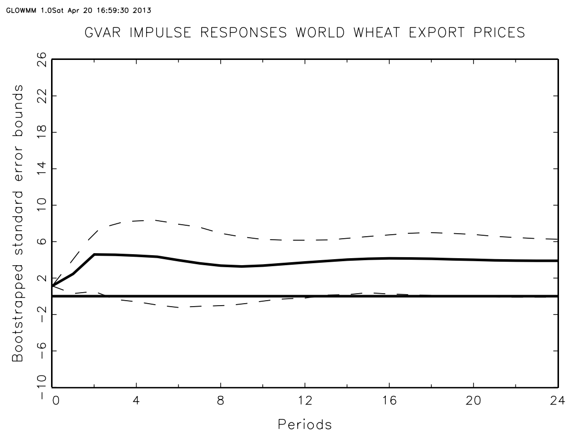


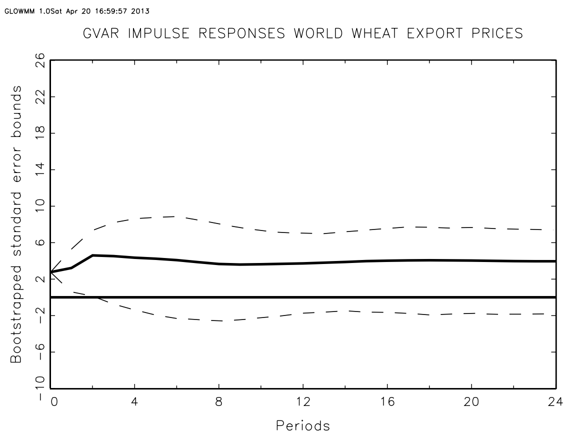
Figure 2: GVAR Impulse Responses of Wheat Export Prices to a USA Stock to Utilization Ratio Shock.



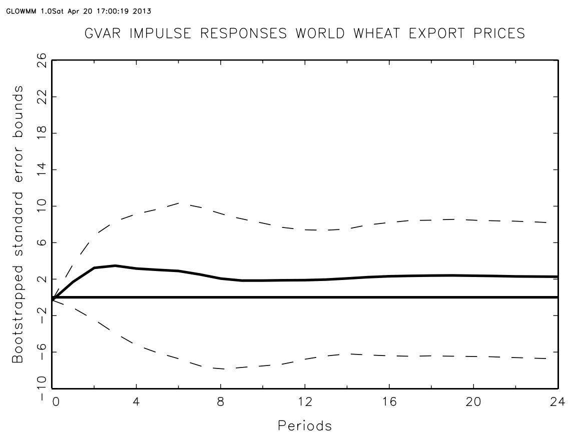
(a) Argentina



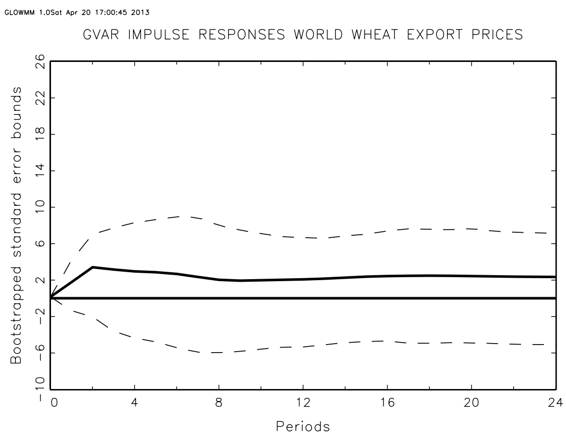
(b) Australia



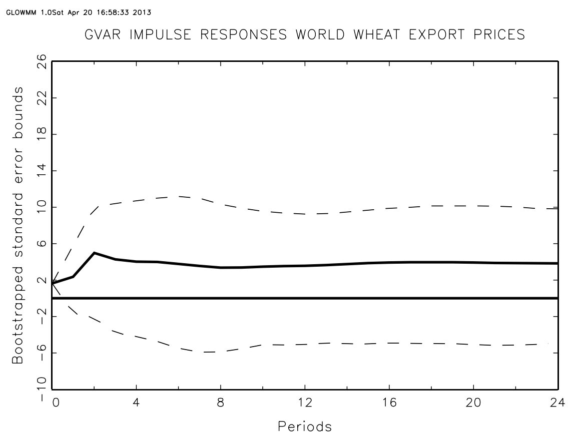
(c) Canada



(d) Russia

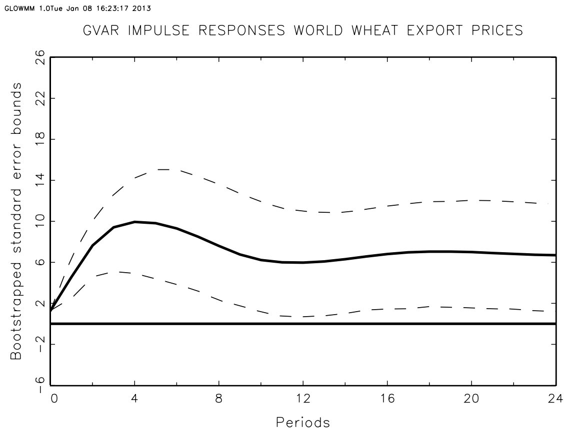


(e) EU

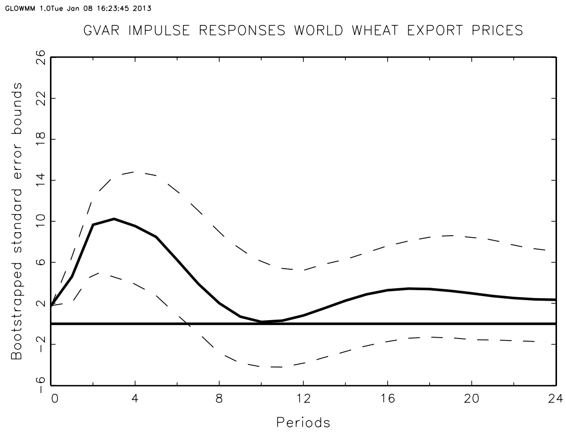


(f) USA

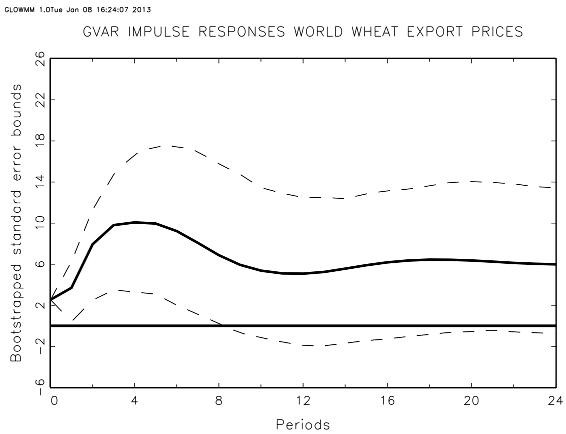
Figure 3: GVAR Impulse Responses of Wheat Export Prices to a Global Stock to Utilization Ratio Shock.



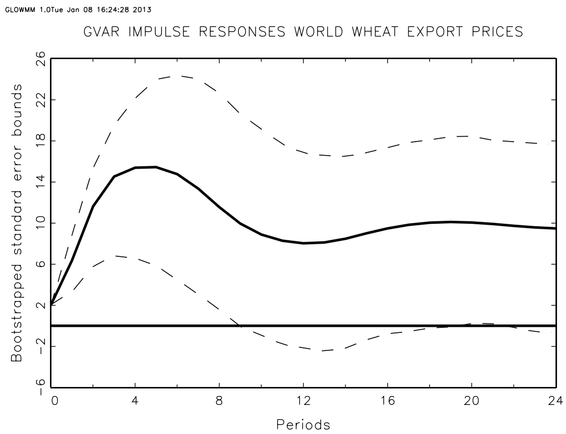
(a) Argentina



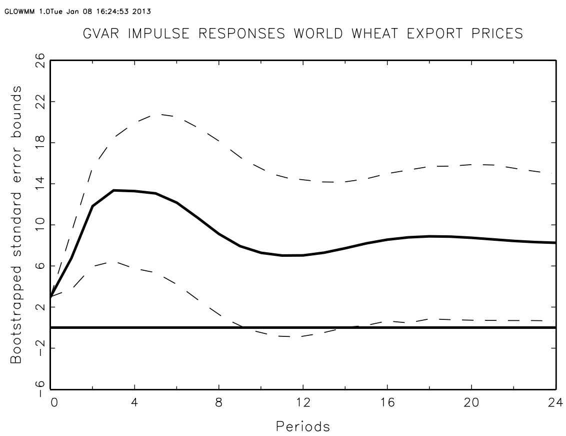
(b) Australia



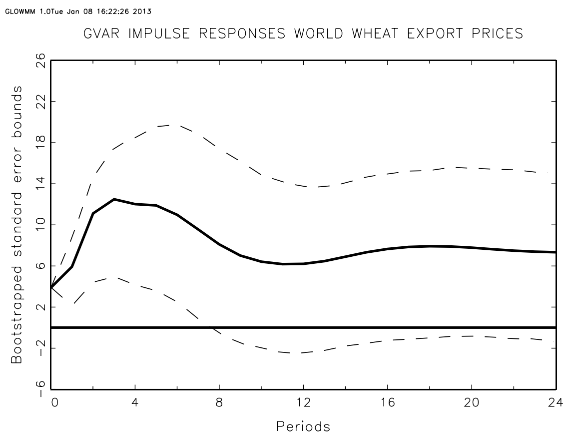
(c) Canada



(d) Russia

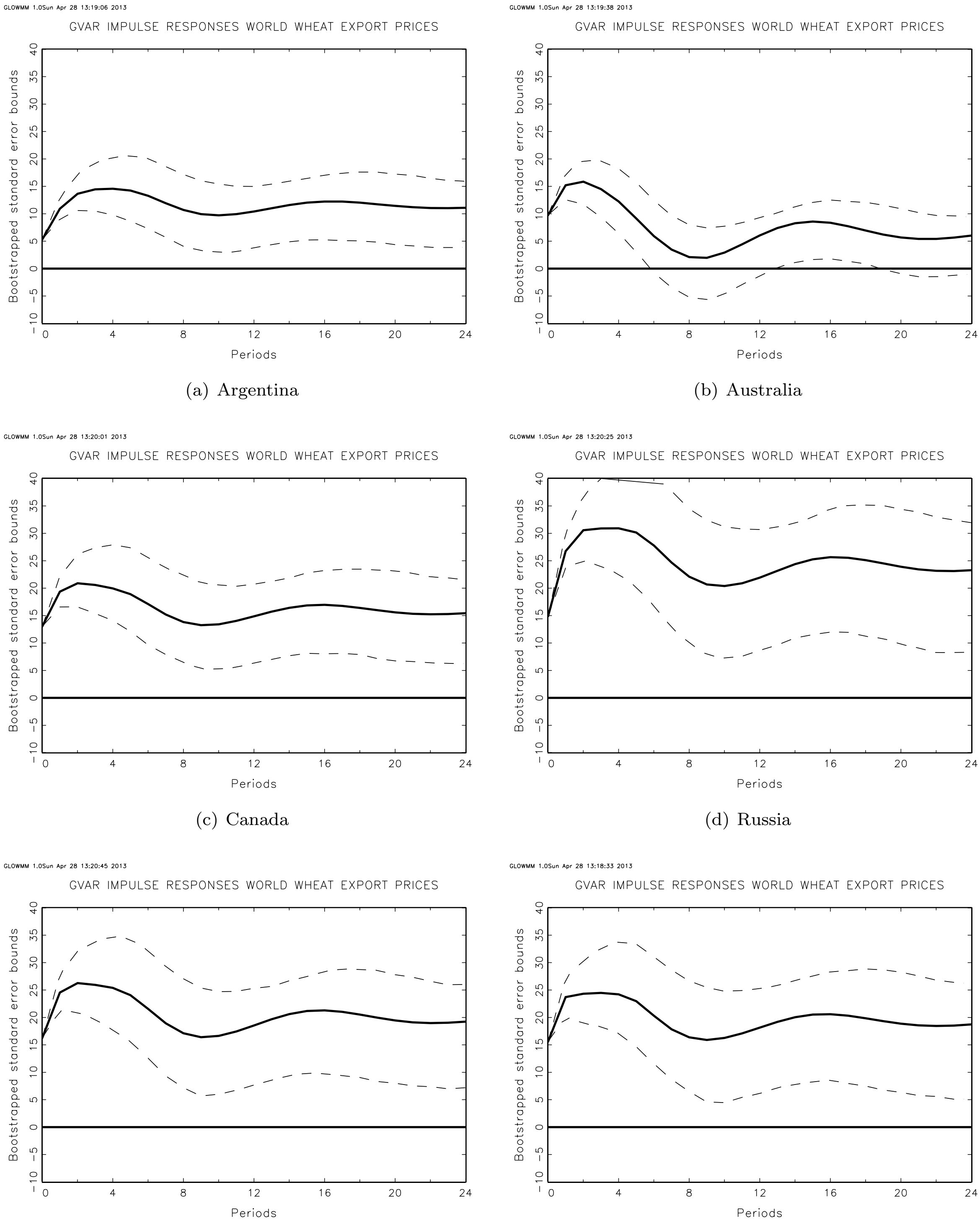


(e) EU



(f) USA

Figure 4: GVAR Impulse Responses of Wheat Export Prices to a US dollar devaluation shock.



(a) Argentina

(b) Australia

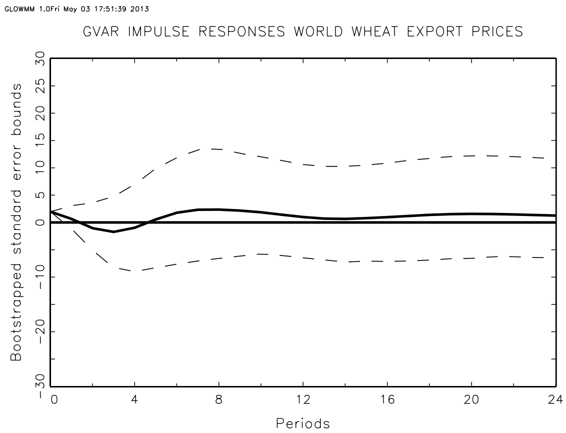
(c) Canada

(d) Russia

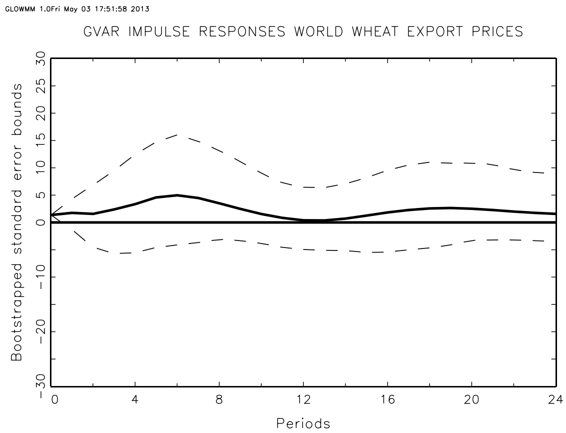
(e) EU

(f) USA

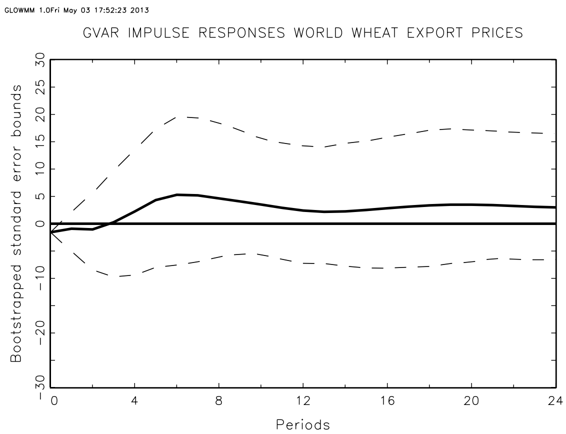
Figure 5: GVAR Impulse Responses of Wheat Export Prices to a Global fertilizer input price shock.



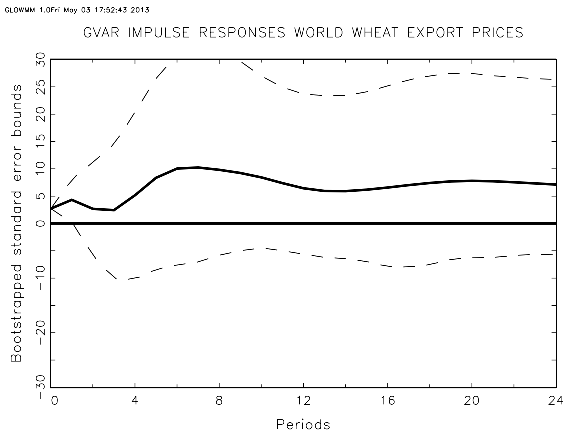
(a) Argentina



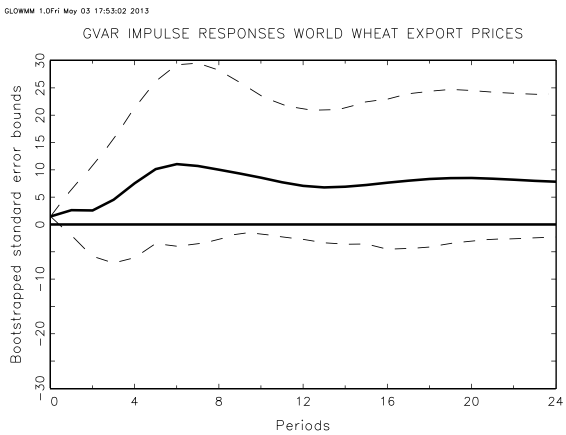
(b) Australia



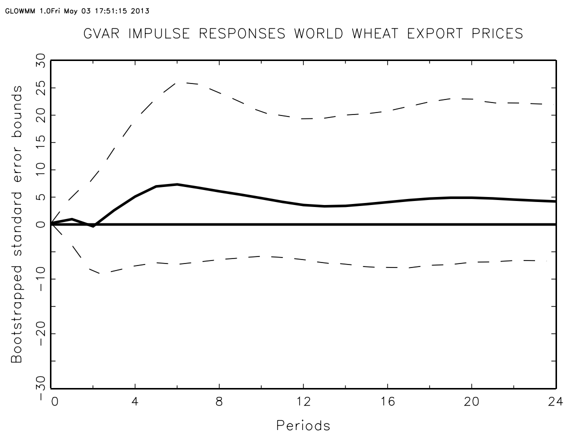
(c) Canada



(d) Russia

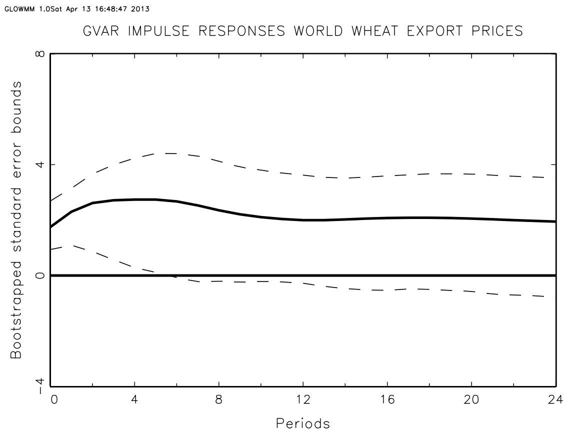


(e) EU

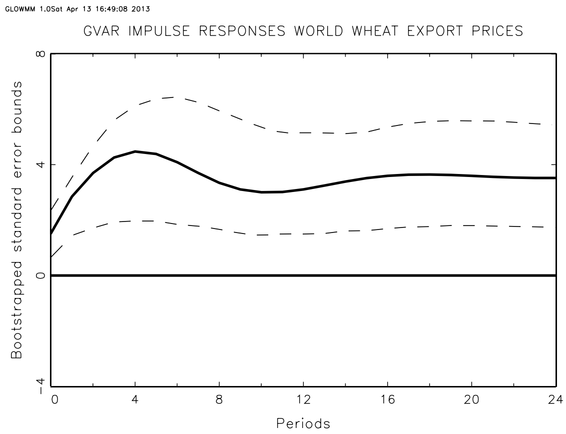


(f) USA

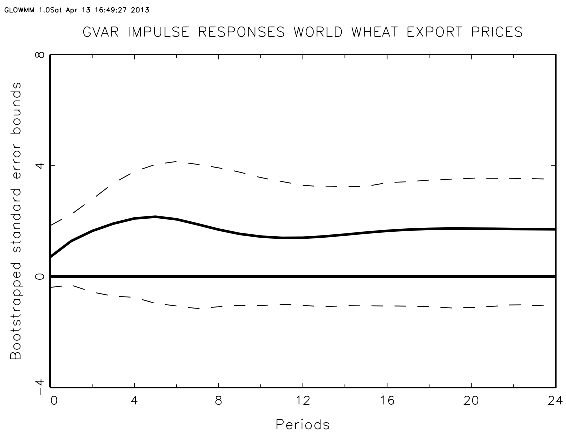
Figure 6: GVAR Impulse Responses of Wheat Export Prices to an Oil price shock.



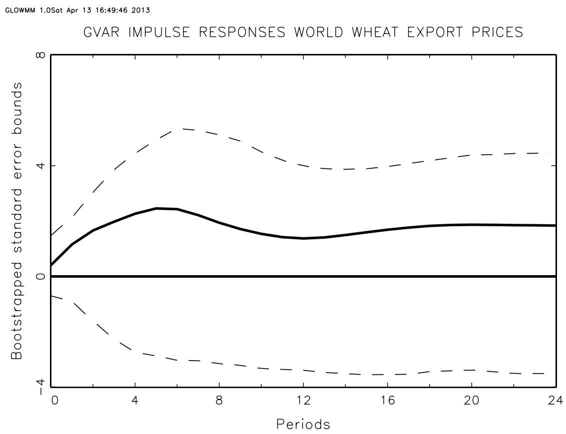
(a) Argentina



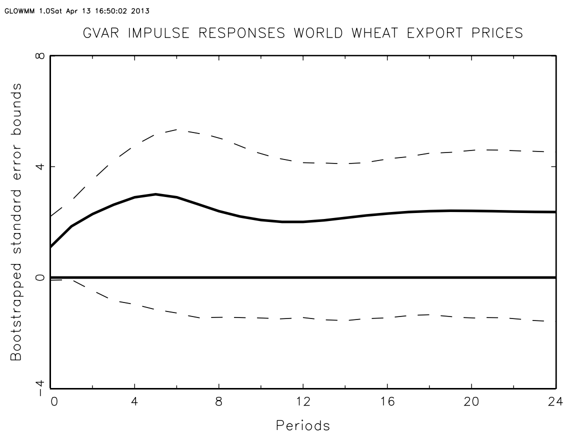
(b) Australia



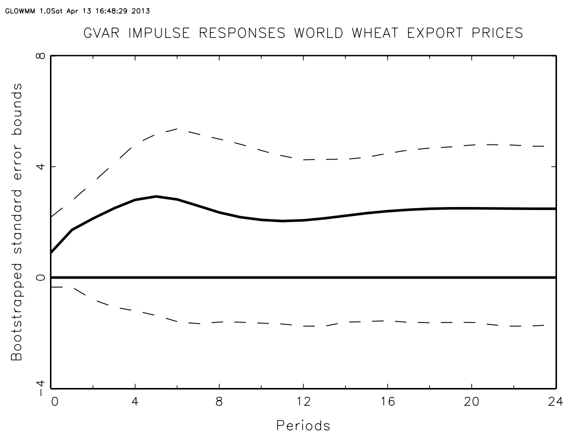
(c) Canada



(d) Russia



(e) EU



(f) USA