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Price transmission from international to domestic markets

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Abstract

This study aims to improve our understanding of the extent and speed of the transmission of international cereal prices to local markets in developing countries. We analyse two samples of price transmission (PT) estimates, one extracted from a comprehensive literature sample of 31 published papers and studies on cereal price transmission and one containing of own estimates of cereal PT using the FAO's GIEWS dataset. We also present the results of a non-parametric analysis of PT in which we analyse the share of periods in which domestic and international prices have jointly increased or decreased.

We find a higher share of cointegrated commodity market pairs in the literature sample (79% compared to 43%). This may be due to publication bias. Cointegration is more prevalent for maize market pairs and less prevalent for rice market pairs. Both the literature and the GIEWS-based estimates point to average long-run PT coefficients of roughly 0.75 and average short-run adjustment parameters of roughly 0.09-0.11. In most cases domestic prices adjust to deviations from the long-run price relationship, but international prices do not. The only notable exception to this rule is rice, which suggests that the determination of international rice prices differs fundamentally from the determination of international wheat and maize prices.

In a subsequent meta-regression analysis we measure how much of the variation in the samples of PT estimates can be explained by country- or product-specific factors. However, this analysis fails to generate compelling results. An analysis of domestic price volatility reveals that median volatility has increased since July 2007.

JEL:

C32, Q11, Q17, Q18

Keywords:

price transmission, cointegration, developing countries, agricultural trade, maize, rice, wheat, commodity prices

Executive Summary

1. This study aims to improve our understanding of the extent and speed of the transmission of international cereal prices to local markets in developing countries. We undertake three types of analysis:
    a. First, we extract a sample of estimated measures of cereal price transmission (PT) from a comprehensive literature sample of published papers and studies.
    b. Second, we use the FAO's GIEWS dataset to estimate our own sample of measures of cereal PT. In a subsequent meta-regression analysis we measure how much of the variation in each of the resulting samples of PT estimates (the literature sample and the GIEWS sample) can be explained by factors that might be expected to influence the strength of PT such as whether the country in question is landlocked.
    c. Third, we present the results of simple, non-parametric analysis of price transmission using the GIEWS data. This analysis measures the share of periods in which domestic and international prices have jointly increased or decreased.
2. 79% of the international/domestic price pairs in our sample of PT studies from the literature are cointegrated compared with 43% in our own estimates based on FAO GIEWS data. Hence, regardless of which database is used, many of the studied price pairs are not cointegrated and thus do not provide evidence of stable PT. This is especially the case if we consider that the literature sample most likely suffers from publication bias that leads to an overrepresentation of findings of cointegration.
3. Overall, maize markets are characterized by a below-average prevalence of cointegration, and rice markets by an above-average prevalence. Which regions of the world display higher/lower shares of cointegration depends on which dataset is considered: according to the literature sample, domestic prices in Africa are less likely than average to be cointegrated with corresponding international prices, but the estimates generated with GIEWS data suggest that domestic prices in Asia are least likely to be cointegrated with international prices.
4. Both the literature and the GIEWS-based estimated point to average long-run PT coefficients of roughly 0.75 and average short-run adjustment parameters of roughly 0.09-0.11. This suggests that on average roughly three-quarters of a change in international prices will be transmitted to domestic markets, and that it takes approximately 6-7 months for one-half of a given price shock on international cereal markets to be transmitted to domestic markets.
5. In most cases, domestic prices adjust to deviations from the long-run price relationship, but international prices do not. The only notable exception to this rule is rice. There is evidence of a statistically significant reaction by international prices to disequilibrium between domestic and international prices in 121 market pairs, of which 111 involve rice. Roughly 40% of all rice prices are affected. These involve a variety of countries and not only 'large' ones such as China or India. These results suggest that the determination of international rice prices differs fundamentally from the determination of international wheat and maize prices. We conclude that most countries are price takers on wheat and maize markets, but the evidence for rice is mixed.
6. Comparing PT in the period prior to July 2007 with PT in the period thereafter reveals no clear pattern. On maize markets the long-run PT coefficients have fallen considerably since mid-2007. This could be interpreted as evidence of a decoupling of domestic from international prices. On rice and wheat markets there is evidence that the long-run PT coefficients have increased, but at the same time the short-run adjustment coefficients have fallen, suggesting that PT has become more complete but slower since mid-2007 for rice and wheat.

7. Employing meta-regression analysis to explain variations in long-run PT coefficients between domestic and international prices fails to generate compelling results. The meta-regressions for the short-run adjustment parameters provide evidence of more rapid PT for maize than for wheat and rice, and more rapid PT in West Africa than in other regions. An increasing ratio of net imports to domestic consumption is associated with slower PT, which may be an indication of increased intervention on politically more sensitive markets. There is evidence that trade openness is positively associated with the speed of PT, but this effect is only significant in the pre-July 2007 period. Finally, there is some counterintuitive indication that improved logistics are correlated with slower PT.
8. The analysis of agreement in the direction in price changes on international and domestic markets suggests that the frequency of agreement is quite low at the monthly level, and only somewhat higher at the quarterly level. This lack of agreement is especially pronounced when international prices are falling; in this case domestic prices only fall as well in roughly 50% of all cases, which is what one would expect if price movements on international and domestic markets were completely independent. When international prices are increasing, there is a higher probability that domestic prices will increase as well, especially at the quarterly level for Europe, Asia, East Africa and Latin America. Overall these results support the findings of generally weak PT that were derived from the cointegration analysis.
9. The analysis of domestic price volatility reveals that median volatility has increased since July 2007. There is no difference between the median volatilities of those prices that are cointegrated with the corresponding international prices and those that are not. This suggests that on average, countries that have decoupled their domestic cereal prices from international prices have not benefited from reduced price volatility as a result. The analysis reveals that in general, domestic prices are most volatile in East and West Africa, followed by Latin America and Latin America. Furthermore, on average domestic maize and wheat prices are more volatile than the corresponding international prices, while domestic rice prices are less volatile.

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1. Introduction

This study aims to improve our understanding of the extent and speed of the transmission of international cereal prices to local markets in developing countries. Spurred by the recent peaks in international food prices, many studies of world-to-domestic price transmission (PT) have been produced. However, to date no one has attempted to extract general lessons about the factors that determine the strength of PT from this extensive empirical literature. Neither has anyone attempted to extract such lessons by estimating PT processes with a consistent set of price data for a large number of countries using a uniform methodology.

To address this gap, we undertake three types of analysis in this study. First, we extract a sample of estimated measures of cereal PT from a comprehensive literature sample of published papers and studies. Second, we use the FAO's GIEWS dataset to estimate our own sample of measures of cereal PT. In a subsequent meta-regression analysis we measure how much of the variation in each of the resulting samples of PT estimates (the literature sample and the GIEWS sample) can be attributed to factors that might be expected to influence the strength of PT. Third, we present the results of simple, non-parametric analysis of price transmission using the GIEWS data. This analysis measures the share of periods in which domestic and international prices both either increased or decreased. This enables us to determine whether domestic prices at least tend to move in the same direction as international prices, even if they are not linked by a stable parametric relationship.

The rest of this study is structured as follows. In section 2 we begin by providing a brief summary of the vector error correction model that has been used in the great majority of empirical studies of PT over the last decade. In section 3 we then describe how we assembled our literature sample of PT estimates (section 3.1), and how we used the GIEWS dataset to generate our own set of PT estimates (section 3.2). In Section 4 we then describe the meta-analysis that we use to explain differences in the estimated strength of PT, beginning with a description of the covariates that we employ as possible determinants of PT (section 4.1) followed by a discussion of the results (section 4.2). Section 5 then presents the results of the non-parametric analysis of the direction of price movements. Section 6 presents some evidence on the volatility of domestic compared with international prices for different cereals and regions, and section 7 concludes.

2. Methods: the vector error correction model

2.1 The structure of the vector error correction model

The study of PT for homogeneous commodities in space, or for a product as it is transformed along the stages of the marketing chain (e.g. wheat – flour – bread), has attracted the interest of agricultural economists for many decades (Meyer 2004). Early empirical studies of PT were based on simple correlation and regression analyses that did not account for dynamics and lead-lag relationships in price data (for a survey, see Fackler and Goodwin, 2001). In the course of the 1980s, these methods were increasingly replaced by dynamic regression models that include lagged prices (e.g. Ravallion, 1986) and studies based on the concept of Granger causality (Gupta and Mueller, 1982). The emerging cointegration literature highlighted several pitfalls associated with the regression analysis of price data. In particular, since price data are often non-stationary, regression can lead to spurious results (Hassouneh et al, 2012). The basic insight of the cointegration approach is that to avoid the pitfall of spurious regression one must test whether non-stationary prices series (also referred to as 'integrated' price series) are not only correlated with one another but are rather 'co-integrated'. Cointegrated means that there exists a linear combination of the non-stationary series that is itself stationary, in other words that the series share a common form of non-stationarity and cannot drift apart indefinitely.

Ardeni (1989) published the first study of PT on agricultural markets based on cointegration methods. It is fair to say that with the exception of a comparatively small literature based on so-called parity bounds models (Barrett and Li, 2002) today essentially the entire empirical PT literature draws on cointegration methods and, in particular, the so-called vector error correction model (VECM). The VECM is a re-parametrization of the standard vector autoregressive (VAR) model which relates the current levels of a set of time series to lagged values of those series. A simple VECM that captures the interactions between international or world prices and domestic price takes the following form:

(1) $$\Delta p_t^d = \varphi_1 + \alpha_1 \underbrace{\left(p_{t-1}^d - \beta_1 p_{t-1}^w\right)}_{error\ correction\ term} + \delta_1 \Delta p_{t-1}^w + \rho_1 \Delta p_{t-1}^d + \varepsilon_{1t} \text{ (a)}$$

$$\Delta p_t^w = \varphi_2 + \alpha_2 \underbrace{\left(p_{t-1}^d - \beta_1 p_{t-1}^w\right)}_{error\ correction\ term} + \delta_2 \Delta p_{t-1}^w + \rho_2 \Delta p_{t-1}^d + \varepsilon_{2t} \text{ (b).}$$

where
p_t^d is the domestic price;
p_t^w is the world price; and
φ, α, β, δ, and ρ are parameters to be estimated.

In matrix notation, and allowing for more than one lag of the price difference terms, this VECM can be written compactly as:

(2) $$\begin{bmatrix} \Delta p_t^d \\ \Delta p_t^w \end{bmatrix} = \begin{bmatrix} \varphi_1 \\ \varphi_2 \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \begin{bmatrix} 1 & \beta_1 \end{bmatrix} \begin{bmatrix} p_{t-1}^d \\ p_{t-1}^w \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \delta_{1i} & \rho_{1i} \\ \delta_{2i} & \rho_{2i} \end{bmatrix} \begin{bmatrix} \Delta p_{t-i}^w \\ \Delta p_{t-i}^d \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}.$$

From the perspective of empirical PT analysis, the main advantage of the VECM over the VAR is that it separates the long-run equilibrium (or 'cointegrating') relationship between p^w and p^d – which is captured by the error correction term $\left(p_{t-1}^d - \beta_1 p_{t-1}^w\right)$ – from the short-run dynamics that ensure that any deviations from this long-run equilibrium are 'corrected' and thus only temporary. The key parameters in the VECM are β_1, which describes how one price reacts to changes in the other in the long run[2], and the so-called 'adjustment' parameters α_1 and α_2. If p^w and p^d are cointegrated, then α_1 and α_2 must have negative and positive signs, respectively. If this is the case, then if for example p^d becomes too large relative to p^w and the error correction term is correspondingly positive, a decrease in p^d in the first equation of the VECM, and an increase in p^w in the second equation, will drive the prices back towards their long-run equilibrium. One-to-one price transmission in the long run requires that $\beta_1 = 1$, while $0 < |\alpha_i| \leq 1$, with large (small) values of α_1 and α_2 indicating that errors are corrected rapidly (slowly).[3]

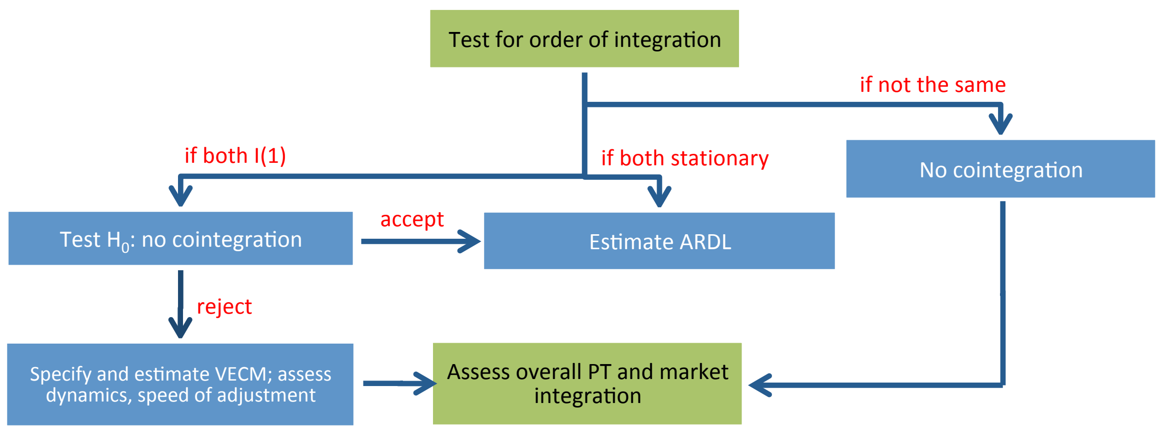
Figure 1 outlines the basic empirical strategy for estimating PT. The first step is to determine whether the individual price series p^w and p^d are both non-stationary (also referred to as 'integrated' or 'I(1)'). This is usually carried out using the ADF (Dickey and Fuller, 1979) and KPSS tests (Kwiatkowski et al., 1992). If the prices are not both I(1), they cannot be cointegrated. If they are both stationary or 'I(0)' they can be studied using Auto-Regressive Distributed Lag (ARDL) models. If the series are both I(1), the null hypothesis that they are not cointegrated can be tested using a two-step OLS procedure proposed by Engle and Granger (1987) or a maximum likelihood procedure developed by Johansen (1988). If the null of no cointegration is rejected, the VECM in equation (2) can be estimated, again

[2] If estimation is based on prices in logarithms then β_1 can be interpreted as the long-run elasticity of price transmission.

[3] The speed of error correction captured by the magnitude of an adjustment parameter must be interpreted relative to the frequency of the data that is used to estimate it. An α of 0.4 estimated with annual data implies that 40% of any deviation from long-run equilibrium is corrected within the space of one year. An α of 0.25 estimated with monthly data is smaller in magnitude but would nevertheless lead to over 95% correction of any deviation from long-run equilibrium in the course of one year. Some authors transform α's into so-called half-lives that indicate how many units of time are required for the correction of one-half of a deviation from the long-run equilibrium. An α of 0.25 estimated with monthly data corresponds to a half-life of 2.41 months.

using methods proposed by Engel and Granger or Johansen. Finally, the resulting estimates of β and α are interpreted.

Figure 1: Conceptual framework for assessing price transmission and market integration



Source: Own depiction based on Rapsomanikis et al. (2003).

2.2 Limitations of the vector error correction model, and alternatives

While the VECM underlies most empirical work in PT analysis, it is restrictive is some settings. In particular, the VECM in equation (2) is linear in two senses (Hassouneh et al, 2012). First, it is linear in the sense that all of the parameters in the model are assumed to be constant over the entire sampling period. Second, it is linear in the sense that the dependent variables react linearly to changes in the independent variables. Numerous studies have shown that in many applications one or both of these types of linearity cannot be expected to hold (Hassouneh et al., 2010; Serra and Goodwin, 2003; Serra et al. 2006; von-Cramon-Taubadel, 1998; von Cramon-Taubadel and Amikuzuno, 2012).

For our purposes, the first type of linearity is especially restrictive. The PT relationship that links an international price to a country's domestic market price need not be constant over time. Changes in the country's trade policy (for example an increase or reduction of import tariffs) can alter the nature of the PT relationship, as can a switch from a net export to a net import position. Furthermore, spatial equilibrium theory (Takayama and Judge, 1971) predicts that short-run price adjustments due to arbitrage will take place only if the difference between international and domestic prices exceeds a threshold that is determined by transport and transaction costs (Barrett and Li, 2002). If the difference between prices is less than this threshold, there is no incentive for traders to engage in arbitrage, and prices can move independently of one another.

In such cases PT will be characterized by different so-called 'regimes' (for example, one regime before and one regime after an import tariff change; or one regime for the net export situation, and one for the net import situation). In recent years several models of regime-dependent PT have been developed and applied in the literature. Most of these can be described as piecewise linear models in which each regime is characterized by a standard VECM as in equation (2) above, and some trigger or transition mechanism determines when the model jumps from one regime to another. This trigger can be exogenous (e.g. coinciding with the date of a policy change) or endogenous (e.g. determined by whether the distance between the international and the domestic prices exceeds a certain threshold). Hassouneh et al. (2012) review a number of the regime-dependent PT models that are common in current research, including the threshold VECM (Goodwin and Piggott, 2001), the asymmetric VECM (von Cramon-Taubadel, 1998), and the smooth transition VECM (Teräsvirta, 1994).

Estimating regime-dependent PT models is considerably more complicated than estimating a standard VECM. Some of these models require additional exogenous variables in addition to the endogenous prices, for example information on the timing of policy changes or other exogenous shocks that lead to regime changes. Others regime-dependent models such as the threshold VECM can be estimated using prices alone, but require additional information and testing to determine the appropriate number of thresholds.[4] Finally, there is no unified testing framework for comparing these regime-dependent models with one another.

Authors who are interested in analyzing PT in a specific product/country setting, or who use such a specific setting to illustrate a new regime-dependent PT model that they have developed or refined, can afford to engage in the additional data collection, specification, testing and interpretation that this entails. As outlined in section 3.2 below, however, the FAO GIEWS data provides us with domestic price series for three main cereal products (maize, rice and wheat) in 71 countries. It is beyond the scope of this study to carry out detailed regime-dependent PT analysis for each of these individual settings. Instead, we are obliged to use a comparatively simple PT model, such as the VECM, the estimation of which can be automated to permit the analysis of a large number of domestic-international price pairs. We recognize that the simple VECM specification in (2) will not be appropriate for all of the domestic-international price pairs in the GIEWS data. The additional insights that can be generated by estimating PT for a large number of price pairs and then analyzing the resulting cross-section sample of results come at the cost of a necessarily simple method of analysis that is not appropriate for each of these pairs individually.

In an attempt to deal with the shortcomings of the simple VECM, we propose two alternative methods of analysis. First, to allow for at least one possible source of non-linearity we modify the basic VECM in equation (2) to include a structural break which we postulate to have taken place in July 2007. This roughly corresponds to the beginning of the first agricultural price peak and the beginning of the recent phase of increased volatility on international commodity markets. Hence, we estimate the following model which allows the nature of price transmission between international and domestic cereal prices to change with the onset of higher and more volatile price in recent years. The resulting specification is as follows, where the superscript * distinguishes between pre-break and post-break parameters:

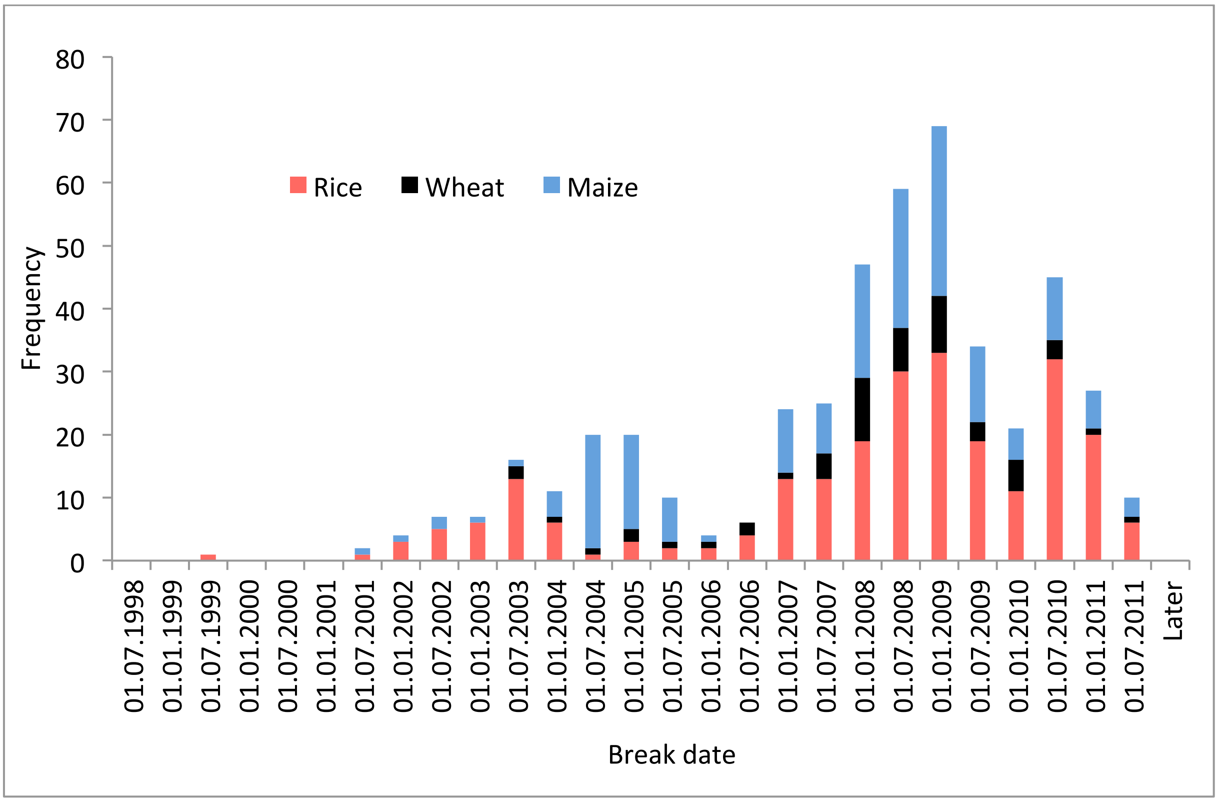
(3)
$$\begin{bmatrix}\Delta p_t^d \\ \Delta p_t^w\end{bmatrix} = \begin{cases} \begin{bmatrix}\alpha_1 \\ \alpha_2\end{bmatrix}\begin{bmatrix}1 & \beta_1\end{bmatrix}\begin{bmatrix}p_{t-1}^d \\ p_{t-1}^w\end{bmatrix} + \sum_{i=1}^k \begin{bmatrix}\delta_{1i} & \rho_{1i} \\ \delta_{2i} & \rho_{2i}\end{bmatrix}\begin{bmatrix}\Delta p_{t-i}^d \\ \Delta p_{t-i}^w\end{bmatrix} + \begin{bmatrix}\varphi_1 \\ \varphi_2\end{bmatrix} + \begin{bmatrix}\varepsilon_{1t} \\ \varepsilon_{2t}\end{bmatrix}, \ t < \text{July 2007} \\ \begin{bmatrix}\alpha_1^* \\ \alpha_2^*\end{bmatrix}\begin{bmatrix}1 & \beta_1^*\end{bmatrix}\begin{bmatrix}p_{t-1}^d \\ p_{t-1}^w\end{bmatrix} + \sum_{i=1}^k \begin{bmatrix}\delta_{1i}^* & \rho_{1i}^* \\ \delta_{2i}^* & \rho_{2i}^*\end{bmatrix}\begin{bmatrix}\Delta p_{t-i}^d \\ \Delta p_{t-i}^w\end{bmatrix} + \begin{bmatrix}\varphi_1^* \\ \varphi_2^*\end{bmatrix} + \begin{bmatrix}\varepsilon_{1t}^* \\ \varepsilon_{2t}^*\end{bmatrix}, \ t \geq July\ 2007. \end{cases}$$

Equation (3) is thus a regime-dependent VECM that links two standard VECMs, one for the period prior to July 2007, and one for the period thereafter. To check whether July 2007 is a plausible cut-off, we applied the Gregory and Hansen (1996) test of the null of no cointegration against the alternative of cointegration with a possible regime shift to each domestic/international price pair in the GIEWS data. Figure 2 shows the distribution of the break dates selected by the Gregory and Hansen test. While there is evidence of regime shifts in some domestic/international price relationships in 2003/04 for rice and 2004/05 for maize, for all three products (rice, maize and wheat) by far the most regime shifts are indicated in 2007/08. July 2007 therefore appears to be a reasonable choice for the cut-off date in the regime-dependent VECM in equation (3).

[4] Furthermore, Greb et al. (2011) demonstrate that the maximum likelihood method used to estimate threshold VECMs in the literature to date is biased.

Our second alternative to the standard VECM abandons the assumption of a parametric relationship between domestic and international prices entirely. Instead, we simply measure how often domestic and international prices have increased or decreased together in the past, and how often they have moved in opposite directions. Hence, for each of the GIEWS price series in each month we code whether it has increased or decreased. We do the same thing for the corresponding international price and then count the number of agreements (i.e. months in which both the domestic price and the corresponding international price increased or decreased) and the number of disagreements (i.e. months in which one price increased while the other decreased). The result is the simplest possible measure of price co-movement that indicates how often producers and consumers on domestic markets are at least receiving the correct qualitative price signals. To account for possible delays in price responses and short-run fluctuations we repeat this analysis using quarterly and annual price changes, and we also modify the analysis with monthly data to measure the agreement between the direction of international price changes in month *t* and the direction of domestic price changes in month *t+1*.

Figure 2: The distribution of break dates chosen by the Gregory and Hansen (1996) test



Source: Own calculations with GIEWS price data.

3. Literature-based and GIEWS data-based estimates of international-domestic cereals price transmission

Following the discussion of methods in the previous section, we follow a three-part approach to generate insights into the nature of international to domestic PT for major cereal products. First, many studies that report VECM estimates for international to domestic PT have been published in recent years. As outlined in section 3.1, we have collected these studies and analyze the estimates of β and α that they report. Second, using the extensive FAO GIEWS price data set, we generate our own estimates of β and α for a large number of countries using the VECM in equation (2) and the regime-dependent VECM in equation (3). This work is outlined in section 3.2 below. Third, using the GIEWS price data we carry out the non-parametric analysis of agreements and disagreements in price increases and decreases described above. In all three types of analysis we consider maize, rice and wheat.

Each of these approaches has its advantages and disadvantages. Most studies in the literature only report a few PT estimates, typically for a single product and one or relatively few counties. As a result, the estimates in these studies can be expected to reflect detailed work by authors who have a comprehensive understanding of the markets that they study, and who have undertaken careful specification searches, for example to determine appropriate lag-lengths for the VECMs that they estimate, etc. As discussed above, the FAO GIEWS price data includes hundreds of price series. Hence, we are obliged to automate the estimation and work with simple uniform specifications that may not be appropriate in all cases. On this count the literature-based estimates might be more reliable.

The other side of this coin, however, is publication bias. The literature might be biased towards studies that report evidence of cointegration, and authors might be inclined to experiment with different specifications and only report on those that provide such evidence. Indeed, in some of the studies we surveyed, the authors openly state that they only report results for those markets for which they find evidence of cointegration. In this regard, our own estimates with the GIEWS price data might provide a more representative picture of PT (or the lack thereof) around the world. Moreover, a problem that is common to all meta-analyses of existing publications is that results can be presented in numerous ways and standards of documentation often differ considerably from study to study. In our context, some studies present only β's and others only α's; some work with prices data in levels, others with price series in logarithms; and not all studies clearly explain the nature of the price data that they use (for example, what international reference price was employed).

Finally, the advantage of the analysis of agreements and disagreements in price increases and decreases is that it is free of any assumptions about the functional relationship between domestic and international prices. If this relationship has been subject to numerous changes over time, imposing a parametric model such as the VECM (with or without a single structural break) will lead to inappropriate results. The non-parametric approach avoids this pitfall. However, it also produces results that are correspondingly less informative. Even if we find that domestic and international prices show a tendency to increase and decrease together, this does not mean that producers and consumers on domestic markets are receiving undistorted price signals; it could be that the magnitude of the domestic price changes is considerably larger (or smaller) on average than the magnitude of the corresponding international price changes.

3.1 Estimates of cereal price transmission in the literature

The set of literature-based estimates of cereal PT is based on a thorough literature search including journal publications, institutional reports, conference papers, thesis and dissertations. We consider only studies that estimate error correction models of PT from international to domestic markets for maize, rice and wheat. We therefore exclude studies that assess only cointegration, causality, or pass-through effects. We also exclude studies that analyze domestic PT, i.e. within country markets, or bilateral country PT. In the end, we consider the 31 studies listed in Appendix Table 1, 30 of which were published in the last 10 years. Since most studies cover more than one country/location, the 31 studies provide 678 individual estimates of PT, 215 for rice (32%), 271 for wheat (40%), and 192 for maize (28%).

16 of the 31 studies consider one or two countries, while 15 consider between 3 and 15 countries. In total, the literature-based estimates of PT cover 52 countries, 9 of which are in East Africa, 7 in West Africa, 14 in Asia, 13 in Latin America, 6 in Europe, 2 in North America, and 1 in Oceania. 15 of the 31 studies were published in institutional reports or as working/discussion papers, 8 were published in peer-reviewed journals, and the rest are conference papers, book chapters or theses/dissertations.

23 of the studies are based on monthly price data, while 5 use annual and 5 use weekly prices. 26 of the 31 studies analyze prices in logarithms, while the remaining 5 work with prices in levels. Beyond simple VECMs, 3 out of 31 studies also test for asymmetric price transmission (Meyer and von Cramon-Taubadel, 2004), 3 articles estimate so-called threshold VECMs (Goodwin and Piggott, 2001), and 3 consider both thresholds and asymmetry.

There is no consensus on what constitutes 'the' international or world price for a commodity such as maize, rice or wheat. However, certain prices or export markets do dominate (see Appendix Figures 1-3). In our literature sample, US No. 2 yellow FOB Gulf is used as the international price in 67% of all estimations involving yellow maize. Thailand export prices are used for 72% of all rice market pairs. While Thailand 5% brokens dominate (55%), several studies also use other qualities such as Thai A1, Thai 100B, Thai 15%, and Thai 35%. For wheat a greater variety of international references prices are used, but 68% of the observations are based on US prices, and US No. 2 hard red winter (HRW) is used in 24% of all cases. The domestic price underlying 36% of the observations is a border price, but producer (21%), wholesale (14%), and retail (15%) prices are also used.

3.2 Own estimates of cereal price transmission based on FAO GIEWS data

The FAO Global Information and Early Warning System (GIEWS) food price data set was established in 2009 as part of the FAO Initiative on Soaring Food Prices (ISFP).[5] The prices reported in GIEWS are collected from national official sources and non-official institutions. The GIEWS price series are monthly and most run through to the end of 2011; some start as early as 1995, others as late as 2008. We impose a minimum length of 10 observations for a time series to be considered in our analysis and analyze PT between domestic and the following international prices:

- wheat -> US No. 2 HRW
- rice -> Thai 5%
- yellow maize -> US No. 2 yellow Gulf
- white maize -> Randfontein (South Africa).

The GIEWS data includes a total of 57 domestic prices for wheat, 262 domestic prices for rice and 180 domestic prices for maize. As is the case with the literature sample, GIEWS mainly provides results for countries in Africa, Asia/Pacific and Latin America. However, while the literature sample also provides results for countries in Europe and North America, GIEWS only includes a small number of observations (7 of 499) for Europe. To estimate the VECMs in equation (2) and (3) above with the GIEWS data a decision about the number of lags (*k*) to include must be reached. As shown in Table 1, the Akaike Information Criterion (AIC – Akaike, 1974) indicates that k=1 in the great majority of cases, so for simplicity we employ one lag throughout.

Table 1: The optimal number of lags to include in VECM estimation as indicated by the AIC

Commodity	Number of lags											
	1		2		3		4		5		6	
Maize	167	92.8%	7	3.9%	3	1.7%	1	0,6%	2	1.1%	0	0%
Rice	185	70.6%	44	16.8%	13	5.0%	10	3,8%	5	1.9%	5	1.9%
Wheat	45	78.9%	9	15.8%	2	3.5%	1	1,8%	0	0%	0	0%

Source: Own calculations with GIEWS price data.

3.3 Comparing literature and GIEWS-based estimates of price transmission

3.3.1 Cointegration

Tables 2 and 3 present information on the numbers and shares of international/domestic price pairs which are found to be cointegrated according to the literature sample and the GIEWS estimates,

[5] We are grateful to David Hallam for providing us with this data in electronic form.

respectively. Overall, the literature sample suggests that international and domestic prices are cointegrated more often than is indicated by our own estimation with GIEWS data. 79% of all market pairs reported in the literature sample are cointegrated, compared with 55% in the GIEWS sample. This is presumably due to the literature bias discussed above, i.e. the fact that the literature tends to report findings of cointegration. The literature sample indicates the lowest prevalence of cointegration for East and West Africa compared with Asia/Pacific and especially Europe and the Americas, but this pattern is not confirmed by the GIEWS results. In the literature sample, the lower prevalence of cointegration for East and West Africa primarily is due to maize (46 and 58% shares of cointegration for East and West Africa, respectively) rather than rice, for which most African prices are cointegrated with international prices (83 and 73%, respectively), or wheat, for which there are only 8 observations for Africa. In both the literature and the GIEWS results there is less frequent evidence of cointegration for maize than for rice. For wheat, however, the literature indicates that cointegration is relatively frequent (88% of all international/domestic price pairs), while the GIEWS results suggest that it is less so (44%). However the wheat results in the literature are strongly influenced by a single study that produces over 100 observations for North America, all of which indicate that domestic and international prices are cointegrated.

Table 2: The prevalence of cointegration in the literature sample

Region	Maize			Rice			Wheat			**Total**		
	# obs.	# coint.	***% coint.***	# obs.	# coint.	***% coint.***	# obs.	# coint.	***% coint.***	# obs.	# coint.	***% coint.***
East Africa	107	49	***46***	24	20	***83***	8	5	***63***	139	74	***53***
West Africa	12	7	***58***	26	19	***73***	0	0	***-***	38	26	***68***
Asia/Pacific	25	17	***68***	93	79	***85***	28	17	***61***	146	113	***77***
Latin America	44	38	***86***	64	57	***89***	61	57	***93***	169	152	***90***
Europe	4	4	***100***	7	6	***86***	20	18	***90***	31	28	***90***
North America	0	0	***-***	1	1	***100***	122	122	***100***	123	123	***100***
Oceania	0	0	***-***	0	0	***-***	32	20	***63***	32	20	***63***
Total	192	115	***60***	215	182	***85***	271	239	***88***	678	536	***79***

Note: We report results of cointegration tests reported in the individual studies in the literature sample. There is no uniform methodology - different authors use different tests and levels of significance.
Source: Own calculations with literature sample.

Table 3: The prevalence of cointegration in the GIEWS estimates

Region	Maize			Rice			Wheat			**Total**		
	# obs.	# coint.	***% coint.***	# obs.	# coint.	***% coint.***	# obs.	# coint.	***% coint.***	# obs.	# coint.	***% coint.***
East Africa	59	21	***36***	35	22	***63***	14	8	***57***	108	51	***47***
West Africa	43	9	***21***	81	58	***72***	6	1	***17***	130	68	***52***
Asia/Pacific	15	2	***13***	63	18	***29***	24	3	***13***	102	23	***23***
Latin America	58	22	***38***	70	39	***56***	11	2	***18***	139	63	***45***
Europe	4	1	***25***	1	1	***100***	2	0	***0***	7	2	***29***
North America	0	0	***-***	0	0	***-***	0	0	***-***	0	0	***-***
Oceania	0	0	***-***	1	1	***100***	0	0	***-***	1	1	***100***
Total	179	55	***31***	251	139	***55***	57	14	***25***	487	208	***43***

Note: Cointegration is determined by Johansen Test with 5% significance level.
Source: Own calculations with GIEWS price data.

3.3.2 Estimates of the long-run price transmission coefficient (β)

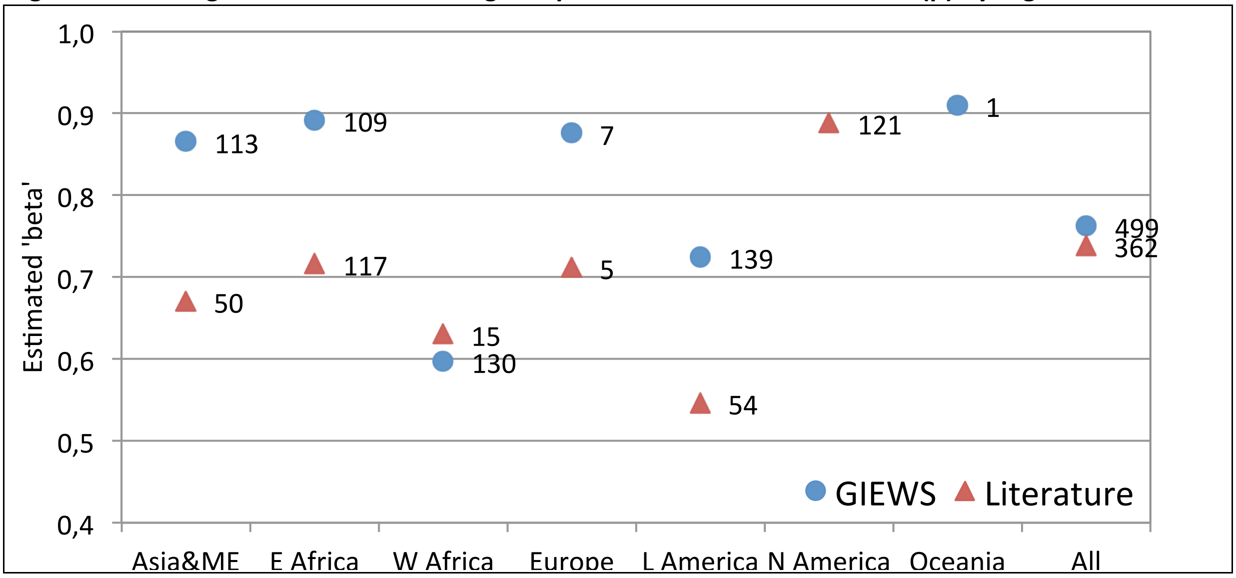
Table 4 summarizes the average estimates of the long-run PT coefficient β taken from the literature and GIEWS samples by cereal product and region, and Figures 2a and 2b provide an overview of the averages by region and by cereal, respectively. On average the literature and the GIEWS estimates of β are similar (0.74 and 0.76, respectively). These averages indicate that on average changes in international prices are transmitted by roughly three-quarters to domestic prices. However, for all regions with the exception of West Africa, the GIEWS estimates are on average roughly 0.2 higher than the literature estimates, and Figure 2a reveals that the literature average is boosted considerably by a large number of observations from North America with an average β = 0.89. Otherwise, Figure 2b shows that the average βs are similar for maize and rice, but that the GIEWS average for wheat is much higher than the corresponding average from the literature sample. These results change very little if only those product/country combinations are retained in the comparison for which there are observations in both the GIEWS and the literature samples (Appendix Table 3).

Table 4: Average estimates of the long-run PT coefficient β taken the literature and GIEWS samples, by product and region

	Maize		Rice		Wheat		*All three cereals*	
	GIEWS	Lit.	GIEWS	Lit.	GIEWS	Lit.	*GIEWS*	*Lit.*
Asia & ME	0.77	1.03	0.53	0.60	1.97	1.09	*0.87*	*0.67*
E. Africa	0.93	0.76	0.87	0.48	0.76	0.65	*0.89*	*0.72*
W. Africa	0.42	1.74	0.64	0.46	1.27	-	*0.60*	*0.63*
Europe	0.82	0.61	0.92	0.54	0.98	0.94	*0.88*	*0.71*
L. America	0.69	-	0.69	0.55	1.14	-	*0.73*	*0.55*
N. America	-	-	-	1.00	-	0.89	-	*0.89*
Oceania	-	-	0.91	-	-	-	*0.91*	-
All regions	*0.72*	*0.78*	*0.66*	*0.55*	*1.41*	*0.89*	*0.76*	*0.74*

Note: Averages by region and cereal weighted by the number of observations in each category.
Source: Own calculations with literature sample and GIEWS price data.

Figure 2a: Average estimates of the long-run price transmission coefficient (β) by region

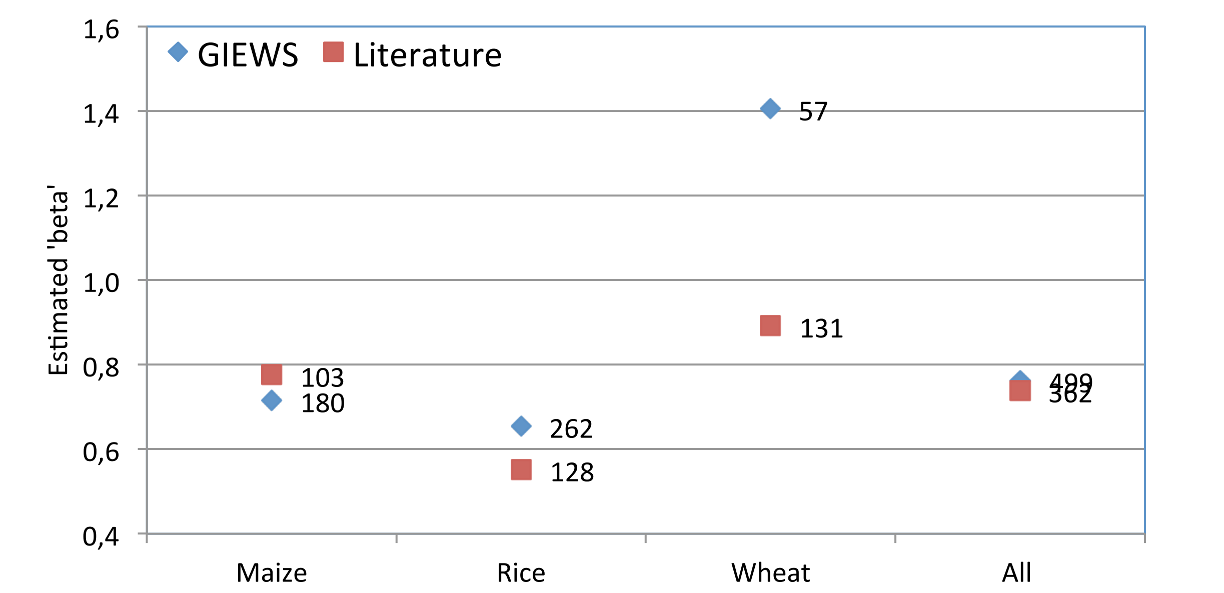


Note: Numbers indicate the number of observations underlying each average.
Source: Own calculations with literature sample and GIEWS price data.

3.3.3 Estimates of the adjustment parameter (α)

Table 5 present average estimates of the adjustment parameters α taken from the literature and GIEWS samples by product and region. We focus on the adjustment parameter from the first equation in (2) above, i.e. the equation that explains changes in domestic prices, because in the majority of all cases, only this α is statistically significant. In other words, the dynamics of international/domestic cereal PT are such that domestic prices adjust to deviations from the long-run price relationship, but international prices do not. The only notable exception to this rule is rice, to which we return below. As discussed above, the adjustment parameter from the first equation in (2) above is expected to be negative.

Figure 2b: Average estimates of the long-run price transmission coefficient (β) by cereal



Note: Numbers indicate the number of observations underlying each average.
Source: Own calculations with literature sample and GIEWS price data.

Table 5: Average estimates of the adjustment parameter α taken from the literature and GIEWS samples, by product and region

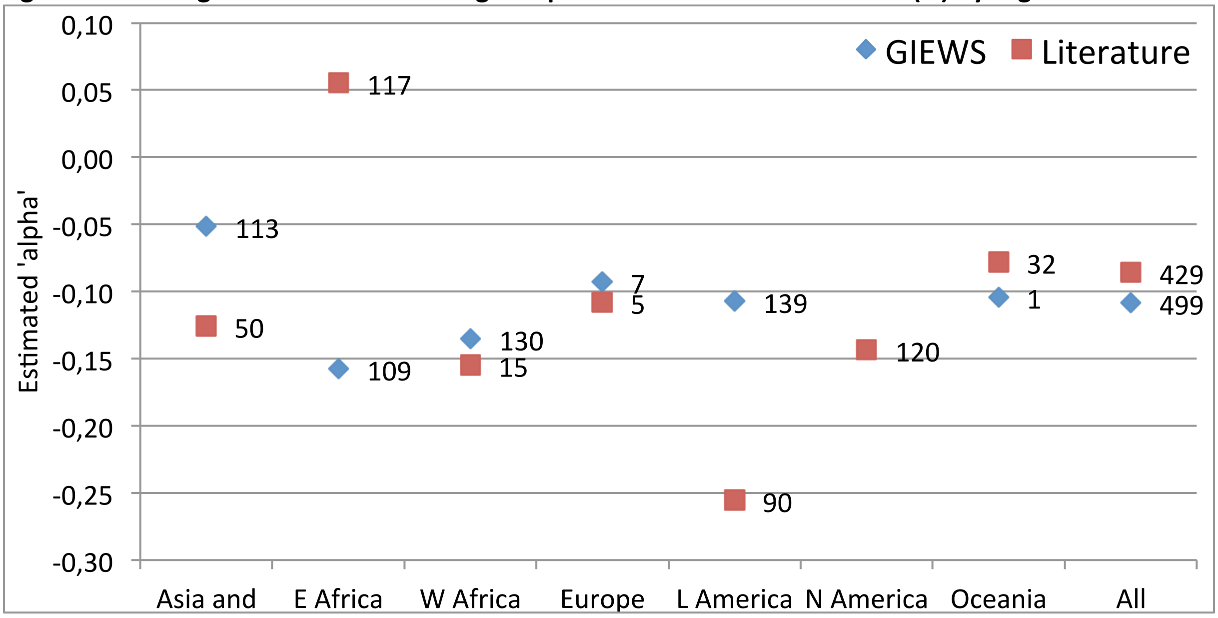
	Maize		Rice		Wheat		*All three cereals*	
	GIEWS	**Lit.**	**GIEWS**	**Lit.**	**GIEWS**	**Lit.**	***GIEWS***	***Lit.***
Asia & ME	-0.11	0.10	-0.04	-0.14	-0.05	-0.07	-0.05	-0.13
E. Africa	-0.16	0.02	-0.17	0.37	-0.12	-0.25	-0.16	0.06
W. Africa	-0.14	-0.10	-0.13	-0.16	-0.18	-	-0.14	-0.16
Europe	-0.10	-0.09	-0.04	-0.15	-0.10	-0.08	-0.09	-0.11
L. America	-0.14	-	-0.09	-0.36	-0.07	-0.10	-0.11	-0.26
N. America	-	-	-	-	-	-0.14	-	-0.14
Oceania	-	-	-0.10	-	-	-0.08	-0.10	-0.08
All regions	-0.13	-0.02	-0.10	-0.09	-0.10	-0.12	-0.11	-0.09

Note: Averages by region and cereal weighted by the number of observations in each category. The expected sign of α is negative.
Source: Own calculations with literature sample and GIEWS price data.

The results presented in Table 5 and summarized by region and by cereal in Figures 3a and 3b, respectively, point to relatively slow PT for most cereal products and regions, irrespective of whether literature averages or averages based on own estimates with GIEWS price data are considered. The average α estimated using GIEWS data is slightly larger in magnitude than the average in the literature (-0.11 as opposed to -0.09) but both indicate a relatively slow rate of PT whereby roughly 10% of any deviation from the long-run equilibrium relationship between international and domestic prices is corrected in the course of one month. This implies that it will take between 6 and 7 months to correct one-half of any disequilibrium that emerges due to unexpected price movements on international or domestic markets.

Somewhat more rapid responses are indicated by the GIEWS averages across all cereals for East and West Africa (average α = -0.16 and -0.14, which correspond to a half-lives of 4 and 5 months) and in particular by the literature estimates for Latin America (average α = -0.26, corresponding to a half-life of somewhat more than 2 months). However, the literature also produces positive average estimates of α for maize in Asia and the Middle East as well as for rice in East Africa. This is counterintuitive, because it suggests that deviations from the long-run equilibrium are not corrected but rather amplified, which would drive domestic and international prices apart over time. However, the average of α = 0.10 for maize in Asia and the Middle East is based on only one observation, and the average of α = 0.37 for rice in East is based on only 15 observations. Finally, viewed by product the only obvious discrepancy is that the average literature estimates of α for maize are considerably lower (= -0.02) than all other averages (Figure 3b). 99 of the 103 observations that underlie this average are from East Africa, which also explains why the average literature-based estimates of α for East Africa as a whole are so low (compare Table 5 and Figure 3a). If only those product/country combinations for which there are observations in both the GIEWS and the literature samples are included in the comparison (see Appendix Table 4), the results point to slightly slower PT on average in the GIEWS sample (average α = -0.09 rather than the -0.11 above), but considerably more rapid PT on average in the literature sample (average α = -0.17 rather than the -0.09 above).

Figure 3a: Average estimates of the long-run price transmission coefficient (α) by region



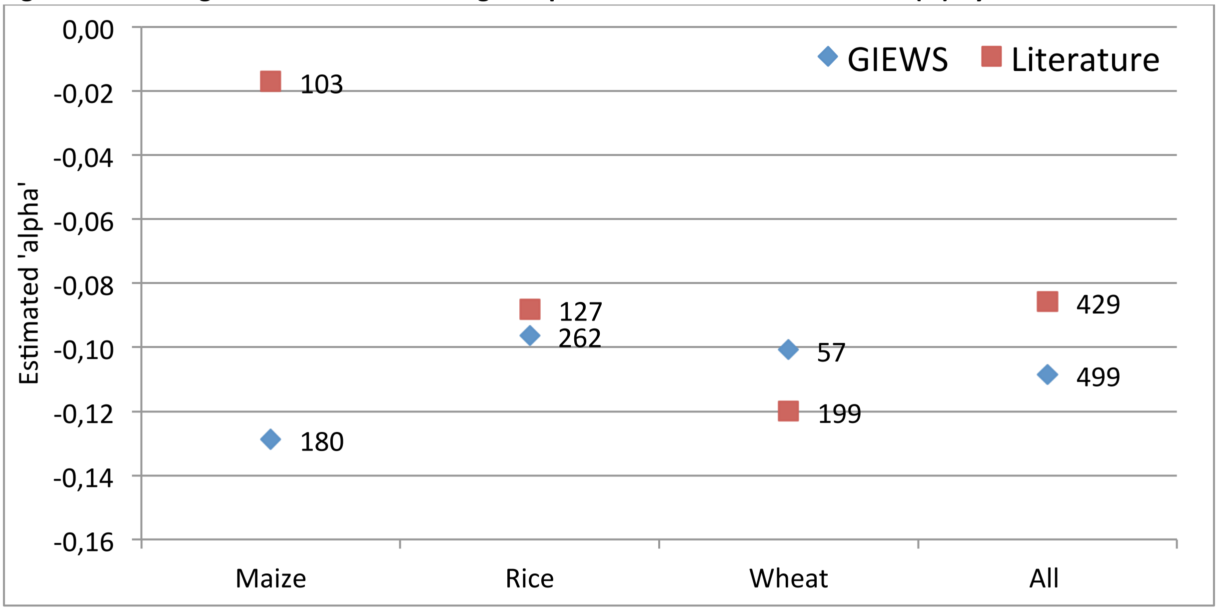
Note: Numbers indicate the number of observations underlying each average.
Source: Own calculations with literature sample and GIEWS price data.

If the adjustment parameters from the second equation in (2) above are considered, we see that these are generally insignificant, except for rice (Appendix Table 6). Specifically, there is evidence of a statistically significant reaction by international prices to disequilibrium between domestic and international prices in 121 market pairs (24%), of which 111 involve rice. Roughly 40% of all rice prices are affected, and in most cases the adjustment parameter in question has the appropriate (positive) sign. These pairs involve many countries and are not confined to a few 'large' countries such as China or India. As pointed out above, the simple linear VECM is restrictive and probably not appropriate for many of the individual price pairs in the GIEWS data. Hence, a certain number of spuriously significant adjustment parameters for international prices can be expected. Nevertheless, the fact that significant adjustment parameters for international prices occur, if at all, almost exclusively for rice price pairs suggests that the determination of international rice prices differs fundamentally from the determination of international wheat and maize prices. These results confirm a very similar finding by Gilbert (2011). We can conclude that most countries are price takers on wheat and maize markets, but the evidence for rice is mixed.

3.3.4 Before and after July 2007

Table 6 contrasts median estimates of the coefficient of PT on cereal markets before and after the onset of the recent phase of price peaks and increased price volatility in mid-2007. If we compare the median estimates from the period prior to July 2007 with the median estimates from the period thereafter, no clear pattern emerges. On maize markets the long-run PT coefficients (β) have fallen considerably since mid-2007, from 0.385 to 0.116 or from 0.438 to 0.103 depending on whether all price pairs or only cointegrated price pairs are considered. On rice and wheat markets the results Are ambiguous. If we consider only the international/domestic price pairs that are cointegrated, the median long-run PT coefficients have increased, from 0.547 to 0.705 for rice and from 0.576 to 1.013 for wheat. However, at the same time the short-run adjustment coefficients (α) have fallen, from 0.201 to 0.140 for rice and from 0.683 to 0.212 for wheat. This suggests that PT has become more complete but slower since mid-2007 for rice and wheat. However, these results must be interpreted with caution. We have used the median rather than the mean because the median is more robust vis-à-vis outliers (for example, implausibly large estimates of β for some international/domestic price pairs). The prevalence of such outliers is nevertheless high in particular in the post-July 2007 VECM results, presumably due to the short length of the available time series.

Figure 3b: Average estimates of the long-run price transmission coefficient (α) by cereal



Note: Numbers indicate the number of observations underlying each average.
Source: Own calculations with literature sample and GIEWS price data.

Table 6: Median price transmission parameters estimated with GIEWS data before and after July 2007 (only for international/domestic price pairs that are cointegrated)

Time period	Maize		Rice		Wheat	
	α	β	α	β	α	β
All international/domestic price pairs						
Before July 2007	-0.192	0.385	-0.204	0.623	-0.136	1.208
After July 2007	-0.221	0.116	-0.053	0.553	-0.143	0.463
Only cointegrated international/domestic price pairs						
Before July 2007	-0.216	0.438	-0.201	0.547	-0.683	0.576
After July 2007	-0.308	0.103	-0.140	0.705	-0.212	1.013

Source: Own calculations with GIEWS price data.

4. Analysis of the determinants of the strength of price transmission

4.1 Method

The averages presented above hide considerable variation in the literature-based and GIEWS-based estimates of α and β for individual country/product combinations. To explain this variation, and thus to generate insights into the factors that influence the strength of PT from international to domestic markets, we estimate meta-regressions. In each regression a set of estimated parameters (α's or β's) from the literature or from GIEWS is regressed on a set of covariates that might be expected to influence PT. These covariates are listed and described in Table 7 and cover geographic (e.g. landlocked), infrastructural (e.g. logistics), institutional (e.g. STE) and market or commodity specific factors (e.g. net importer). We include dummy variables for cereals (omitting rice) and regions (omitting Asia/Pacific) to capture any corresponding fixed effects.

4.2 Results

We first present the results of logit regressions that predict whether pairs of international and domestic prices are cointegrated. The dependent variable equals 1 when the two prices are cointegrated, and 0 otherwise, and this variable is explained using the covariates listed in Table 7 – for example whether the country in question is landlocked, whether it has an STE for cereals, etc.

Table 7: Covariates used in the meta-analysis of the determinants of price transmission

Name	Description	Source / link	Expectation / theory
Commodity fixed effects	Wheat, maize, rice		Unobserved commodity-specific heterogeneity
Region fixed effects	Europe; East and South Africa; West and Central Africa; MENA and Asia; Oceania; Latin America	http://unstats.un.org/unsd/methods/m49/m49regin.htm	Unobserved region-specific heterogeneity
Landlocked	1 if country has no access to sea	Google maps	For landlocked countries, international trade must cross more borders
Trade openness	Total trade as a share of income ,average 2006-2010 (Import + Export /GDP)	World Bank Development Indicators	Open economies are better integrated into world markets and thus PT should be stronger
STE	1 for countries that have state trading enterprises (STEs)	Literature*	STEs interfere with trade and insulate the domestic prices from international fluctuations
Ease of trade	Ease of trading across borders, between 0 (worst) to 1 (best)	World Bank, Doing Business, Ease of Trading across borders.	Transaction costs reduce PT
Logistics	Logistics performance index of quality of trade and transport-related infrastructure between 1 (worst) to 5 (best)	World Bank 2007	Better logistics mean lower costs of trade and higher PT
Net importer	Net cereal import ratio (export – import, 3 year average 2009-2011) to domestic consumption	USDA , PSD Online	If the share of staple imports in domestic consumption is high, more is undertaken to insulate domestic markets
Retail	1 if domestic price is measured at the retail rather than a more upstream level	Literature / GIEWS	The farther 'inland' a domestic price is measured, the weaker its link to international prices

*Note: * See Appendix Table 5 for a list of the countries with STEs.*

The results for the literature estimates in the first column of Table 8 indicate that wheat markets have an almost 50% higher probability of being cointegrated than rice or maize markets, and that West African prices have a roughly 14% lower probability of being cointegrated with international prices than prices in the default region, Asia. A high net import ratio for a product reduces the probability of cointegration with international prices by 31%; a high import ratio may lead to more policy intervention to insulate domestic markets from international price movements. If an STE is responsible for trading the product in question, the probability of cointegration increases by roughly 11%, and if the domestic price being considered is a retail price, the probability that it is cointegrated with international prices falls by almost 30%. The former result is puzzling but the latter is plausible, as retail prices are further removed from international prices than wholesale or border prices.

The logit results for the GIEWS sample in Table 8 also indicate that retail prices are less likely to be cointegrated with international prices, but otherwise they differ in several respects from the logit results for the literature sample. Maize and wheat are less likely to be cointegrated with the corresponding international prices than rice prices are (by roughly 30 and 20%, respectively), and domestic prices in East Africa, West Africa and Latin America are more likely to be cointegrated with international prices (by 25, 32 and 19%, respectively). If an STE is in place, the probability of cointegration falls by almost 22%. Improvements in logistics have a surprising negative impact on the probability of cointegration between domestic and international prices. Ease of trade has the expected positive impact, and being landlocked the expected negative impact on the probability of cointegration, but neither of these effects is significant. Most of these results also hold if only the time period after July 2007 is considered. However, if the period prior to July 2007 is considered the logit regression is much less informative. This is probably due to the fact that many GIEWS price series are very short prior to July 2007, leaving too few observations for dependable cointegration testing. Hence, the logit regression for the pre-July 2007 period is based on fewer and less trustworthy test results.

Table 8: Logit regression of cointegration status on factors that might influence price transmission (marginal effects rather than coefficient estimates are reported)

Covariate	Literature	GIEWS entire period	GIEWS before July 2007	GIEWS after July 2007
Maize	0.050	-0.296 ***	0.044	-0.269 ***
Wheat	0.476 ***	-0.202 ***	-0.151	-0.130 *
East Africa	-0.146	0.251 **	0.091	0.310 ***
West Africa	-0.136 *	0.321 ***	0.093	0.388 ***
Europe	-	0.189	-0.175 ***	0.163
Latin America	-0.049	0.189 **	-0.041	0.286 ***
Trade openness	-0.001	0.000	0.002	0.000
Net importer	-0.312 ***	0.035	0.033	0.136
STE	0.107 **	-0.216 ***	0.283	0.009
Retail	-0.291 ***	-0.126 **	0.064	-0.127 **
Ease of trade	0.437	0.395	0.245	0.509
Logistics	0.027	-0.527 ***	-0.152	-0.460 ***
Landlocked	0.051	-0.125	-0.074	0.119

*Note: The literature sample includes too few observations for Europe to permit estimation. *, ** and *** refer to significance at the 10%, 5% and 1% levels, respectively.*

Meta-regression results for individual estimates of α and β are summarized in Tables 9, 10 and 11. Table 9 presents results for all of the estimates of α and β derived from the literature sample, and for the GIEWS estimates of α and β from all domestic/international price pairs. Table 10 again presents results for all of the estimates of α and β derived from the literature sample. However, in Table 10 the Heckman procedure is used to generate results for the literature sample that are conditional on cointegration. Moreover, in Table 10 the GIEWS estimates are based only on α and β from cointegrated domestic/international price pairs. Finally, Table 11 presents only GIEWS-based estimates, in this case only for estimates of α and β from non-cointegrated domestic/international price pairs.

Table 9: Estimated coefficients for the meta-regressions (GIEWS results based on estimates of α and β using all international/domestic price pairs)

Covariate	Literature		GIEWS entire period		GIEWS before 07/2007		GIEWS after 07/2007	
	α	***β***	***α***	***β***	***α***	***β***	***α***	***β***
Intercept	0.782**	3.869*	-0.323***	-0.712	0.265	-2.765	-0.082	4.230
Maize	0.066	0.163	-0.067***	0.131	-0.033	-0.046	-0.137***	0.719
Wheat	0.077	0.363*	0.002	0.491**	-0.025	5.088**	-0.112***	5.091***
East Africa	0.448***	-0.331	-0.013	0.148	-0.339***	2.360	0.004	3.164
West Africa	0.052	0.751*	-0.051*	0.148	-0.408***	2.216	-0.149***	2.648
Europe	-	-	0.038	0.644	-0.050	-0.033	0.025	3.108
Latin America	-0.156***	-0.407*	0.008	0.252	-0.356***	2.275	-0.005	3.722**
Trade openness	0.000	0.004	0.000	0.000	-0.004***	0.077**	0.000	-0.008
Net importer	0.060*	0.401*	0.054**	-0.227	0.014	0.102	-0.004	0.362
STE	-0.090	-0.144	0.031	0.390*	-0.244***	-3.216	0.019	-1.115
Retail	0.001	-0.437	0.002	0.197	-0.025	-2.418	-0.020	1.095
Ease of trade	-1.414**	-5.383*	-0.035	1.303	0.197	-7.242	-0.173	9.935
Logistics	0.015	-0.022	0.094***	-0.013	-0.023	0.878	0.054	-6.168***
Landlocked	-0.736***	-0.562	0.023	0.447*	-0.076	-1.765	0.048	0.316
R^2	0.424	0.524	0.170	0.041	0.225	0.052	0.210	0.072

*Note: All meta-regressions estimated using OLS. The literature sample includes too few observations for Europe to permit estimation. *, ** and *** refer to significance at the 10%, 5% and 1% levels, respectively.*

Table 10: Estimated coefficients for the meta-regressions (GIEWS results based on estimates of α and β only from cointegrated international/domestic price pairs)

Covariate	Literature (Heckman procedure)		GIEWS entire period		GIEWS before 07/2007		GIEWS after 07/2007	
	α	***β***	***α***	***β***	***α***	***β***	***α***	***β***
Intercept	0.720**	4.834**	-0.262*	0.725	0.718	-0.504	0.045	-5.871
Maize	0.035	0.187	-0.069**	0.057	-0.068	0.009	-0.167***	-1.441
Wheat	0.139**	0.218	0.034	0.146	-0.591	0.279	-0.170**	8.762**
East Africa	0.446***	-0.298	-0.033	-0.017	-0.778***	-0.178	-0.041	5.596
West Africa	0.087	0.790*	-0.031	-0.008	-0.977***	0.024	-0.184**	3.069
Europe	-	-	0.078	0.393	-	-	0.130	5.941
Latin America	-0.130**	-0.460*	-0.015	0.142	-1.043***	0.300	-0.023	4.023
Trade openness	0.001	0.005	0.000	0.001	-0.008***	0.004	0.000	0.000
Net importer	0.021	0.666**	0.053	-0.160	0.278	-0.900*	-0.005	0.720
STE	-0.060	-0.117	-0.023	0.141	-0.826***	-0.038	0.043	-2.963
Retail	-0.084	-0.268	-0.020	0.004	0.008	-0.094	-0.054	1.546
Ease of trade	-1.498**	-6.490*	0.118	0.433	0.882	-0.826	0.148	3.976
Logistics	0.037	-0.125	0.038	-0.282	-0.006	0.504	-0.113	-0.152
Landlocked	-0.711***	-0.865	0.008	0.156	-0.089	0.211	0.143**	1.633
R^2	0.435	0.538	0.101	0.032	0.489	0.212	0.265	0.119

*Note: Meta-regression with literature data estimated using Heckman procedure. The literature sample and the GIEWS sample before July 2007 includes too few observations for Europe to permit estimation. *, ** and *** refer to significance at the 10%, 5% and 1% levels, respectively.*

Consider first the meta-regressions based on estimates of α and β derived from the literature. We see first that the results in the first column of Table 9 (estimated with OLS) are very similar to the results in the first column of Table 10 (estimated with the Heckman procedure). This suggests that estimating these meta-regressions conditional on cointegration does not have a significant impact on the results.[6] Similarly, the GIEWS-based meta-regressions in Table 9, which are based on all estimates of α and β, are generally quite similar to the corresponding GIEWS-based meta-regressions in Table

[6] This conclusion is supported by the fact that the inverse Mills Ratio is only significant at the 10% level in the equation for α in Table 10, and not significant in the equation for β.

10, which are based only on estimates of α and β from cointegrated domestic/international price pairs. For example, in both tables we see in the second column that α is roughly 7 percentage points more negative for maize prices than for rice and wheat prices, suggesting that PT on maize markets is somewhat more rapid. This supports the finding in Table 5 and Figure 3b that α's for maize tend to be somewhat larger (in magnitude). Indeed, this result is also corroborated by the results in Table 11 which are based only on non-cointegrated price pairs. Here the estimated coefficient for maize indicates that α is roughly 8 percentage points more negative for maize prices.

Similar parallels can be found across all three tables for example for the West Africa fixed effect (-5.1 percentage points in Table 9, -3.1 percentage points in Table 10, and -7.7 percentage points in Table 11) and for the ratio of net imports to consumption (5.4, 5.3 and 5.8 percentage points less error correction according to the results in Tables 9, 10 and 11, respectively). Some parallel findings are counter-intuitive, however. In particular, in both Table 9 and Table 11 we see that improvements in logistics are associated with large (less negative) values of α, and therefore with slower PT.

Table 11: Estimated coefficients for the meta-regressions (GIEWS results based on estimates of α and β only from non-cointegrated international/domestic price pairs)

Covariate	GIEWS entire period		GIEWS before 07/2007		GIEWS after 07/2007	
	α	***β***	***α***	***β***	***α***	***β***
Intercept	-0.315***	-1.893	0.285	-5.128	-0.021	6.038
Maize	-0.083***	0.200	-0.036	0.406	-0.150***	1.342
Wheat	-0.007	0.639*	0.009	7.028**	-0.115***	4.451*
East Africa	0.001	0.250	-0.253***	4.144	0.038	2.742
West Africa	-0.077**	0.161	-0.348***	3.155	-0.105***	2.651
Europe	0.016	0.807	0.016	0.122	-0.001	3.242
Latin America	0.029	0.263	-0.211***	3.624	0.013	4.422*
Trade openness	0.001**	-0.002	-0.002***	0.093**	0.000	-0.006
Net importer	0.058*	-0.187	-0.012	0.311	-0.015	0.592
STE	0.043*	0.431	-0.130***	-5.846*	0.020	-0.318
Retail	0.007	0.362	-0.039	-3.046	-0.012	0.636
Ease of trade	-0.194	2.220	-0.149	-12.210	-0.347**	12.656
Logistics	0.120***	0.191	-0.032	2.257	0.073	-7.854***
Landlocked	0.010	0.629	-0.082	-2.150	0.008	-1.625
R^2	0.239	0.059	0.222	0.080	0.293	0.075

*Note: The literature sample and the GIEWS sample before July 2007 includes too few observations for Europe to permit estimation. *, ** and *** refer to significance at the 10%, 5% and 1% levels, respectively.*

Moving to the GIEWS-based results for the pre-July 2007 period, we again see many parallels between Tables 9, 10 and 11. In particular, all three tables display evidence of significantly more negative α's (and therefore more rapid PT) for East and West Africa, for Latin America, for more trade open countries and, surprisingly, for countries with STEs. In the post-July 2007 period, the results in all three tables point to significantly more negative α's for maize and wheat, and for West Africa.

These parallels are less apparent for the meta-regressions in Tables 9, 10 and 11 that explain the variation in the β's. Overall, the meta-regressions indicate that the selected covariates are able to explain a larger proportion of the variance in the adjustment parameters (the α's) than of the variance in the long-run price transmission coefficients (the β's). The meta-regressions for the GIEWS-based estimates of β generally produce fewer significant coefficients, and they also produce many coefficients that are implausibly large, especially in the pre- and post-July 2007 subsamples. Since β is expected to be close to 1, it is difficult for example to interpret coefficients that suggest that β increases by over 7 for price pairs involving wheat, or falls by almost 6 in the presence of an STE (see the second column of Table 11).

In summary, the meta-regressions for the α's do generate a few signals. In particular, there is strong evidence of more rapid PT for maize across all of the GIEWS results regardless of what period is considered and whether cointegrated and/or non-cointegrated results are considered. Similarly, evidence of more rapid PT in Latin America appears repeatedly in Tables 9 through 11. There is weaker evidence for a positive relationship between trade openness and the speed of PT, and a negative relationship between net import ratios and PT. Before July 2007 it appears that PT was stronger in the presence of STEs, and when estimation is carried out without allowance for a break in July 2007, it appears that better logistics are associated with slower PT. These last two results run counter to our *a priori* expectations. The meta-regressions for the β's have lower explanatory power than those for the α's, and they fail to produce many robust and plausible results.[7]

5. Analysis of agreement in the direction of domestic and international price movements

The analysis presented in section 4 above is based on the assumption that PT is characterized by the specific parametric structure embodied in the VECM. The VECM is a popular and powerful model, but it might be too restrictive in present setting. For example, the VECM assumes that a domestic price will adjust by a fixed proportion of any given change in the international price, regardless of the magnitude of this change. To relax this assumption, we next study whether domestic prices and international prices simply move in the same directions in most periods, regardless of the magnitudes of these movements. If domestic and international prices tend to move in the same directions, then producers and consumers are at least confronted with appropriate qualitative price signals.

Table 12 first presents results for monthly price changes by region and by cereal, and Figures 4a and 4b provide corresponding visual summaries by region and cereal. Table 13 and Figures 5a and 5b present corresponding results for lagged monthly price changes (international price change in month *t* compared with the domestic price change in month *t+1*);Table 14 and Figures 6a and 6b present the results for quarterly price changes; and Table 15 and Figures 7a and 7b for annual price changes.

Table 12: The direction of monthly price movements on domestic and international markets – agreement and disagreement by region and cereal

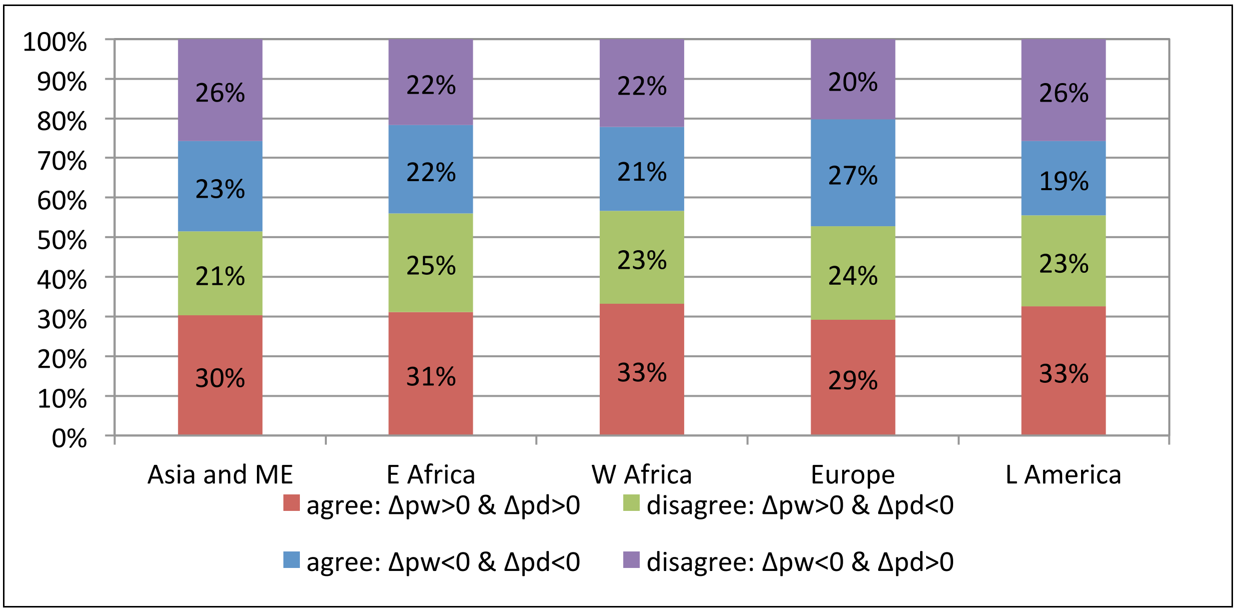
	Agree: Δpw<0 & Δpd<0	Agree: Δpw>0 & Δpd>0	Disagree: Δpw>0 & Δpd<0	Disagree: Δpw<0 & Δpd>0	Sum: agree	Sum: disagree
			By region			
Asia and ME	23%	30%	21%	26%	53%	47%
E. Africa	22%	31%	25%	22%	53%	47%
W. Africa	21%	33%	23%	22%	54%	46%
Europe	27%	29%	24%	20%	56%	44%
L. America	19%	33%	23%	26%	51%	49%
			By cereal			
Maize	20%	32%	25%	23%	52%	48%
White maize	20%	34%	24%	21%	54%	46%
Rice	24%	30%	22%	25%	54%	46%
Wheat	24%	30%	22%	25%	53%	47%
			All regions and cereals			
Total	22%	32%	23%	23%	54%	46%

Source: Own calculations with GIEWS price data.

[7] We also experimented with weighted meta-regressions that account for the fact that some studies provide more observations to the literature sample than others, and that some countries are more prevalent in the GIEWS data than others. These meta-regressions did not generate any additional insights.

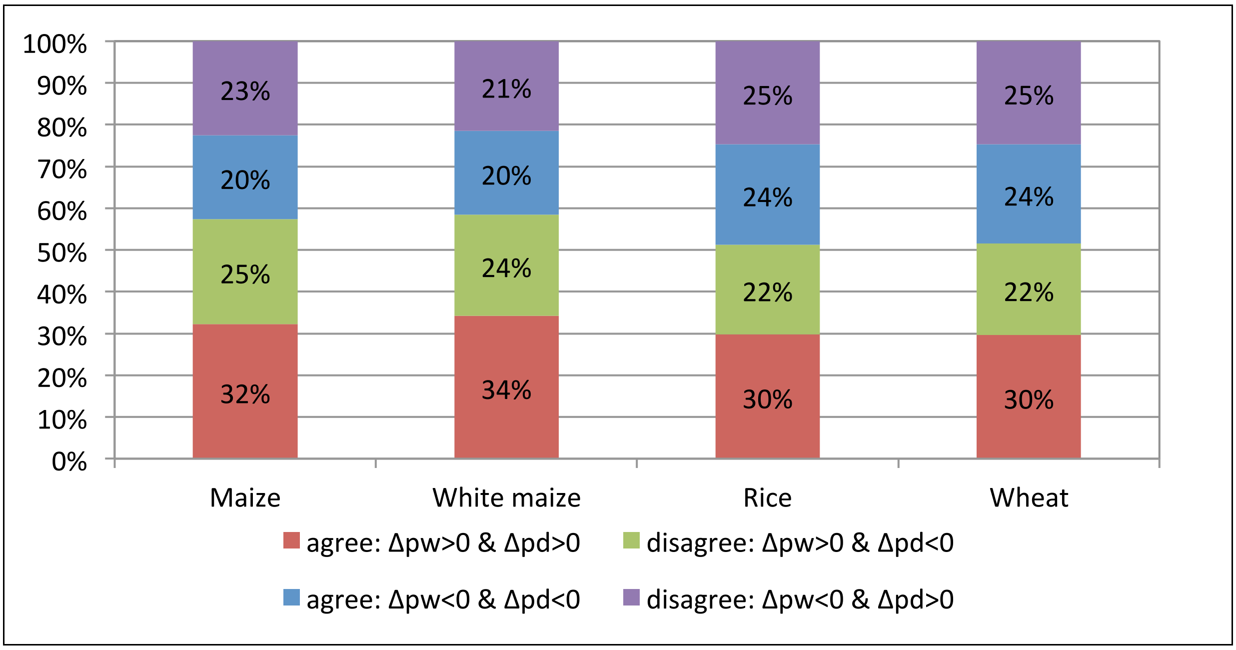
The results indicate that there is a slight preponderance of positive changes in international market prices over the time periods covered by the GIEWS data; international price increased in 55% of all months (32% + 23% in the last row of Table 12), and decreased in 45% of all months.[8] In 58% of the months in which international prices increased, domestic prices increased as well (32 of 55%). However, domestic prices decreased in only 49% of the months in which international prices decreased, as well (22 of 45%).

Figure 4a: The direction of monthly price movements on domestic and international markets – agreement and disagreement by region



Source: Own calculations with GIEWS price data.

Figure 4b: The direction of monthly price movements on domestic and international markets – agreement and disagreement by cereal



Source: Own calculations with GIEWS price data.

[8] Note that the share of months in which international prices increase is not the same over all regions or cereals because for each region and cereal different periods in which domestic prices overlap with international prices are available in the GIEWS data.

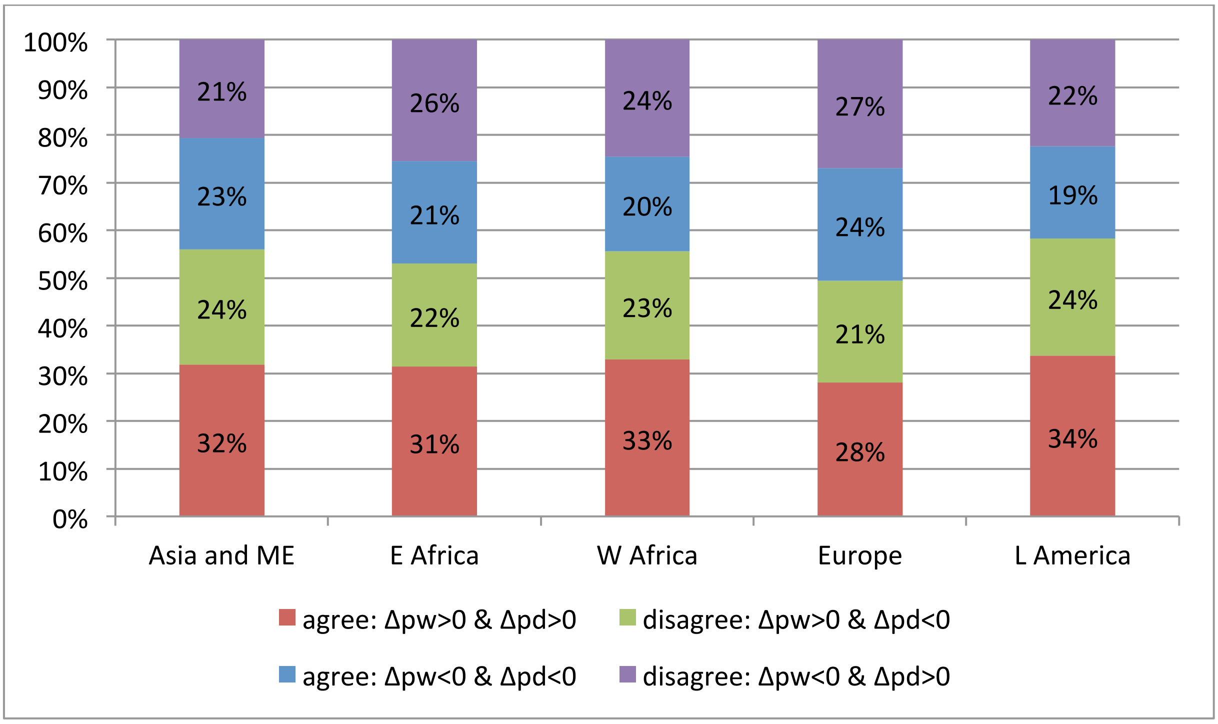
Overall, the agreement between the direction of price changes on international markets and on domestic markets is quite low, especially when international prices are falling. Table 12 and Figures 4a and 4b show that this result holds quite uniformly across regions and products. The only slight exception is that prices in Europe tend to move in the same direction as international prices in a slightly higher proportion of all months (56%), while prices in Latin America tend to move in the same direction somewhat less often (51%). While falling international prices tend to be passed on to markets in Europe (27 of 47%, or in 57% of all cases), this is not the case in Latin America, where falling international prices are only passed on in 42% of all cases (19 or 45%).

Table 13: The direction of lagged monthly price movements on international (month *t*) and domestic (month *t+1*) markets – agreement and disagreement by region and cereal

	Agree: Δpw<0 & Δpd<0	Agree: Δpw>0 & Δpd>0	Disagree: Δpw>0 & Δpd<0	Disagree: Δpw<0 & Δpd>0	Sum: agree	Sum: disagree
			By region			
Asia and ME	23%	32%	21%	24%	55%	45%
E. Africa	21%	31%	26%	22%	53%	47%
W. Africa	20%	33%	24%	23%	53%	47%
Europe	24%	28%	27%	21%	52%	48%
L. America	19%	34%	22%	24%	53%	47%
			By cereal			
Maize	20%	33%	25%	21%	53%	47%
White maize	19%	34%	25%	21%	54%	46%
Rice	23%	30%	23%	25%	52%	48%
Wheat	24%	31%	22%	24%	54%	46%
			All regions and cereals			
Total	21%	32%	23%	23%	54%	46%

Source: Own calculations with GIEWS price data.

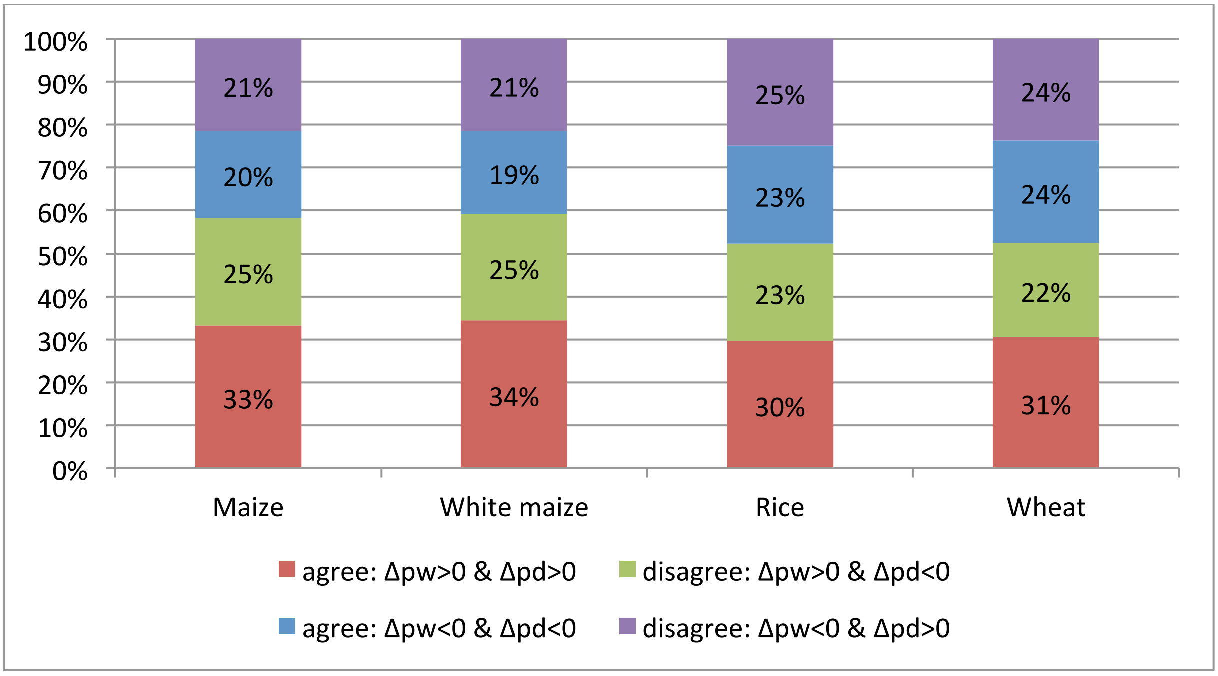
Figure 5a: The direction of lagged monthly price movements on international (month *t*) and domestic (month *t+1*) markets – agreement and disagreement by region



Source: Own calculations with GIEWS price data.

Table 13 and Figures 5a and 5b show that these results do not change appreciably when lagged price changes are considered (international price changes in month *t* and domestic price change in month *t+1*). The only perhaps notable change is that the share of agreements between international and European price changes falls from 56% to 52% when lagged changes are considered. Hence, to the extent that European prices co-move with international prices, they appear to do so contemporaneously at the monthly frequency.

Figure 5b: The direction of lagged monthly price movements on international (month *t*) and domestic (month *t+1*) markets – agreement and disagreement by cereal



Source: Own calculations with GIEWS price data.

As expected, agreement between the direction of international and domestic price becomes more frequent when quarterly rather than monthly price changes are considered (Table 14). Focusing on quarterly rather than on monthly price changes eliminates smaller short-run price fluctuations and accounts for possible lags in PT. With quarterly data the overall share of agreements in the direction of price changes increases to 56% (from 54% with monthly data in Table 12). This increase in the share of agreements takes place only in phases of increasing international prices. With monthly data 58% of all increasing international prices coincide with increasing domestic prices; with quarterly data this share increases to 61% (35% of 57%). In contrast, the share of decreasing international prices that coincide with decreasing domestic prices is unaffected by the shift from monthly to quarterly data, remaining unchanged at 49% (21% of 43%).

The share of agreements increases in particular in Asia (from 53% with monthly data to 60% with quarterly data) and in Europe (from 56% with monthly data to 72% with quarterly data). The share of agreements also increases for East Africa and for Latin America, but it decreases (from 53% with monthly data to 51% with quarterly data) for West Africa (see also Figure 6a). Comparing Tables 12 and 14 also reveals that moving from monthly to quarterly price changes leads to an increased share of agreement for all cereals except white maize (see also Figure 6b).

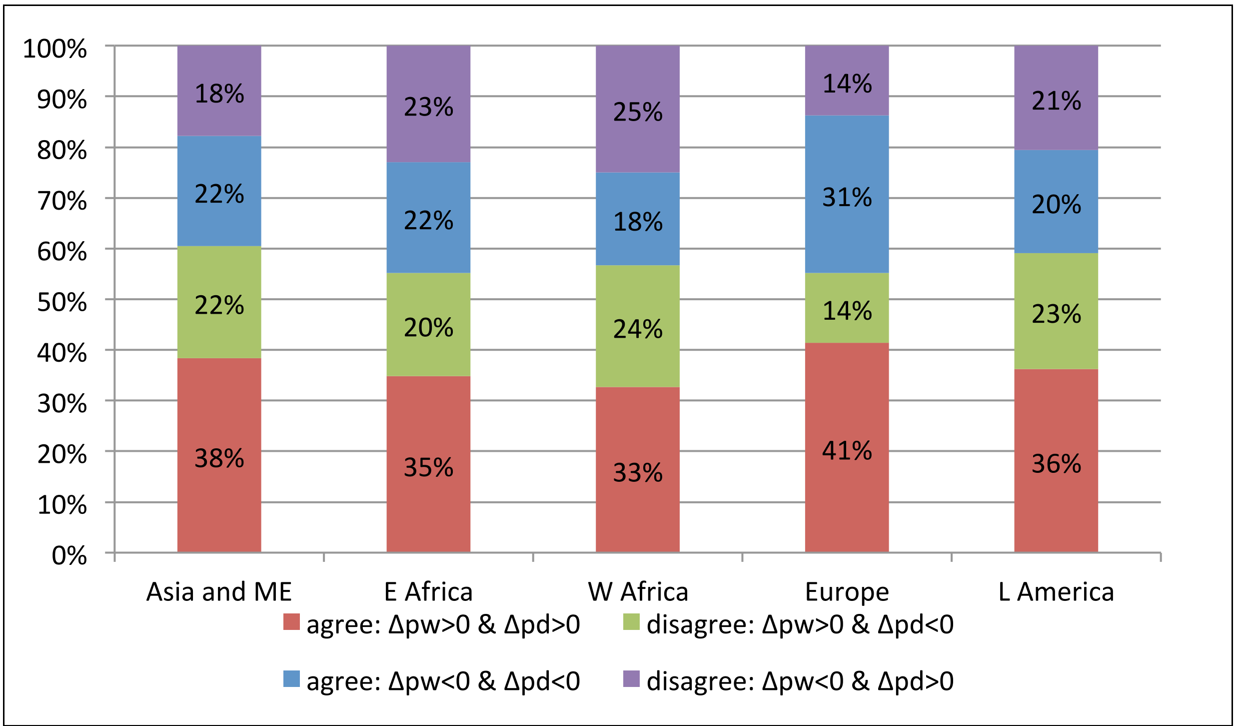
Finally, Table 15 reveals that with annual data the overall share of agreements in the direction of price changes remains unchanged at 56% as with quarterly data. However, the share of agreements in phases of increasing international prices increases strongly; with quarterly data 61% of all increasing international prices coincide with increasing domestic prices; with annual data this share climbs to 67%. In contrast, the share of decreasing international prices that coincide with decreasing domestic prices falls from 49% with quarterly data to 38% with annual data. Especially striking are the increases in the shares of agreements for Asia (from 60% with quarterly data to 65% with annual data) and Europe (from 72% to 100%) and for rice (from 59% to 64%) and wheat (from 58% to 69%) (see also Figures 7a and 7b).

Table 14: The direction of quarterly price movements on domestic and international markets – agreement and disagreement by region and cereal

	Agree: Δpw<0 & Δpd<0	Agree: Δpw>0 & Δpd>0	Disagree: Δpw>0 & Δpd<0	Disagree: Δpw<0 & Δpd>0	Sum: agree	Sum: disagree
			By region			
Asia and ME	22%	38%	22%	18%	60%	40%
E. Africa	22%	35%	20%	23%	57%	43%
W. Africa	18%	33%	24%	25%	51%	49%
Europe	31%	41%	14%	14%	72%	28%
L. America	20%	36%	23%	21%	57%	43%
			By cereal			
Maize	22%	36%	21%	22%	58%	42%
White maize	17%	34%	25%	24%	51%	49%
Rice	22%	37%	20%	21%	59%	41%
Wheat	23%	35%	22%	20%	58%	42%
			All regions and cereals			
Total	21%	35%	22%	22%	56%	44%

Source: Own calculations with GIEWS price data.

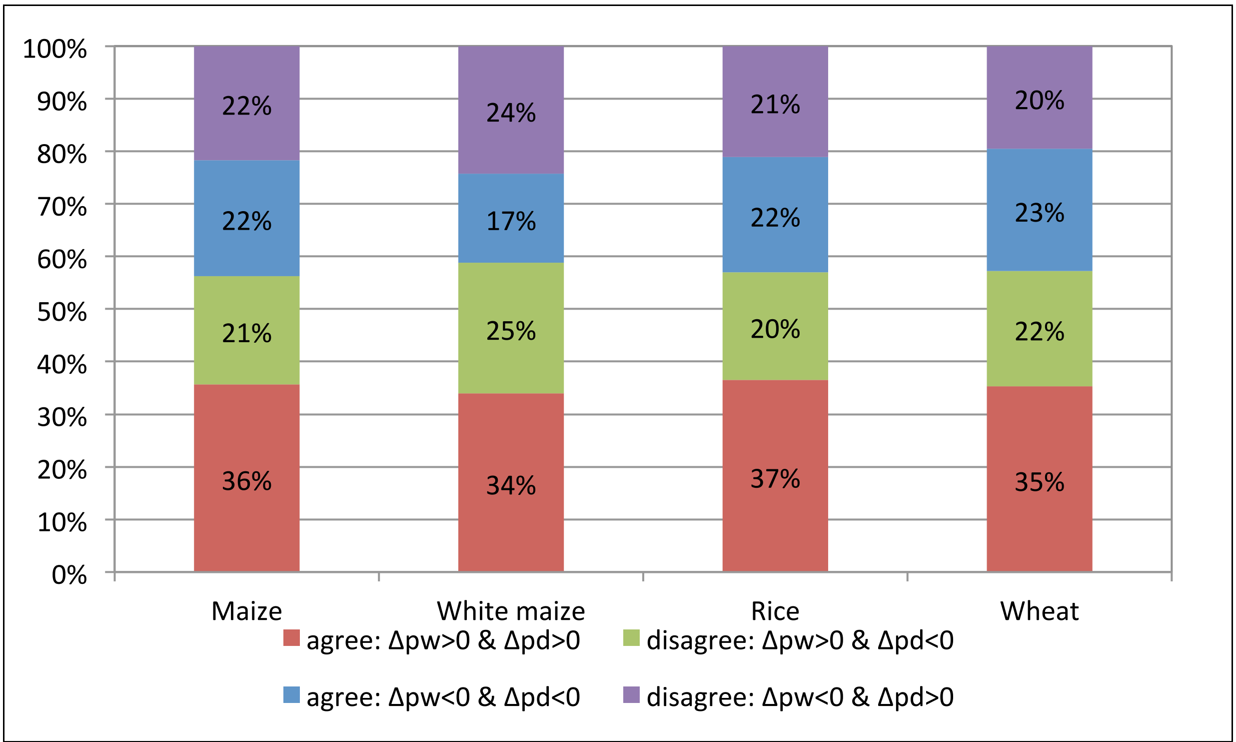
Figure 6a: The direction of quarterly price movements on domestic and international markets – agreement and disagreement by region



Source: Own calculations with GIEWS price data.

Overall, the results presented here support the findings of generally weak PT that were derived from the VECM analysis in the previous sections. They suggest that co-movement of international and domestic prices is more frequent than movement in opposite directions, but the imbalance is not pronounced and movement in opposite directions occurs often (47% of all monthly price movements, 44% of all quarterly price movements, and 44% of all annual price movements). Perhaps surprisingly, differences in the direction of change are as often due to falling international prices that are not reflected in falling domestic prices (23%, 22% and 24% of all cases in monthly, quarterly and annual data, respectively) as they are to increasing international prices that are not reflected in increasing domestic prices (23%, 22% and 20% of all cases, respectively). Intervention to shield domestic markets from increasing international prices would lead to the latter type of disagreement, but cases in which domestic markets fail to fall with international prices are equally common.

Figure 6b: The direction of quarterly price movements on domestic and international markets – agreement and disagreement by cereal



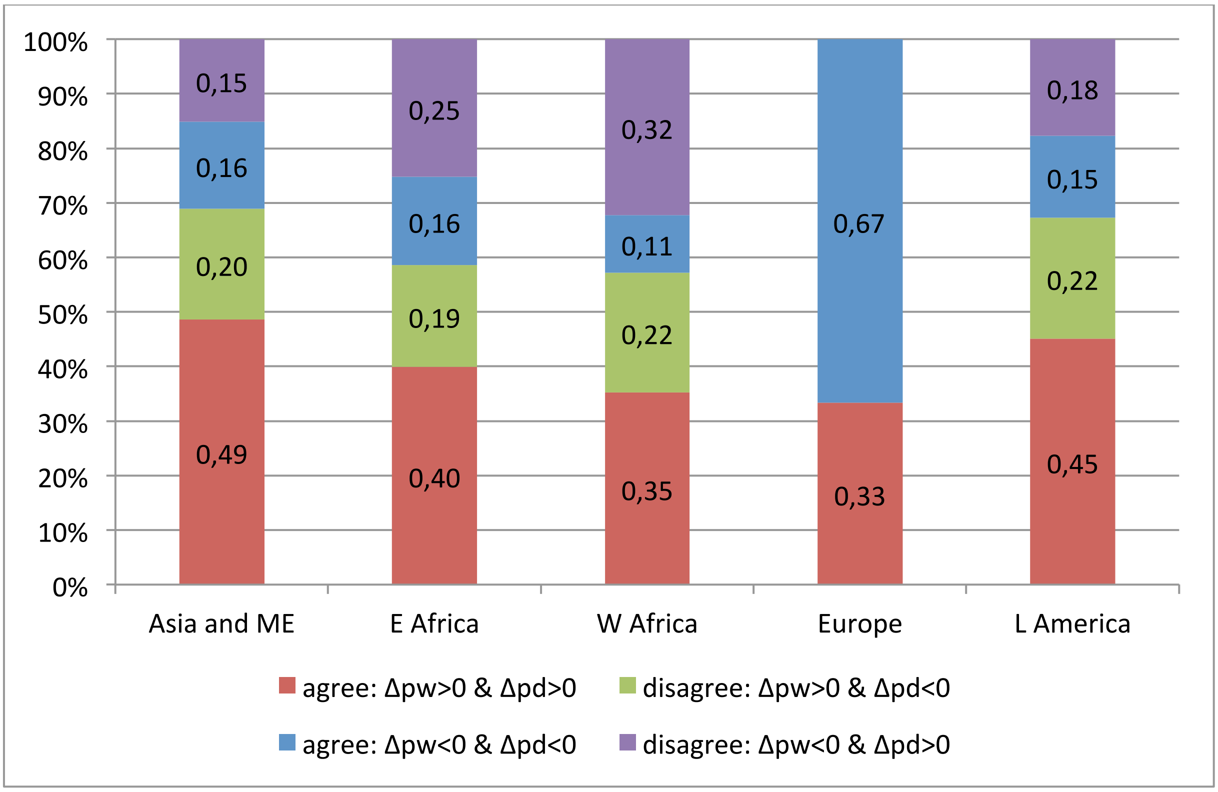
Source: Own calculations with GIEWS price data.

Table 15: The direction of annual price movements on domestic and international markets – agreement and disagreement by region and cereal

	Agree: Δpw<0 & Δpd<0	Agree: Δpw>0 & Δpd>0	Disagree: Δpw>0 & Δpd<0	Disagree: Δpw<0 & Δpd>0	Sum: agree	Sum: disagree
			By region			
Asia and ME	16%	49%	20%	15%	65%	35%
E. Africa	16%	40%	19%	25%	56%	44%
W. Africa	11%	35%	22%	32%	46%	54%
Europe	67%	33%	0%	0%	100%	0%
L. America	15%	45%	22%	18%	60%	40%
			By cereal			
Maize	12%	34%	25%	30%	46%	54%
White maize	11%	38%	19%	32%	49%	51%
Rice	18%	46%	19%	17%	64%	36%
Wheat	20%	49%	18%	13%	69%	31%
			All regions and cereals			
Total	15%	41%	20%	24%	56%	44%

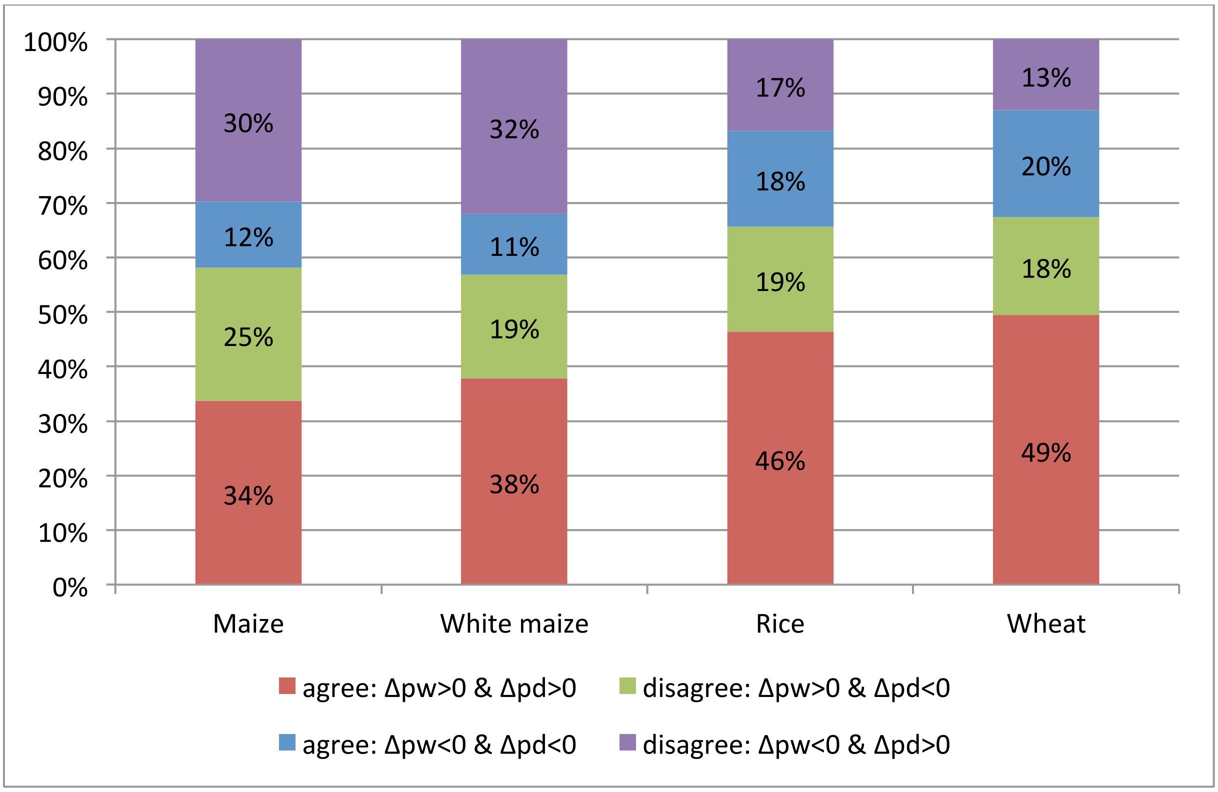
Source: Own calculations with GIEWS price data.

Figure 7a: The direction of annual price movements on domestic and international markets – agreement and disagreement by region



Source: Own calculations with GIEWS price data.

Figure 7b: The direction of annual price movements on domestic and international markets – agreement and disagreement by cereal



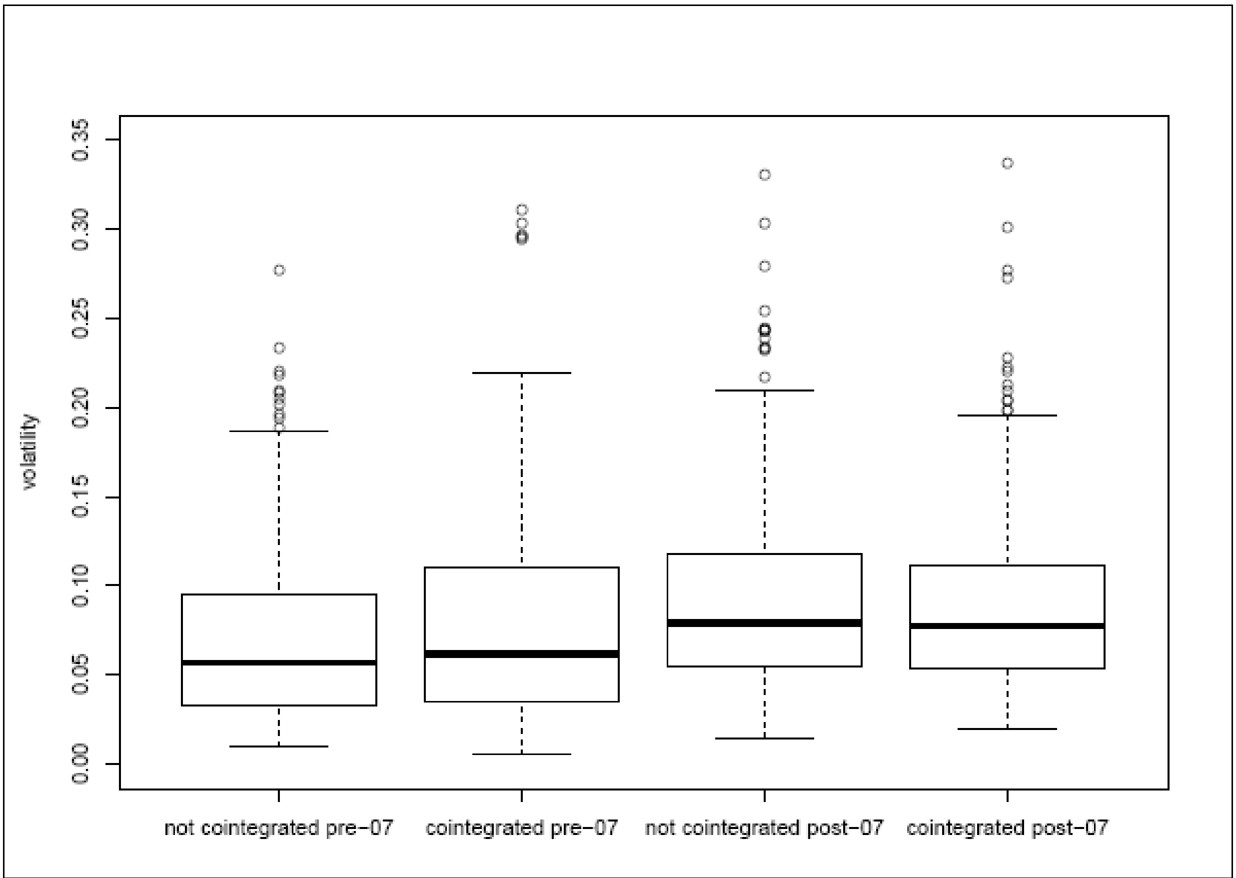
Source: Own calculations with GIEWS price data.

6. Price volatility

In this section we compare cereal price volatility on international and domestic markets. Volatility is measured as the standard deviation of returns (the log ratio of prices in month *t* to prices in month *t-1*). Results are summarized in Figures 8 through 11 and Table 15.

First, Figure 8 illustrates that median volatility over all domestic cereal prices in the GIEWS dataset is higher after July 2007 than before (see also Table 15). There is no difference between the median volatilities of those prices that are cointegrated with the corresponding international prices and those that are not. This suggests that on average, countries that have decoupled their domestic cereal prices from international prices have not benefited from reduced price volatility as a result.

Figure 8: Boxplots of volatilities for cointegrated and non-cointegrated domestic prices, pre- and post-2007, maize, rice and wheat combined



Source: Own calculations with GIEWS price data.

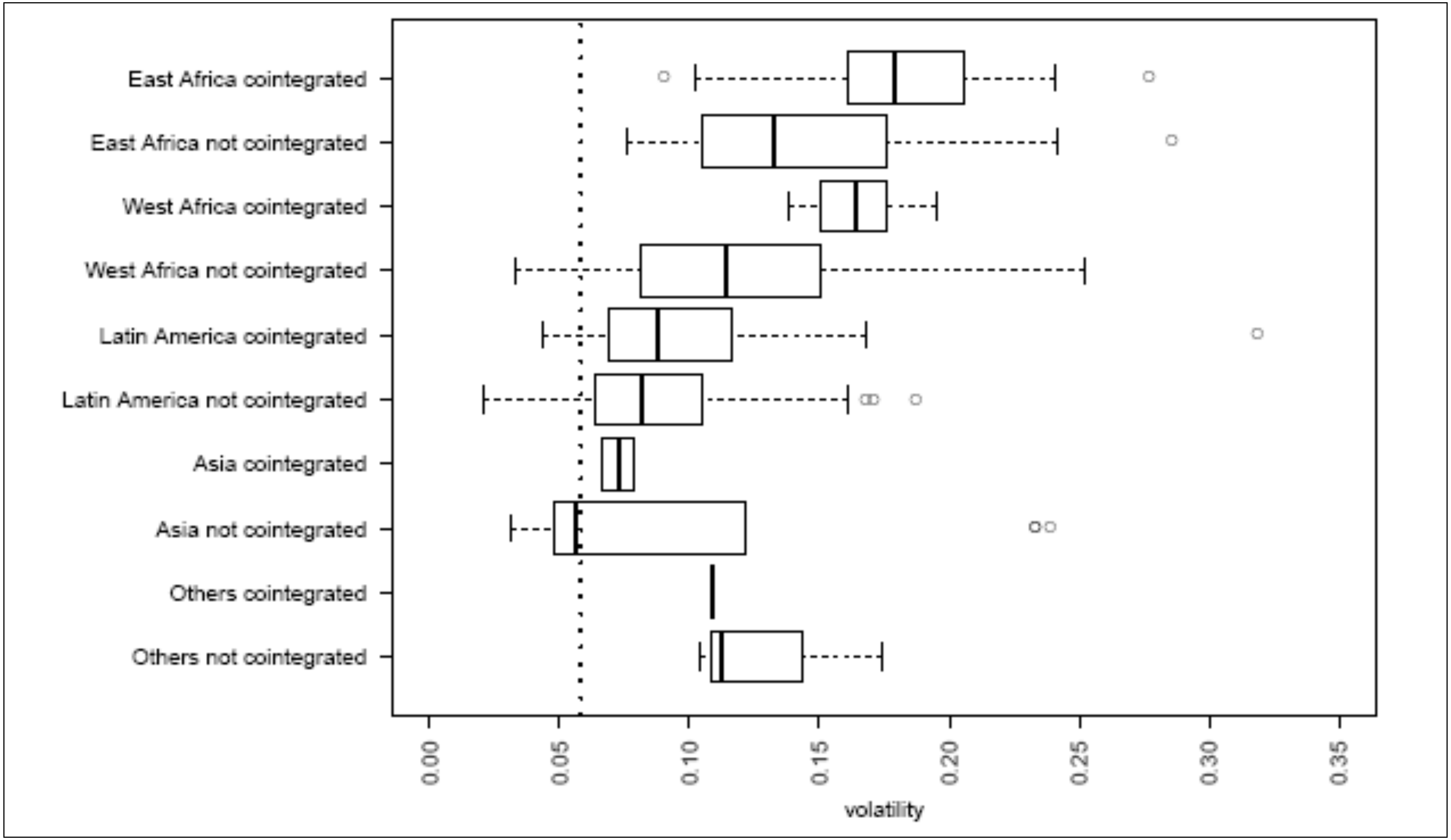
Table 16 and the results presented in Figures 9 through 11 for maize, rice and wheat respectively indicates that in general, domestic prices are most volatile in East and West Africa, followed by Latin America and Latin America. This pattern is interrupted somewhat for wheat, but the calculated volatilities for wheat are based on relatively few observations and, therefore, are less reliable. For maize in all regions we observe that median volatilities are lower for prices that are not cointegrated with the corresponding international prices, suggesting that decoupling prices does results in lower volatility on average for maize. However, this is not the case for rice and wheat, where non-cointegrated domestic prices are more, rather than less volatile than cointegrated prices.

Table 16: The volatility of monthly international and domestic cereal prices

Prices	Maize			Rice			Wheat			All cereals		
	Median volatility	Standard deviation	n	Median volatility	Standard deviation	n	Median volatility	Standard deviation	n	Median volatility	Standard deviation	n
International	**0.06**			**0.07**			**0.06**			**0.06**		
All domestic	**0.11**	0.06	179	**0.06**	0.05	262	**0.08**	0.04	57	**0.07**	0.06	498
Cointegrated	**0.14**	0.06	55	**0.06**	0.06	139	**0.09**	0.04	14	**0.07**	0.07	208
Non-cointegrated	**0.11**	0.06	124	**0.06**	0.03	123	**0.07**	0.04	43	**0.07**	0.05	290
Pre-2007	**0.10**	0.08	153	**0.04**	0.04	234	**0.05**	0.04	51	**0.06**	0.07	438
Post-2007	**0.11**	0.06	179	**0.06**	0.05	262	**0.09**	0.05	57	**0.08**	0.06	498
Cointegrated pre-2007	**0.14**	0.10	51	**0.05**	0.05	119	**0.08**	0.06	14	**0.06**	0.08	184
Cointegrated post-2007	**0.14**	0.06	55	**0.06**	0.06	139	**0.10**	0.03	14	**0.08**	0.07	208
Non-cointegrated pre-2007	**0.09**	0.07	102	**0.04**	0.03	115	**0.05**	0.03	37	**0.06**	0.06	254
Non-cointegrated post-2007	**0.11**	0.06	124	**0.06**	0.03	123	**0.08**	0.05	43	**0.08**	0.05	290
East Africa	**0.15**	0.05	59	**0.09**	0.03	35	**0.09**	0.03	14	**0.11**	0.05	108
West Africa	**0.13**	0.05	43	**0.07**	0.03	81	**0.13**	0.06	6	**0.08**	0.05	130
Latin America	**0.08**	0.05	58	**0.05**	0.02	70	**0.07**	0.03	11	**0.06**	0.04	139
Asia	**0.07**	0.08	15	**0.05**	0.07	74	**0.06**	0.03	24	**0.05**	0.07	113
Other	**0.11**	0.03	4	**0.04**	0.02	2	**0.10**	0.00	2	**0.10**	0.04	8
E Africa cointegrated	**0.18**	0.05	21	**0.09**	0.03	22	**0.09**	0.04	8	**0.12**	0.06	51
E Africa non-cointegrated	**0.13**	0.05	38	**0.09**	0.03	13	**0.09**	0.02	6	**0.11**	0.05	57
W Africa cointegrated	**0.16**	0.02	9	**0.06**	0.03	58	**0.14**	-	1	**0.07**	0.04	68
W Africa non-cointegrated	**0.11**	0.06	34	**0.07**	0.04	23	**0.11**	0.07	5	**0.09**	0.06	62
L America cointegrated	**0.09**	0.06	22	**0.04**	0.02	39	**0.05**	0.04	2	**0.05**	0.05	63
L America non-cointegrated	**0.08**	0.04	36	**0.06**	0.02	31	**0.07**	0.02	9	**0.07**	0.04	76
Asia cointegrated	**0.07**	0.01	2	**0.06**	0.14	18	**0.09**	0.01	3	**0.06**	0.12	23
Asia non-cointegrated	**0.06**	0.08	13	**0.05**	0.02	56	**0.05**	0.03	21	**0.05**	0.04	90
Other cointegrated	**0.11**	-	1	**0.04**	0.02	2	**-**	-	0	**0.05**	0.04	3
Other non-cointegrated	**0.11**	0.04	3	**-**	-	0	**0.10**	0.00	2	**0.10**	0.03	5

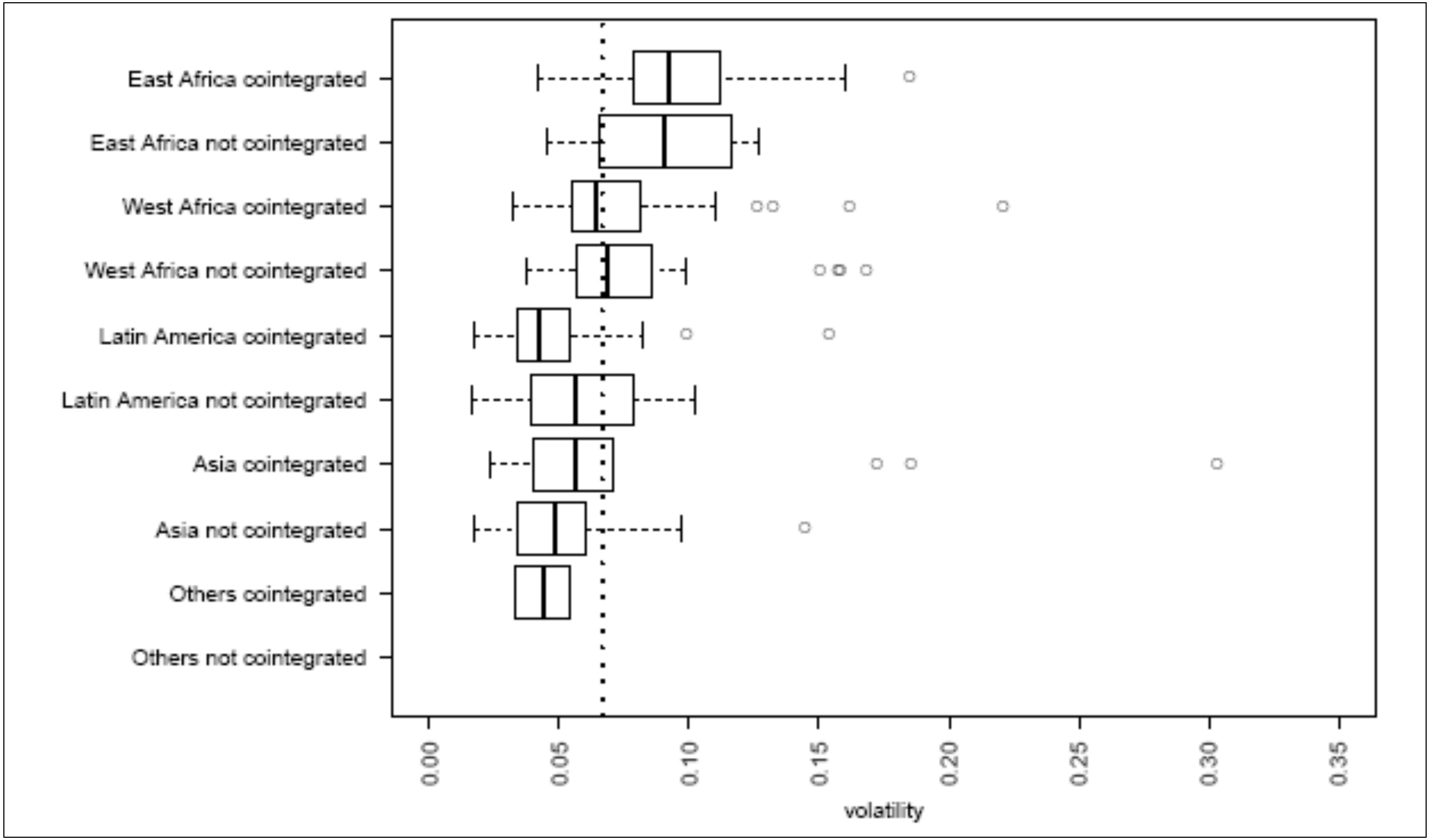
Note: 'n' is the number of individual price series that underlie the volatility calculation. Volatility is calculated as the standard deviation of the log ratio of prices in the current month to prices in the previous month.
Source: Own calculations with GIEWS price data.

Figure 9: Boxplots of domestic price volatilities for maize by region, and the volatility of the international maize price (vertical dotted line)



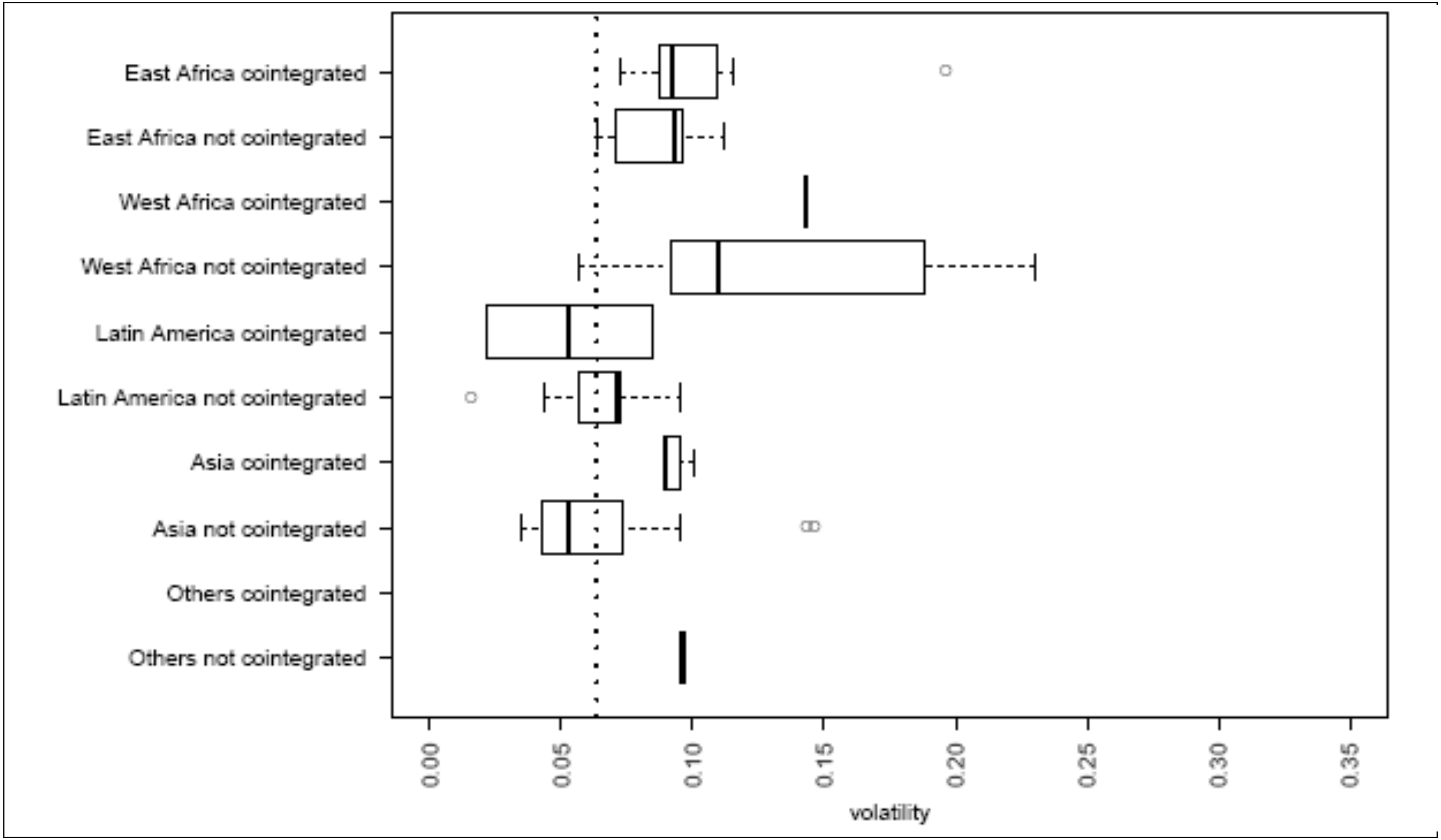
Source: Own calculations with GIEWS price data.

Figure 10: Boxplots of domestic price volatilities for rice by region, and the volatility of the international rice price (vertical dotted line)



Source: Own calculations with GIEWS price data.

Figure 11: Boxplots of domestic price volatilities for wheat by region, and the volatility of the international wheat price (vertical dotted line)



Source: Own calculations with GIEWS price data.

Finally, comparing domestic price volatility with international price volatility (first lines of Table 15) reveals that on average, domestic maize and wheat prices are more volatile than the corresponding international prices, while domestic rice prices are less volatile. Figures 9 through 11, in which international price volatility is depicted by the dashed vertical lines, break this comparison down by region. Figure 9 shows that the great majority of domestic maize prices in all regions are considerably more volatile than the international maize price. For rice (Figure 10), domestic prices in East Africa are more volatile than the international price, equally volatile on average in West Africa, and less volatile in Latin America and Asia. For wheat the picture (Figure 11) is very mixed, with domestic prices in East and West Africa considerably more volatile than the international price, and Latin America and Asia showing mixed results. Again, as Table 15 shows, there are relatively few observations for wheat in some regions in the GIEWS data, so these last results must be interpreted with caution.

7. Discussion

The analysis above generates a number of insights into the nature of PT from international to domestic cereal markets. First, 79% of the international/domestic price pairs in our sample of PT studies from the literature are cointegrated compared with 43% in our own estimates based on FAO GIEWS data. Hence, regardless of which database is used, many of the studied price pairs are not characterized by cointegration and thus do not provide evidence of stable PT. This is especially the case if we consider that the literature sample most likely suffers from publication bias that leads to an overrepresentation of findings of cointegration. Overall, maize markets are characterized by a below average prevalence of cointegration, and rice markets by an above average prevalence. Which regions of the world display higher/lower shares of cointegration depends on which dataset is considered: according to the literature sample, domestic prices in Africa are less likely than average to be cointegrated with corresponding international prices, but our own estimates generated with GIEWS data suggest that domestic prices in Asia are least likely to be cointegrated with international prices.

Overall, both the literature and our own GIEWS-based estimated point to average long-run PT coefficients of roughly 0.75 and average adjustment parameters of roughly 0.09-0.11. This suggests that on average roughly three-quarters of a change in international prices will be transmitted to domestic markets, and that it takes approximately 6-7 months for one-half of a given price shock on international cereal markets to be transmitted to domestic markets. For wheat and maize it is exclusively the domestic prices that react to disequilibrium between themselves and the corresponding international prices. But in the case of rice, roughly 40% of all price pairs display international price reactions to disequilibrium as well. Hence, the determination of international prices for rice appears to differ fundamentally from that for wheat and maize. The reasons for this difference would be an interesting topic for future research.

If we compare PT in the period prior to July 2007 with PT in the period thereafter, no clear pattern emerges. On maize markets the long-run PT coefficients (β) have fallen considerably since mid-2007. This could be interpreted as evidence of a certain degree of decoupling of domestic from international prices. On rice and wheat markets the results depend on whether all price pairs or only cointegrated price pairs are considered. In the latter case there is evidence that the long-run PT coefficients have increased, but at the same time the short-run adjustment coefficients (α) have fallen, suggesting that PT has become more complete but slower since mid-2007 for rice and wheat.

Employing meta-regression analysis to explain variations in long-run PT coefficients (β) between domestic and international prices fails to generate compelling results. The meta-regressions for the adjustment parameters (α) do produce some more suggestive results. All other things being equal, there is some evidence of more rapid PT for maize than for wheat and rice, and more rapid PT in West Africa than in other regions. An increasing ratio of net imports to domestic consumption is associated with slower PT, which may be an indication of increased intervention on politically more sensitive markets. There is evidence that trade openness is positively associated with the speed of PT, but this effect is only significant in the pre-July 2007 period. In this period there is also robust evidence that the presence of an STE is associated with more rapid PT. Finally, there is some puzzling indication that improved logistics is correlated with slower PT.

The analysis of agreement in the direction in price changes on international and domestic markets suggests that the frequency of agreement is quite low at the monthly level, and only somewhat higher at the quarterly level. This lack of agreement is especially pronounced when international prices are falling; in this case domestic prices only fall as well in roughly 50% of all cases, which is what one would expect if price movements on international and domestic markets were completely independent. When international prices are increasing, there is a higher probability that domestic prices will increase as well, especially at the quarterly level for Europe, Asia, East Africa and Latin America. Overall these results support the findings of generally weak PT that were derived from the cointegration analysis.

The analysis of domestic price volatility reveals that median volatility has increased since July 2007. There is no difference between the median volatilities of those prices that are cointegrated with the corresponding international prices and those that are not. This suggests that on average, countries that have decoupled their domestic cereal prices from international prices have not benefited from reduced price volatility as a result. The analysis reveals that in general, domestic prices are most volatile in East and West Africa, followed by Latin America and Latin America. Furthermore, on average domestic maize and wheat prices are more volatile than the corresponding international prices, while domestic rice prices are less volatile.

The results presented here must be interpreted with caution. First, a lack of cointegration between two prices does not necessarily mean that there is no PT between (McNew and Fackler, 1997). The underlying PT relationship may be characterized by regime-dependence, for example as a result of policy intervention or shifts between net import and net export positions. Hence, failure to find evidence of cointegration might be due to a failure to test for the right type of cointegration. The higher share of cointegrated price pairs in the literature sample is likely due to publication bias that leads to an overrepresentation of 'significant' results. However, the authors of studies in the literature might also find more evidence of cointegration because they employ models and tests that are better tailored to the specific country/product settings that they study. The strength of the GIEWS price data is that it provides broad and consistent coverage of a large number of country/product combinations. However, the sheer number of price series available in GIEWS means it is not possible to implement a detailed modeling strategy for each individual series. Instead, we must resort to a uniform modeling strategy that can be automated. We have estimated one slightly more flexible VECM that allows for a regime shift in July 2007, but this is no substitute for careful, case-by-case specification and estimation of an appropriate model for each individual price pair.

Second, the GIEWS price series are quite short. Few series have more than 150 monthly observations, and many have considerably less. It is reasonable to expect that the nature of cereal price transmission from international to domestic markets has changed in recent years at prices have increased and become more volatile, and some of the results that we produce with the GIEWS data appear to confirm this expectation. There are, however, only roughly 55 monthly observations available for the period since 2007.

Additional work might lead to additional or more robust insights into PT. First, the simple VECM employed to estimate the GIEWS price data might be made somewhat more flexible. It could be modified to allow for asymmetric price transmission, i.e. to test whether increases in international prices are transmitted to domestic prices in the same manner as decreases (von Cramon-Taubadel, 1998). The results of the simple non-parametric analysis of agreement in the direction of international and domestic price changes suggests that increasing international prices are being transmitted more often to domestic prices than decreasing international prices. Alternatively, it might be possible to estimate threshold VECMs (TVECMs) with the GIEWS data (Goodwin and Piggott, 2001; Greb et al., 2011). The TVECM can account for phases with and without trade and trade reversals and by distinguishing between these phases or regimes provide better estimates of PT parameters.

Second, the analysis of agreement in the direction of price changes on international and domestic markets could be extended to consider half-yearly and annual price changes, and to explore possible delays in the response of domestic to international prices. It may be that more agreement in the direction of price changes is found if current international price changes are aligned with domestic price changes several months later, and that the length of this lag varies between countries and/or products.

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9. Appendix

Appendix Table 1: Studies included in the literature sample

Authors, Year Published	Title	Institution / Publication	Type of publication	Number of market pairs
Baquedano, Liefert, &Shapouri, 2011	World market integration for export and food crops in developing countries: a case study for Mali and Nicaragua	Agricultural Economics	Journal	4
Djuric, Götz, & Glauben, 2011	Effects of the governmental market interventions on the wheat market in Serbia during the food crisis 2007/2008	IAMO	Conference	2
Ghoshray, 2011	Underlying Trends and International Price Transmission of Agricultural Commodities	ADB	Report	10
Gilbert, 2011	Grains Price Pass-Through, 2005-09	FAO	Report	10
Minot, 2011	Transmission of World Food Price Changes to Markets in Sub-Saharan Africa	IFPRI	Report	58
Myers & Jayne, 2011	Multiple-regime spatial price transmission with an application to maize markets in southern Africa	American Journal of Agricultural Economics	Journal	3
Aldaz-Carroll, Varela, & Iacovone, 2010	Boom, Bust and Up Again? Evolution, Drivers and Impact of Commodity Prices: Implications for Indonesia	World Bank	Report	2
Goetz, Glauben, & Bruemmer, 2010	How did policy interventions in wheat export markets in Russia and Ukraine during the food crisis 2007/2008 influence world market price transmission?	IAMO, U of Göttingen	Conference	10
Robles & Torero, 2010	Understanding the Impact of High Food Prices in Latin America	ECONOMIA	Journal	4
Araujo Enciso, 2009	Evidence of non-linear price transmission between maize markets in Mexico and the US	U of Göttingen	Conference	18
Bamuturaki, 2009	World market integration and price transmission in selected markets in Tanzania	U of Hohenheim	Thesis	2
Dutoit, Hernandez-Villafuerte, & Urrutia, 2009	Price transmission in Latin American maize and rice markets	UN ECLAC, U of Göttingen	Report	46
Rapsomanikis et al., 2009	The 2007-2008 Food Price Swing: Impact and policies in Eastern and Southern Africa	FAO	Report	42
World Bank, 2009	Eastern Africa: A study of the regional maize market and marketing costs	U of Göttingen, World Bank	Report	12
Cudjoe, Breisinger, & Diao, 2008	Local impacts of a global crisis: food price transmission and poverty impacts in Ghana	IFPRI	Report	2
Ghoshray, 2008	Asymmetric Adjustment of Rice Export Prices: The Case of Thailand and Vietnam	International Journal of Applied Economics	Journal	5
Imai, Gaiha, & Thapa, 2008	Transmission of World Commodity Prices to Domestic Commodity Prices in India and China	Brooks World Poverty Institute	Report	12
Listorti & Esposti, 2008	Making the world market price endogenous within AGMEMOD modeling framework: an econometric solution	UniversitàPolitecnica delle Marche	Conference	1
Warr, 2008	The transmission of import prices to domestic prices: an application to Indonesia	Applied Economics Letters	Journal	3
Myint, 2007	Myanmar rice market: market integration and price causality	Yezin Agricultural U	Thesis	2
Reddy, 2006	Commodity market integration: case of Asian rice markets	CSIRD	Report	18
Thomas & Morrison, 2006	Trade reforms and food security: Country Case Studies and Synthesis	FAO	Report	18
Yavapolkul, Gopinath, & Gulati, 2006	Post–Uruguay Round price linkages between developed and developing countries: the case of rice and wheat markets	Agricultural Economics	Journal	4
Conforti, 2004	Price transmission in selected agricultural markets	FAO	Report	134
Sagidova, 2004	Price transmission in grain market: case of Ukraine	Kyiv-Mohyla Academy	Thesis	4
Baffes & Gardner, 2003	The transmission of world commodity prices to domestic markets under policy reforms in developing countries	Journal of Policy Reform	Journal	44
Hai, 2003	Rice markets in the Mekong river delta, Vietnam: a market integration analysis	Centre for ASEAN Studies	Report	1
Rapsomanikis et al., 2003	Market integration and price transmission in selected food and cash crop markets of developing countries: review and applications	FAO	Report	3
Sharma, 2003	The transmission of world price signals: the concept, issues, and some evidence from Asian cereal markets	OECD	Book	16
Ghoshray, 2002	Asymmetric Price Adjustment and the World Wheat Market	Journal of Agricultural Economics	Journal	180
Mohanty, Smith, & Peterson, 1996	Time series evidence of relationships between U.S. and Canadian wheat prices	Iowa State University	Report	8

Appendix Table 2: Cointegration between international and domestic prices in the GIEWS dataset by product and country

Country	Maize						Rice						Wheat					
	entire period		pre- break		post- break		entire period		pre- break		post- break		entire period		pre- break		post- break	
	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs
Afghanistan													3	4	0	4	2	4
Argentina	1	1	0	1	1	1							0	3	0	3	0	3
Bangladesh													0	4	0	3	0	4
Benin	7	7	5	7	2	7	4	4	3	4	1	4						
Bhutan							1	2			1	2	0	1			0	1
Bolivia	1	3	1	3	1	3	4	6	0	6	4	6	0	3	0	3	0	3
Brazil	1	2	0	2	0	2	3	5	0	5	0	5	1	2	0	2	0	2
Burkina Faso							8	9	0	3	8	9						
Burundi	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Cambodia							0	4	0	3	1	4						
Cameroon	0	5	0	5	0	5	5	5	2	5	4	5						
Cape Verde	1	9	0	3	2	9	2	6	2	6	0	6						
Chad	1	3	0	3	3	3	3	3	2	3	2	3						
China							0	2	1	2	0	2						
Colombia	3	3	0	3	1	3	4	5	0	5	5	5						
Costa Rica	0	2	0	1	0	2	0	2	0	2	0	2						
D.R. Congo	0	3			0	3	2	4			2	4						
Djibouti							2	2	1	2	1	2						
Dominican Republic	0	2	0	2	1	2	3	4	2	4	4	4						
Ecuador	2	8	2	8	0	8	4	9	0	9	3	9						
Egypt	0	4			0	4	2	4			2	4	0	2			0	2
El Salvador	0	2	1	2	0	2	2	2	0	2	2	2						

Note: Empty cells indicate that there were no or insufficient (<10) observations for the country/product/period combination in question. Cointegration tested by Johansen at 5%.

Appendix Table 2: Cointegration between international and domestic prices in the GIEWS dataset by product and country (continued)

Country	Maize						Rice						Wheat					
	entire period		pre- break		post- break		entire period		pre- break		post- break		entire period		pre- break		post- break	
	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs
Eritrea													1	1			0	1
Ethiopia	1	8	0	4	4	8							7	11	2	11	7	11
Gabon							0	1			0	1						
Ghana	0	3	0	3	0	3	0	2	0	2	0	2						
Guatemala	3	3	1	3	3	3	2	3	0	2	1	3						
Guinea							0	2			1	2						
Haiti	1	14	2	14	1	14	3	14	2	13	1	14						
Honduras	3	3	0	1	1	3	2	2			2	2						
India							2	8	2	8	2	8	0	8	0	8	0	8
Indonesia							1	1			1	1						
Israel	0	1	0	1	0	1							0	1	0	1	0	1
Kenya	0	6	1	5	1	6												
Lao People's Dem. Rep.							1	3	1	3	0	3						
Lesotho							0	1			0	1						
Madagascar							0	2	0	2	0	2						
Malawi	0	6			2	6	0	2			0	2						
Mali							11	14	0	4	11	14						
Mauritania							0	1	0	1	0	1	0	1			0	1
Mexico	4	5	2	5	2	5	1	4	0	4	3	4						
Mongolia							0	1			0	1						
Mozambique	11	14	9	14	5	13	8	10	2	10	4	10						

Note: Empty cells indicate that there were no or insufficient (<10) observations for the country/product/period combination in question. Cointegration tested by Johansen at 5%.

Appendix Table 2: Cointegration between international and domestic prices in the GIEWS dataset by product and country (continued)

Country	Maize						Rice						Wheat					
	entire period		pre- break		post- break		entire period		pre- break		post- break		entire period		pre- break		post- break	
	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs
Myanmar							1	1			1	1						
Namibia	0	1			0	1												
Nicaragua	3	6	3	5	2	6	10	10	1	8	10	10						
Niger	0	6	0	6	2	6	9	12	5	12	6	12						
Nigeria	0	1	0	1	0	1												
Pakistan							0	5	2	5	1	5	0	4	0	4	4	4
Panama	0	2	0	2	0	2	1	2	1	2	2	2						
Peru	0	2	0	2	0	2	0	1	0	1	0	1	1	2	0	2	0	2
Philippines	2	8	0	8	0	8	6	28	19	28	2	28						
Republic of Moldova	0	2			0	2												
Russian Federation	0	1	0	1	0	1	1	1	0	1	0	1	0	1			0	1
Rwanda	1	1	0	1	1	1	1	1	0	1	1	1						
Samoa									0	1								
Senegal							9	11			8	11						
Somalia	6	11	0	10	5	11	9	12	6	11	3	12						
South Africa	0	1	1	2	0	2							0	1	0	1	0	1
Sri Lanka							1	1	0	1	1	1						
Sudan													1	5	0	5	2	5
Thailand	0	1	0	1	0	1	1	1	1	1	0	1						
Timor-Leste	0	1			0	1	1	1			1	1						
Togo	0	6	0	6	2	6	4	6	1	6	2	6						
Tunisia							1	1	1	1	1	1						

Note: Empty cells indicate that there were no or insufficient (<10) observations for the country/product/period combination in question. Cointegration tested by Johansen at 5%.

Appendix Table 2: Cointegration between international and domestic prices in the GIEWS dataset by product and country (continued)

Country	Maize						Rice						Wheat					
	entire period		pre- break		post- break		entire period		pre- break		post- break		entire period		pre- break		post- break	
	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs	# of cointegrated pairs	# of pairs
Uganda	0	3	0	1	1	2	2	3	0	3	2	3						
Ukraine	1	1	0	1	1	1							0	1	0	1	0	1
United Rep. of Tanzania	2	5	1	1	3	5												
Uruguay							0	1			0	1	0	1	0	1	0	1
Vietnam							1	1			0	1						
Zambia	0	1	0	1	0	1	0	1			0	1						
Zimbabwe	0	1	1	1	0	1												
Sum	55	179	30	141	47	178	139	251	57	193	108	251	14	57	2	50	15	57
Share of cointegrated pairs	30.7%		21.3%		26.4%		55.4%		29.5%		43.0%		24.6%		4.0%		26.3%	

Note: Empty cells indicate that there were no or insufficient (<10) observations for the country/product/period combination in question. Cointegration tested by Johansen at 5%.

Appendix Table 3: Average estimates of the long-run PT coefficient β taken from the literature and GIEWS samples, by product and region. Comparison only includes those product/country combinations for which there are observations in both the GIEWS and literature samples.

	Maize		Rice		Wheat		*All three cereals*	
	GIEWS	Lit.	GIEWS	Lit.	GIEWS	Lit.	*GIEWS*	*Lit.*
Asia & ME	0.90	1.03	0.31	0.60	1.51	0.11	*0.60*	*0.59*
E. Africa	0.85	0.84	1.28	0.58	1.04	0.65	*0.98*	*0.80*
W. Africa	1.62	1.74	0.52	0.40	-	-	*0.63*	*0.59*
L. America	0.70	-	0.73	0.62	0.95	-	*0.74*	*0.62*
All regions	*0.85*	*0.86*	*0.56*	*0.59*	*1.24*	*0.43*	*0.75*	*0.69*

Note: Averages by region and cereal weighted by the number of observations in each category.
Source: Own calculations with literature sample and GIEWS price data.

Appendix Table 4: Average estimates of the adjustment parameter α taken from the literature and GIEWS samples, by product and region. Comparison only includes those product/country combinations for which there are observations in both the GIEWS and literature samples.

	Maize		Rice		Wheat		*All three cereals*	
	GIEWS	Lit.	GIEWS	Lit.	GIEWS	Lit.	*GIEWS*	*Lit.*
Asia & ME	-0.07	0.10	-0.02	-0.12	-0.02	-0.07	*-0.03*	*-0.12*
E. Africa	-0.12	-0.09	-0.09	-0.06	-0.15	-0.25	*-0.12*	*-0.10*
W. Africa	-0.26	-0.10	-0.15	-0.14			*-0.16*	*-0.13*
L. America	-0.16		-0.07	-0.34	-0.12		*-0.11*	*-0.34*
All regions	*-0.13*	*-0.09*	*-0.07*	*-0.22*	*-0.09*	*-0.18*	*-0.09*	*-0.17*

Note: Averages by region and cereal weighted by the number of observations in each category.
Source: Own calculations with literature sample and GIEWS price data.

Appendix Table 5: Countries with state trading enterprises (STEs) for maize, rice or wheat

Product	Countries with STEs
Maize	China, Kenya, Malawi, Zambia, Zimbabwe
Rice	Australia, China, Dominican Republic, India, Iraq, Japan, Kenya, Korea, Malaysia, Pakistan, Philippines, Thailand, Vietnam
Wheat	Australia, Canada, China, Cyprus, Egypt, Arab Rep., India, Iran, Japan, Korea, Pakistan, Sri Lanka, Sudan, Syria, Tajikistan, Tunisia

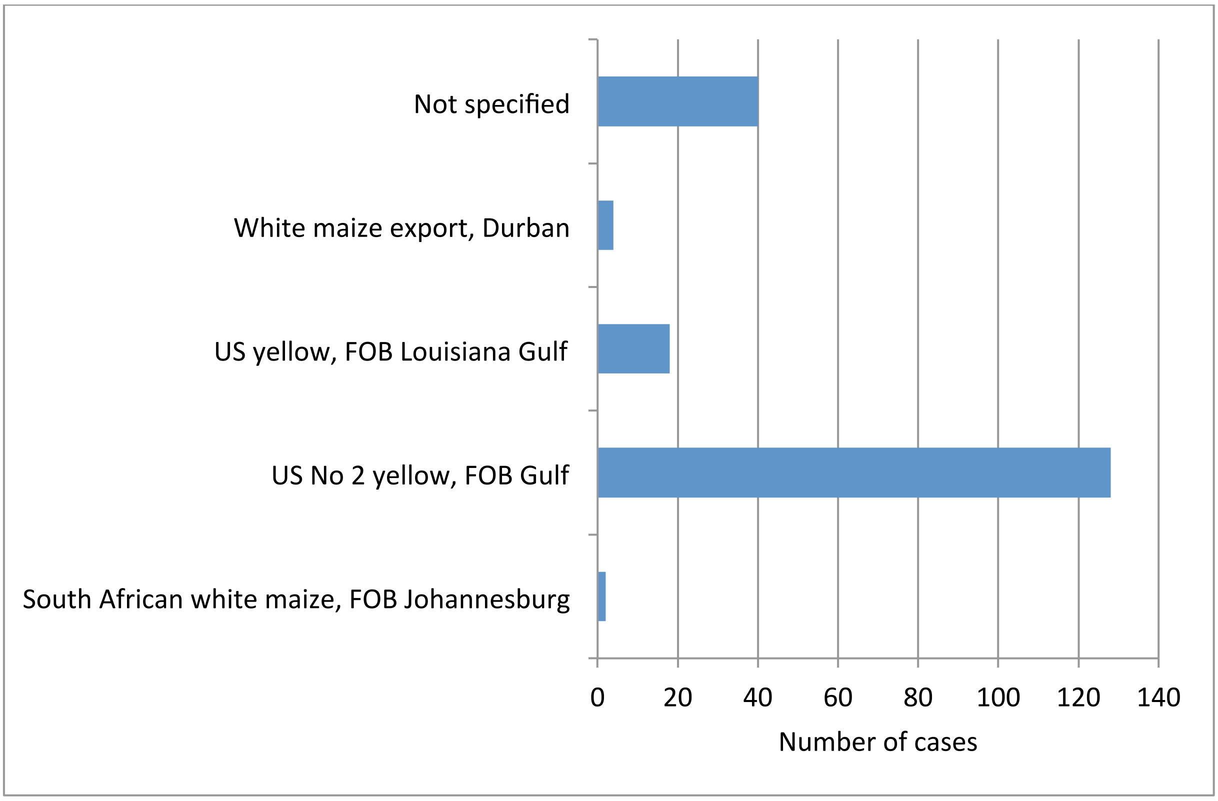
Source: Compiled using Ackerman (1997; 1998), Ackerman and Dixit (1999), Chang and de Gorter (2004), OECD (2007), Young (1999) and Young and Abbott (1998).

Appendix Table 6: Numbers and shares of cases in which the adjustment parameter for the international price is significant

Product and Market level	Number of series	Of which cointegrated	Number of cases in which P_{INT} reacts to disequilibrium (α_2 significant)	Of which in the appropriate direction ($\alpha_2 > 0$)
Maize wholesale	71	29 (41)	6 (8)	4 (6)
Maize retail	109	26 (24)	3 (3)	2 (2)
Wheat wholesale	26	4 (15)	0 (0)	0 (0)
Wheat retail	31	10 (32)	1 (3)	0 (0)
Rice wholesale	97	53 (55)	46 (47)	41 (42)
Rice retail	165	86 (52)	65 (39)	63 (38)
Total	499	208 (42)	121 (24)	110 (22)

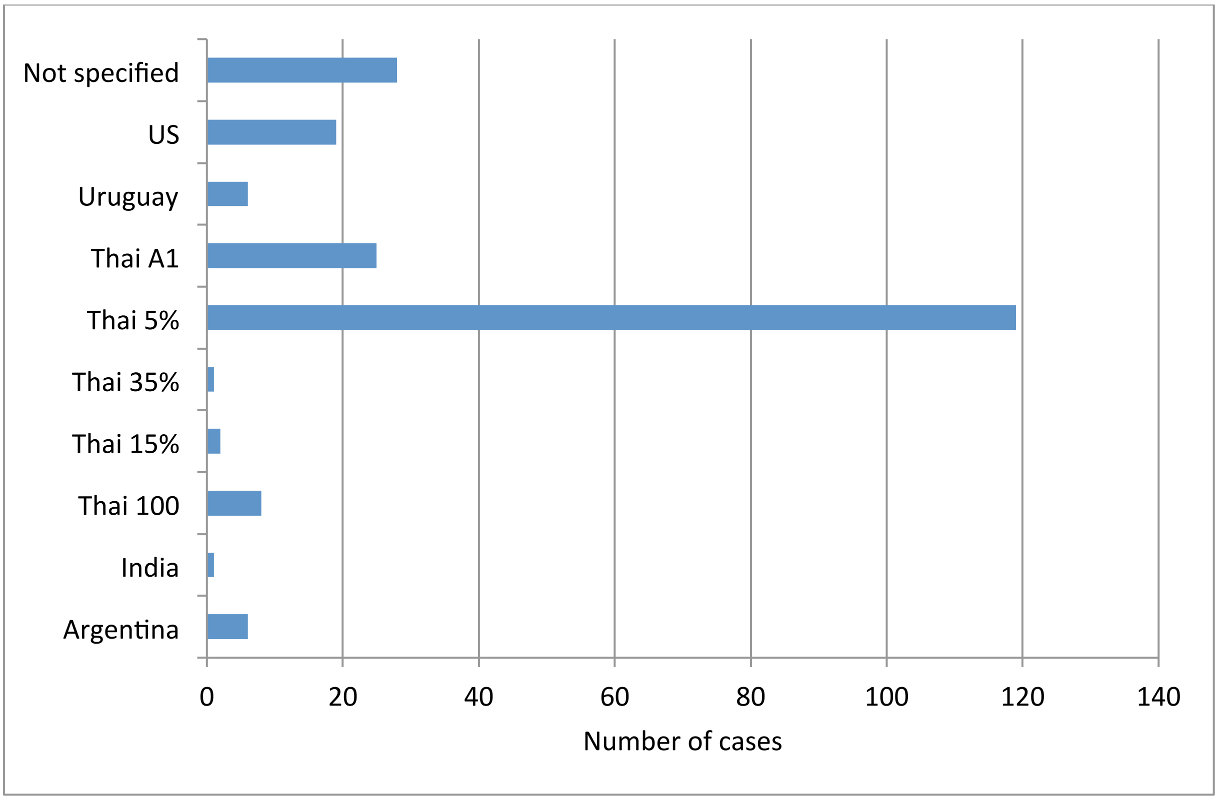
Note: Number in brackets is the share of the corresponding number of series, in %.
Source: Own calculations with GIEWS price data.

Appendix Figure 1: The prevalence of different international maize prices in the literature sample



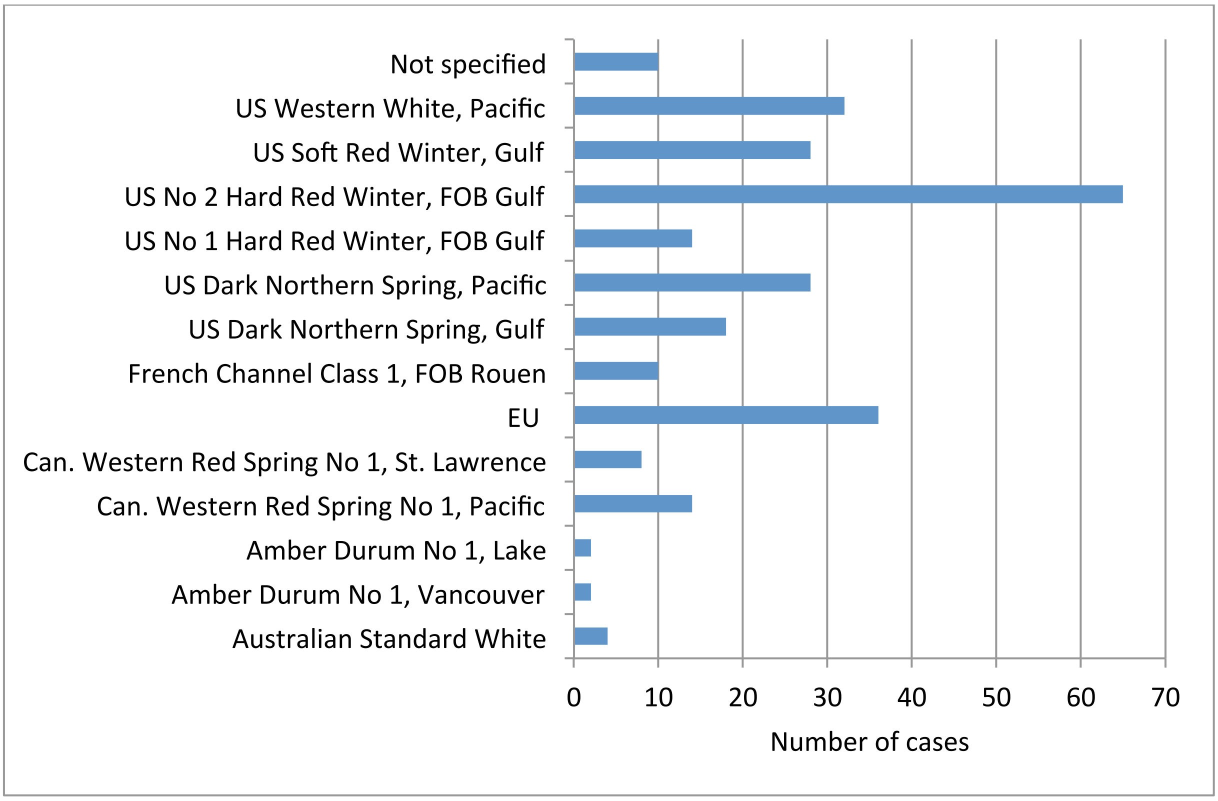
Source: Own calculations with literature sample.

Appendix Figure 2: The prevalence of different international rice prices in the literature sample



Source: Own calculations with literature sample.

Appendix Figure 3: The prevalence of different international wheat prices in the literature sample



Source: Own calculations with literature sample.