

## ANALYSIS AND DETERMINANTS OF RETAIL AND WHOLESALE STAPLE FOOD PRICE VOLATILITY IN DEVELOPING COUNTRIES

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ULYSSES project assess the literature on prices volatility of food, feed and non-food commodities. It attempts to determine the causes of markets' volatility, identifying the drivers and factors causing markets volatility. Projections for supply shocks, demand changes and climate change impacts on agricultural production are performed to assess the likelihood of more volatile markets. ULYSSES is concerned also about the impact of markets' volatility in the food supply chain in the EU and in developing countries, analysing traditional and new instruments to manage price risks. It also evaluates impacts on households in the EU and developing countries. Results will help the consortium draw policy-relevant conclusions that help the EU define market management strategies within the CAP after 2013 and inform EU's standing in the international context. The project is led by Universidad Politécnica de Madrid.

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## Executive summary

Developing countries in Africa, Asia and Latin America were deeply affected by the food and economic crisis. Indeed, many countries are still suffering from high food price volatility. This paper goes beneath the global scale analyses to find out what happened to domestic agricultural market volatility in developing countries for three staple foods commodities: rice, wheat and maize. We measured the volatility using simple methodologies at retail and wholesale level for 36 developing countries using FAO database. Secondly we attempted to explain the cross-country variation in price volatility through the use of several explanatory variables related to macroeconomics and trade conditions. Given that most of the poor are net food consumers, such large price volatility has severe impacts on the effective purchasing power of the poor, which in turn likely affected the number of meals eaten as well as the nutritional quality of the food consumed.

### 1 Introduction

High level of volatility can be a serious problem for farmers in developing countries especially considering that small farmers are usually net consumers. Several authors, such as J. Anderson & Roumasset (1996); Cohen & Garrett (2009); de Hoyos & Medvedev (2011); Ivanic & Martin (2008), concluded that higher and more volatile food prices will substantially hurt poor net food consumers because food is typically a large share of expenditure for the poor. Food price increases can have important effects on effective purchasing power, even if they do not directly affect nominal income per se (Compton Wiggins & Sharada (2010)).

In recent high-profile reports (FAO et al. (2011); HLPE (2011); Tangermann (2011)) have discussed various measures to prevent, manage or cope with price volatility. There seems to be a general consensus that, due to change and increased linkages between food markets and volatile energy markets, high and volatile food prices are here to stay (Dawe & Timmer (2012)).

In the last years food price volatility has been extensively studied at international level but empirical studies of domestic prices instability are still scarce. Therefore, this paper assesses local real price volatility of rice, maize and wheat in 36 developing countries between January 2005 and December 2012. Volatility differentials across the wholesale and retail levels of the food value chain are also discussed. Secondly, we use a mixed model to estimate the impact of selected volatility determinants on both market levels for each commodity. Our objective is to provide answers to the following questions: What does staple food price volatility looks like in developing countries? What are the differences between retail and wholesale volatility levels? And can we explain domestic volatility in developing countries with selected determinants?

### 2 Volatile and high staple food prices at domestic level

According to Timmer (1995) the unstable prices for important food staples, such as maize, rice, wheat and cassava, in the case of some African countries, or beans for Central American countries, can have acute economic, social, and political consequences. But even, in the case of persistent volatility, it can also have adverse macroeconomic consequences by hindering economic growth in commodity-dependent developing countries (Prakash (2011)). It has been argued that food price instability can impose negative externalities on the general economy, particularly when a food staple is a wage good or represents a large proportion of a country's gross domestic product (GDP) (Bidarkota & Crucini (2000); Dawe (2001); P. Timmer & Dawe (2007))



In a paper published by the International Centre of Trade and Sustainable Development (ICTSD), (Valdés & Foste (2012)) deduced that a high level of volatility in food staple market complicates price discovery and represents a serious risk for the governments, producers and consumers. For governments, unforeseen variations in export prices can complicate budgetary planning and can jeopardize the attainment of debt targets (Dehn (2000)). Meanwhile Carvalho, Avanzi, Silva, Mello, & Cerri, (2010) concluded that high price volatility prevents the efficient allocation of resources by producers and consumers. The former may over produce due to the false signals of temporary high prices, which are followed by lower prices. On the other hand Subervie (2007) showed that agricultural outputs are lower in periods of high volatility.

Smallholder farmers in developing countries, often with limited access to efficient saving instruments, cope with revenue variability through crop diversification with the consequence that they largely forego the potential benefits obtainable through specialization Dehn (2000). In conclusion, Gilbert & Morgan (2010) claimed that we should expect vulnerability to commodity price variability to hinder growth. Factors that contribute to volatility in commodity prices include the physical characteristics of the commodity, the market structure, output elasticity and the availability of substitutes. Price volatility is not inherently bad if it is properly planned for, particularly now that markets have provided means to hedge/protect to some extent against price risk (Jayne (2012)).

When we look for the determinants, at global level, high and volatile prices are caused by a wide variety of supply and demand factors, including low food stocks, biofuel production, higher and volatile oil prices, drought, stagnating yield and declining public expenditure on agricultural research, urbanization and rising income levels, speculation on food commodity futures markets, and depreciation of the dollar in 2008 against most currencies (FAO et al. (2011); HLPE (2011)). In their review, Brümmer et al (2013) sort the existing literature on the analyses of volatility drivers in three main categories: (i) descriptive models which do not estimate directly the causal relationship between price volatility and its drivers (Anderson & Nelgen (2012); Chandrasekhar (2012); Clapp (2009); Gilbert & Morgan (2010); Nisanke, 2012; Wright (2011)) (ii) studies based on mathematical modelling such as partial equilibrium models (Babcock, (2012); Miao, Yu, Xi, & Tang (2011)) and (iii) empirical models which use reduced-form (Balcombe (2009); Ott 2012)), cointegration analysis (Pietola, Liu & Robles (2010)), or different specifications of the GARCH(1,1) model (Hayo, Kutan, & Neuenkirch (2011); Karali, Power, & Ishdorj (2011); Roache (2010); Zheng, Kinnucan, & Thompson (2006)). As we can see a large number of researchers tried to explain what happened during the period of the food crisis and what is currently happening to grain markets as well as some other main staple food commodities. They have created a reference corpus to explain international prices volatility through the use of several volatility measurements methodologies and econometric techniques.

**Table 1:** A short list of recent studies on food price volatility determinants

Authors	Volatility	Level	Model
Roache(2010)	Spline-GARCH	International	Panel fixed effect (across commodities)
Gilbert & Morgan (2010)	SDLOG , GARCH	International	Discussion
Balcombe (2011)	SDLOG	International	Random parameters/ Panel Fixed effect (across commodities)
Huchet-Bourdon (2011)	CV, SD of 1st Diff.	International	Correlation coefficients
Apergis & Reztis (2011)	GARCH, GARCH-X	Greece	GARCH, GARCH-X
Von Braun & Tadesse (2012)	CV	International	OLS & FGLS in panel (across commodities)
Kornher (2013)	SDLOG	Developing countries (domestic prices)	Dynamic panel fixed effect (across commodities and countries)



Tadesse <i>et al.</i> (2013)	CV, 1st Diff.	International	SUR, OLS and panel FGLS with fixed effect (across commodities)
Dommez & Magrini (2013)	Midas-GARCH	International	

Source: Authors

Among recent articles, Roache (2010) defines, measures, and explains low frequency volatility of the main international food commodities with the spline-GARCH model. Gilbert & Morgan (2010) find mixed evidences whether food prices have become more variable. They compute the SDLOGs and conditional volatility from a GARCH model. The study also features a discussion on potential volatility drivers like production, consumption, stocks and speculation. Balcombe (2009) decomposes volatility into a cyclical and a trend component with a factor model. He also uses a panel approach and regress the standard deviations of the log returns against several volatility determinants. Huchet-Bourdon (2011), after showing that recent commodity price volatility is not very much different from the price volatility in 1970s, explores volatility drivers with correlation coefficients. Apergis & Rezitis (2011) study domestic food price volatility in Greece. They highlight the impact of several macroeconomic factors, such as production, exchange rate or budget deficit, on volatility levels. von Braun & Tadesse (2012) review and discuss evidence and theories causes and impacts of high and volatile international food prices. Tadesse, Algieri, Kalkuhl, & von Braun (2013) also explore empirical evidence on the quantitative importance of selected volatility drivers on international food prices whereas Kornher & Kalkuhl (2013) focus on domestic price volatility and present estimates of the impact of a variation of stocks, production, international price volatility, and governance on staple food price volatility. In a recent article Magrini & Donmez (2013) used a GARCH-MIDAS model that smooth the unconditional volatility and allows for incorporating low-frequency macroeconomic data.

It is important to understand volatility, and explain how factors lead to deviation of prices from their equilibrium point (Galtier (2009)) for example high volatile oil prices and depreciation of the dollar against most currencies in 2008 have also contributed to the volatility of agricultural commodity prices.

This paper focuses on the factors influencing local prices volatility in developing countries for staple food commodities, but we are also exploring if volatility levels for staple food commodities and the determinants of these levels are the same at two different points of the value chain: retail and wholesale level.

We know that price volatility is transmitted across food chains, but some chains are substantial more sensitive than others. Transmitting prices variations further down the chain is one way of dealing with price volatility, but this may not always be possible or a wise commercial practice. Even though food sectors can have various structures, (Trienekens (2011)) food prices volatility can usually be measured at the producer, wholesale, or retail level. In developing countries, most data on food prices are at the wholesale or retail level. If margins between producer, wholesale, and retail prices are a constant proportion of the price, then measuring the volatility at any of the three levels will give the same result. However, if margins are fixed, then producer prices will be the most volatile and retail prices the least, with the volatility of wholesale prices falling in between. Minot (2012) explains that in practice, however, other factors influence the marketing margins such as the degree of competition at each level in the channel, the availability of information, changes in road quality or congestion, and the volume of trade between markets.



## 4 Method

In the field of agricultural economics, most of the literature contains two main types of historical volatility measurements, conditional and unconditional. Simple approaches like the coefficient of variation (CV) and the standard deviation of the log returns (SDLOG) provide a measure of total price variation while generalized autoregressive conditional heteroskedasticity (GARCH) models first remove the predictable component of prices before measuring volatility (conditionally to the mean equation). It is the main tool to measure volatility, but, in the context of this paper, it is a strong assumption to make that small producers in developing countries can correctly anticipate all the predictable components. Removing this predictable component implies a reduction of price variations before computing the volatility measure. These variations impact the farmers and poor people whether they are theoretically predictable or not because their response possibilities can be rather inelastic (fixed land size, small budgets...).

Selecting an appropriate measure of volatility is crucial as results might differ depending on this choice. The simplest way to measure price volatility is the CV, the standard deviation of prices over a particular time interval divided by the mean price over the same interval. One advantage of this measure is that it has no unit. It allows then easy comparison of, for example, domestic price volatility measured in different countries. However, the CV can create misleading impressions if there are strong trends in the data, because trend movements will be included in the calculations of volatility. Moreover, there is no universally accepted method for removing the trend component because different observers will have different ideas about the nature of the underlying trends (e.g. linear, quadratic). As mentioned earlier, an often used alternative to the CV is the SDLOG (Balcombe (2009); Gilbert & Morgan (2010); Huchet-Bourdon (2011); Minot (2012)). This measure also has no unit, but it is less affected by strong trends over time. For low levels of instability, it is approximately equal to the coefficient of variation. For these reasons, the SDLOG is widely used to measure realised volatility.

In this paper we consider the standard deviation of log differences in prices (SDLOG) as our volatility measure. Volatility is computed over periods of 12 consecutive monthly prices for each country, starting with January 2005 at the earliest. For example, we calculated the real price volatility from the period between January and December, and so on until the most recent date for each unit of our panel. The problem of seasonal trends is tackled by measuring yearly volatility. This measure of volatility is computed for each country and commodity at both retail and/or wholesale level:

$$\frac{\sqrt{\sum_{t=1}^{12} \frac{(r_t - \bar{r})^2}{12}}}{\bar{r}}$$

Where  $r_t = \log(p_t) - \log(p_{t-1})$  and  $\bar{r} = \sum_{N=1}^{12} \frac{1}{N} r_t$ .

The second part of our analysis consists in studying the effect of different volatility drivers across developing countries for three major food commodities and at two stages of the food chain. To this end we make use of a linear mixed model. More flexible than the standard random effect model, the mixed model allows one or more of the coefficients to randomly vary from country to country. Since the seminal paper of Laird & Ware (1982), such methodology has been widely applied in the field of biomedical social sciences or spatial and geostatistics but, to our knowledge, it is still rather unused in the context of economic analysis. See, for example, Searle, Casella, & McCulloch (1992) for historical developments of the mixed model.



In a panel dataset collected across different countries, it is likely that we observe a dependence arising from the clustering. Therefore, random effects might be introduced to capture the country level effects of each explanatory variable. Thus each country equation has two parts: the average effects called the fixed effects, common to all countries and their country-to-country deviations, treated as random effects. These additional deviations are a way of capturing the degree of heterogeneity in our sample.

Consider the mixed model formulation of Laird and Ware (1892). Let  $y_i = (y_{i1}, y_{i2}, \dots, y_{iT})'$  be a vector of realized annual volatility for country  $i$  covering  $T$  years,  $X_i = (x_{i,1,t}, \dots, x_{i,k,t})$  a matrix of  $k$  explanatory variables specific to country  $i$  for the same period of  $T$  years whose effects are assumed to be fixed and  $Z_i = (z_{i,1,t}, \dots, z_{i,p,t})$  contains the explanatory variables for which there is an associated random effect coefficient. Then,

$$y_i = X_i\beta + Z_iu_i + \varepsilon_i \quad \text{for } i = 1, 2, \dots, n$$

with  $\beta$  the  $1 \times k$  vector of fixed effects,  $u_i$  the  $1 \times p$  matrix of random coefficients and  $\varepsilon_i$  contains the random errors. The number of random effects,  $p$ , may not equal<sup>1</sup> the number of fixed effects,  $k$ . The random effects,  $u_i$ 's, can be thought of as  $n$  realizations of a  $p \times 1$  vector that is normally distributed with mean 0 and  $p \times p$  variance matrix.

Volatility is assumed to be independent across countries.  $u_i$  and  $\varepsilon_i$  are also assumed to be independent with

$$\varepsilon_i \sim N(0, \sigma^2 I_{T_i})$$

$$u_i \sim N(0, \sigma^2 D)$$

$$y_i \sim N(X_i\beta, \sigma^2 V_i)$$

Where  $D$  is a non-negative definite matrix and  $V_i = Z_i D Z_i' + I_{T_i}$

The parameters are estimated by the Maximization of the Likelihood function (MLE) through a two-step procedure<sup>2</sup>.

As explained in section 2, the literature has brought and extensively discussed a list of explanatory factors to be considered when studying agricultural prices volatility.

In developing countries, domestic prices of grains are affected by international prices but local supply and demand factors might play a bigger role. Studies have shown that international prices of food grains do have an impact on African markets for rice, wheat and, to a lesser degree, maize, but the effect is often swamped by the dominant effect weather-related domestic supply shocks. Domestic food prices are often influenced by long term trends in domestic production, productivity per capita, efficiency of domestic food markets and seasonal price fluctuations (stemming from intra-annual climatic variations and market imperfections (Cornia, Deotti, & Sassi (2012); Minot (2012)) For example in the case of Africa three key structural problems stand out as most important in the region: (i) widening gap between domestic cereal supply and demand, (ii) marketing constraints, and (iii) political instability and policy uncertainties.

We present below a subset of variables that are appropriate in the context of developing countries:

<sup>1</sup>The rest of  $u_i$  is then filled with 0's to maintain appropriate matrix dimensions.

<sup>2</sup> See Wu (2009) for comprehensive treatment of estimation procedures



- a- **International volatility:** Contrary to mainstream volatility analysis, we focus on domestic food commodities prices. All domestic economies are connected to world markets in one way or another with various intensities. We focus on some of the most internationally traded grain commodities. Numerous studies have published results on food price transmission from world to domestic prices. Therefore international volatility is likely to impact domestic prices.
- b- **Oil volatility:** Oil, and more generally energy, is a major element in the food production process. It impacts farm inputs price volatility such as fertilizers and fuel as well as the transportation costs that, in turns transmit down the value chain. It also indirectly affects food production by competing with biofuels..
- c- **Exchange rate:** International price movements on domestic markets can be smoothed or amplified by a simultaneous exchange rate variation.
- d- **Yields:** The quality of yields plays an important role on the prices behavior. First the information on good or bad yield can trigger optimism or pessimism among buyers and sellers. Second, good yields increase stocks that may buffer demand variations hence stabilizing prices.
- e- **Imports dependency:** Economies that are highly integrated into world market are more susceptible to have their domestic price follow world price. To account for external dependency in a given national food market we use the ratio of imports and exports of a given commodity over the total availability, i.e., production and stocks subtracted of exports.
- f- **GDP per capita:** Some demand shocks, such as consumption shrink or shift, may play a role. Though it should be smaller than initially advocated during the 07-08 food crisis. We use the GDP per capita growth rate as a proxy for demand but also to control for the general level of economic activity.

Given the context of the analysis some potential drivers are left out of the model as they are more relevant to the analysis of international prices. For example, speculation and financialization of food commodity markets, for which there is an ongoing debate (Robles, Torero, & von Braun (2009); Schutter (2010); Wright (2011)), or biofuels production.

Using the classification set out by Tadesse et al. (2013) in their framework of the causes of food prices volatility, our drivers would be classified as follows. Oil and international prices volatility as well as economic growth are exogenous shocks defined as the root causes of volatility. Their impact depends on conditional causes such as the market conditions represented by the trade ratios. These two first set of drivers might be amplified by endogenous shocks such as the yields.

## 5 Data

In order to examine price volatility of staple food prices in developing countries, we use monthly nominal rice, wheat and maize price data from the FAO-GIEWS price database (FAO, 2013), as well as monthly data on the consumer price index (CPI) from the International Monetary Fund (2013). The GIEWS database currently includes 1120 monthly domestic retail and/or wholesale price series of major foods consumed in 81 countries and 38 international cereal export price series, covering a total of 20 different food commodity categories. Data sources in most cases are official government sources; full details of specific sources for each country are available from the FAO (2013). Yields variables are obtained from FAOSTAT, while trade data comes from the CCBS FAO database. Finally, GDP series come from the World Bank.

We included only countries for which monthly data on both nominal prices and the CPI are available for at least 36 months, with the earliest month being January 2005 or later. For





more than 90 percent of countries in the sample, our most recent data covers until December 2012.

According to Dawe & Morales-Opazo (2009), when data is available for multiple locations, multiple qualities or multiple marketing levels for a given staple food in a given country, a set of ordered selection criteria is needed to choose which data series needs to be analysed. In the case of wheat, if there was data for both wheat and wheat flour, we used data on wheat and then wheat flour. In the case of maize, we used data on white maize if available, and if not we used data on maize, grain, and then yellow maize.

Our next criterion was based on commodity quality. We chose the lowest quality available, assuming that lower qualities in grains are more important for the poor. That being said, prices of different qualities generally seemed to move broadly together within the same country.

Finally, we used real national average prices when available. When national average prices were unavailable, we used prices from the market of the most important economic centre, often the capital city, for which data was available.

**Table 2:** Countries coverage

	Maize		Rice		Wheat	
	<i>Retail</i>	<i>Wholesale</i>	<i>Retail</i>	<i>Wholesale</i>	<i>Retail</i>	<i>Wholesale</i>
# countries	25	25	36	25	27	13
# overlaps		13		12		7

Prices are deflated by their respective national consumer price index as this analysis encompasses a large number of countries with very different inflation rates. It is therefore important to control for inflation. In other cases, however, use of nominal price data would also be appropriate.

Staple foods were chosen because they are particularly important for the poor in terms of expenditure and caloric intake. While aggregate food price inflation is also important, the weights used in constructing such measures do not reflect the expenditure patterns of the poor, which are more oriented towards staple foods. Ideally, one would like to deflate nominal commodity prices by a CPI that excludes the commodity in question, because such a procedure would give the true relative price increase of a given commodity. However such an indicator is difficult to obtain, so we divide by the aggregate CPI. Since all of our countries show real price increases, the use of aggregate CPI in constructing the real price understates the true magnitude of the price increase relative to other commodities.

The sources of data for the explanatory variables that we use in the econometrics model are different depending of the variable. In the case of International volatility we also use monthly nominal price data from the FAO-GIEWS price database (FAO, 2013). We have obtained import dependency data from the same source; for oil volatility and exchange rates values we use IMF statistics (IMF, 2013); yields are from FAOSTAT (FAO, 2013) and in the case of GDP per capita we use data from World Development Indicator (World Bank, 2013).

## 6 RESULTS

### 6.1 What does food price volatility looks like in developing countries?

This section provides some context to compare international and real local domestic volatility levels in developing countries for the three major grain commodities.



Table 3 shows the average price and volatility in our sample, by continent, together with the level of average import dependency. Maize in Africa is, on average, the most volatile commodity with a mean of 10.7%. The levels of rice and wheat volatility are also higher in Africa than in Asia or LAC. In other words, Africa has the highest average price volatility for all commodities. Inadequate market infrastructure and weak institutions in Africa may have contributed to the high levels of volatility. The three commodities exhibit similar levels of volatility in Asia and LAC with mean values around 4%.

Wheat in developing countries is mainly imported and represents a higher share of international trade volume than maize and rice. Its international average quotation for the period 2005-12 is nevertheless more volatile than the local domestic prices in all the three regions. International rice and maize price volatilities are higher than domestic price volatilities in Asia or LAC but lower than those in Africa (Table 3).

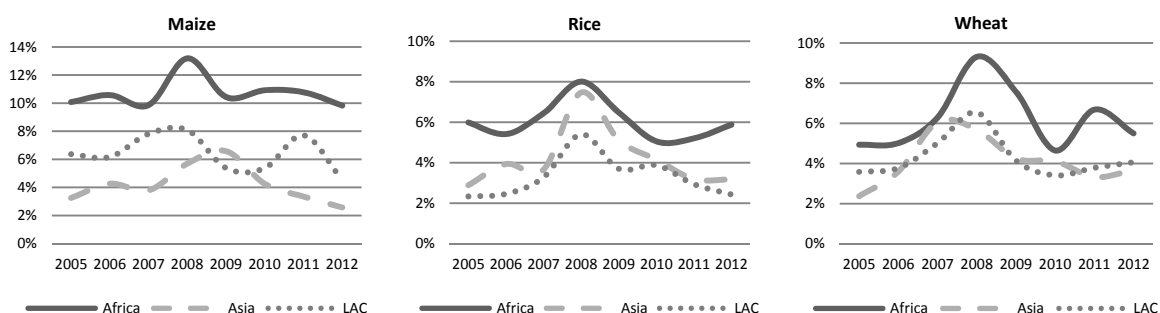
**Table 3:** Maize, rice and wheat prices during 2005-2012

	Maize			Rice			Wheat		
	Africa	Asia	LAC	Africa	Asia	LAC	Africa	Asia	LAC
Average price level (\$/t)	305	295	498	791	463	906	548	370	689
Imports dependency	12%	31%	40%	35%	21%	62%	64%	37%	62%
Price volatility	10.7%	4.2%	6.4%	6.0%	4.2%	3.3%	6.2%	4.7%	4.3%
International volatility		6.9%			4.9%			8.1%	

Source: Analysis of price data from GIEWS

In some specific cases, the difference between international and domestic volatility can be even stronger. For instance, in 2012, the price volatility of maize on South Africa’s SAFEX exchange was 9.92%, but the domestic price volatility in Maputo, Mozambique only reached 4.54%. There typically is grain trade between South Africa and Mozambique, but the trade volume does not appear high enough to make a permanent long term co-movement of price volatility in the two countries. Among the possible reasons for high differential between national and international volatility, could include the existence of market power - limiting the extent of arbitrage -, high transport costs and asymmetric information – resulting in market actors not engaging in profit-maximizing behaviour (Jayne (2012)) but also governmental policies that may dampen or exacerbate instability.

**Figure 1:** Volatility by region for Maize, Rice and Wheat.



Source: Analysis of price data from GIEWS

Figure 1 presents the average intra-annual volatility across continents for each commodity. The most volatile commodity is maize with volatility ranging from 2.5% to 13.2%. The prices of the three staples have been particularly unstable in 2008-09 in Africa. Across continents, wheat oscillates in the same range as rice but with a peak of 9.3% in in 2008 in Africa.

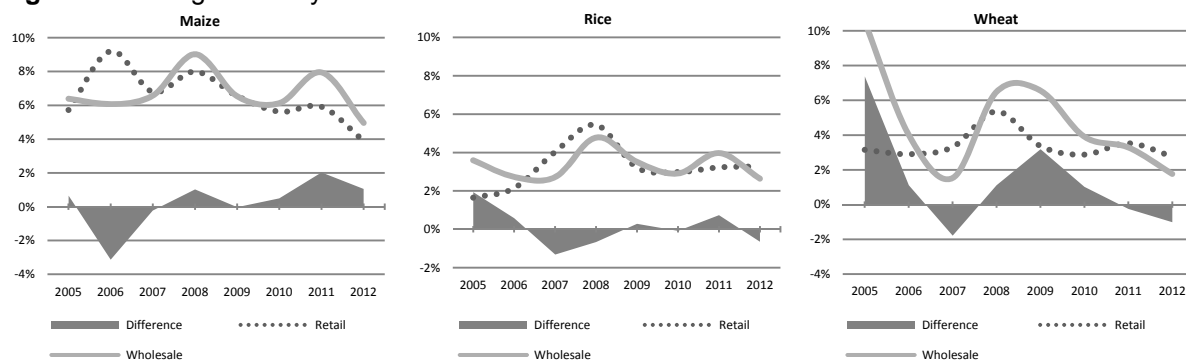


We clearly observe a rise in volatility around 2007-08 before returning to pre-crisis levels. In some cases (e.g. wheat) a second increase took place in 2011. No significant major trend arises from the graphical analysis. This means that real local food price volatilities have not shown any clear trend in developing countries between 2005 and 2012 except during the food crisis when volatilities spiked.<sup>3</sup>

### 6.3 What are the differences across the wholesale and retail levels?

The average volatility differential in countries where we have data for both levels is computed as the mean wholesale volatility minus the mean retail volatility. Figure 2 shows the two curves moving closely together for each commodity. The differentials between the two market levels were slightly negative in some years and slightly positive in other years for maize and rice, with no clear pattern on whether wholesale or retail price volatility is greater. For the most part, the level of the wholesale and retail volatilities closely followed each other for the two commodities. In the case of wheat, however, wholesale price volatility exceeded retail price volatility in six out of eight years.

**Figure 2:** Average volatility difference between wholesale and retail levels



Source: Analysis of price data from GIEWS

When disaggregated,<sup>4</sup> the volatility differential varied markedly from one country to another. Volatility is higher at wholesale in some cases especially during the two food price crises, for instance with maize in Dominican Republic, wheat in Brazil, wheat or rice in India and Colombia. Thus, either the impact of volatility determinants of both levels varied differently with prices levels or the increased instability at wholesale level was buffered by transaction costs and marketing margins when moving across the value chain. Price transmission across the value chain is generally subject to asymmetries that, in turns, impact volatility differentials. Vavra & Goodwin (2005) explain how market power, adjustment and menu costs or government interventions can be the source of asymmetric transmission and inhibit changes across market levels.

In some cases such as rice in Panama and Brazil or wheat in Ethiopia and El Salvador, volatility is higher at retail level. The net rice trade position of Brazil is fluctuating while Panama has been a net rice importer for the whole period (FAOSTAT). El Salvador and Ethiopia are also net wheat importers. Government policies in importing countries may be directed towards stabilizing prices at wholesale level but may have limited influence at retail level.

<sup>3</sup> Country level volatility series can be found in table 7 to 12 of the Appendix.

<sup>4</sup> Country level graphs with both retail and wholesale volatility can be found in the Appendix.



## 6.4 What happened with other traditional staple food commodities?

Although other products (such as cassava and other root crops) are important staples in many African countries, these commodities cannot be stored for long after harvesting and, for this reason, are not the focus of governments efforts to stabilize food prices. Nevertheless, in the case of Cassava, it does play an important role in helping households adapt to grain price instability (Dorosh & Thurlow (2011); Prudencio, Orkwor, & Kissiedu (1992)). Cassava in sub-Saharan Africa is grown mainly on small holdings by low-income farmers who make little or no use of external inputs. Table 3 shows the volatility for Cassava prices in selected African countries.

The volatility, on average, for the analysed period and African countries shown in table 4, is generally lower for cassava (7.6%) than for maize (10.7% in Africa), which is the most important staple food commodity for these countries (Table 3 and 4). However, the average volatility of cassava is higher than rice (6.0%) and wheat (6.2%) in Africa. It is clear that 2008 and 2009 were higher volatility years for cassava in concordance with the high volatility levels for other traditional staple food commodities as wheat, maize and rice.

**Table 4:** Price Volatility for cassava at Domestic Level in selected African countries

	Angola	Burundi	DR Congo	Uganda	Zambia	Average
2006		14.40%				14.40%
2007		3.90%	4.90%			4.40%
2008	1.30%	2.60%	18.60%	5.60%	12.00%	8.00%
2009	0.70%	9.90%		6.70%	9.00%	10.22%
2010	1.70%	3.70%	4.90%	8.00%	14.20%	6.50%
2011	1.40%	4.40%	7.20%	4.60%		4.40%
2012	1.00%	6.20%	5.50%	9.10%		5.40%

Source: Analysis of price data from GIEWS

The case of beans in Central America is similar to cassava due to the importance of beans in the food basket of these countries. Table 5 shows the price volatility for beans in three Central American countries. The average figure for Beans is higher than the other staple food prices including maize in LAC.

**Table 5:** Price Volatility for beans in selected Central American countries

	Costa Rica		El Salvador		Guatemala	
	Retail	Wholesale	Retail	Wholesale	Retail	Wholesale
2005	4.8%	3.2%			3.1%	10.1%
2006	6.2%	0.7%	0.9%	2.7%	1.9%	3.3%
2007	6.8%	0.4%	12.1%	12.0%	7.0%	3.6%
2008	2.4%	14.5%	8.0%	8.6%	4.6%	9.1%
2009	5.1%	12.5%	4.7%	6.9%	1.5%	4.2%
2010	4.9%	4.9%	12.1%	12.9%	1.4%	4.9%
2011	2.0%	18.0%	9.5%	12.2%	1.2%	3.6%
2012	2.8%	5.8%	4.9%	9.0%	0.8%	6.1%

Source: Analysis of price data from GIEWS



## 6.5 Can we explain cross-country variations in domestic price Volatility?

In order to inquire the respective impact of our selected volatility drivers, the linear mixed model<sup>5</sup> described in section 5 is estimated under two configurations of the dataset. A first set of regressions is performed while keeping the retail and wholesale levels separate. Table 5 presents the first set of results for each commodity. The second set of mixed model estimates, contained in table 6, is obtained after pooling the different commodities together and lifting the retail wholesale separation. The panel observation unit then becomes the year-country-commodity and the random effects apply to each country-commodity. Columns 1 to 3 feature the models by continent and the two last columns contain results obtained with all observations.

The most interesting outputs for this paper are the fixed effects estimates. The random effects differ across countries and are summarized by their standard deviations. As we have a relatively small number of observations, the random slopes are only estimated for the common variables, i.e. international volatility and oil volatility. Small standard deviations estimates of the random slopes and intercepts indicate low heterogeneity in the countries responses.

Three main drivers of domestic price volatility emerge from the quantitative analysis: international price volatility of the respective commodities, oil volatility and yields. In table 5, the common result across commodities and levels of the food chain is the average volatility reducing effects of yields. The effect is systematically higher at the retail level. A 10% increase in yields would reduce the volatility by 1.2 - 1.8% at wholesale level and 1.4 - 3.7% at retail level. All significant estimates of the average impact of international volatility are positive: oil volatility increases domestic price volatility in most of the specifications. Oil volatility is usually the strongest driver with 3.4 - 4.8% increase in domestic price volatility after a 10% increase (in oil price volatility).

**Table 5:** Mixed model estimates

Fixed Effects	Rice		Maize		Wheat	
	Retail	Wholesale	Retail	Wholesale	Retail	Wholesale
International volatility	.0105 (.10)	.275*** (.08)	-.349 (.20)	.322** (.10)	.466** (.20)	.291** (.10)
Oil volatility	.481*** (.10)	.366*** (.10)	.348* (.20)	-.0475 (.10)	.398** (.20)	.484*** (.10)
Exch. Vol.	-.0644 (.05)	.0163 (.05)	-.0625 (.05)	.00883 (.04)	-.0447 (.06)	.0179 (.04)
Yields	-.243*** (.04)	-.154*** (.04)	-.374*** (.06)	-.179*** (.03)	-.137** (.07)	-.117*** (.03)
Imports ratio	-.019 (.04)	.0178 (.04)	-.128** (.06)	.010 (.03)	-.193 (.20)	-.452** (.20)
GDPgth	.0983 (.08)	.120 (.09)	.0874 (.08)	.0084 (.04)	-.0245 (.10)	.0265 (.06)
<b>Random Effects (standard deviations)</b>						
International	.170*** (.06)	1.6e-09 (.)	2.5e-06 (.)	1.2e-06** (6e-06)	4.5e-08 (.0003)	.136*** (.07)
Oil	.0944** (.10)	.146 (.)	6.9e-05 (.)	.0487 (.20)	.122 (.20)	.0866** (.09)
Intercept	1.9e-06*** (8e-06)	2.2e-08 (.)	.509 (.)	.502** (.20)	.428 (.40)	1.7e-09*** (1e-08)
# obs.	153	109	106	145	72	51

Note: Standard error in parenthesis - \*\*\*p<0.01 \*\*p<0.05 \*p<0.1.

<sup>5</sup> Classical random and fixed effect were, however, tested and implemented. Signs and magnitude of the coefficients were similar though less significant, thereby justifying the choice of using the mixed model.



In the second set of regressions, yields variables continue to be strong volatility determinants throughout all panel specifications. Results from the completely pooled dataset suggest that, on average, import dependency and GDP growth per capita do not have a significant role in driving volatility levels, neither does exchange rate volatility. On the other hand, the effects of international price volatility and oil price volatility have a highly significant impact on domestic volatility. Yields have a strong negative impact, implying that productivity and supply factors have a dampening role in explaining food price volatility in developing countries.

The comparisons across regions in table 6 suggest that, on average, oil instability impacts domestic volatility in the same way across continents. But yields are a more important driver in Africa than in the two other groups where international markets of the three staples play a bigger role. Globally, a 10% increase in oil or international price volatility would increase domestic volatility of staples by an average of respectively 2.9 - 3% and 1.4 - 1.7%, while the same increase in yields would reduce it by 1.8 - 2%.

**Table 6:** Mixed model estimates for pooled data

<b>Fixed Effects</b>	<b>Africa</b>	<b>Asia</b>	<b>LAC</b>	<b>All (1)</b>	<b>All (2)</b>
International volatility	-.0606 (.09)	.244** (0.10)	.279** (.10)	.173*** (.06)	.143** (.06)
Oil volatility	.377*** (.10)	.363*** (.10)	.350** (.2)	.299*** (.07)	.309*** (.07)
Exch volatility	.00223 (.03)	-.0384 (.04)	-.0152 (.06)	-.0117 (.02)	-.0179 (.02)
Yields	-.215*** (.03)	-.170*** (.03)	-.185*** (.05)	-.186*** (.02)	-.203*** (.02)
Imports ratio	-.109*** (.02)	.0228 (.02)	-.066 (.04)		-.028 (.02)
GDP cap growth rate	.0257** (.01)	-.0074 (.01)	.0089 (.02)		.0063 (.007)
<b>Random Effects</b>					
<b>(standard deviations)</b>					
International Volatility	3.9e-09*** (2e-08)	.088*** (.04)	1.6e-09 (.)	.141*** (.04)	.136*** (.04)
Oil volatility	1.3e-06 (.002)	6.4e-09 (.)	2.5e-09 (.)	.148*** (.05)	.143*** (.06)
Intercept	.377*** (.06)	.132 (.20)	.539 (.)	.242* (.20)	.270* (.20)
# obs.	251	198	161	634	610

Note: Standard error in parenthesis - \*\*\*p<0.01 \*\*p<0.05 \*p<0.1.

Our estimated impacts of oil price volatility on domestic price volatility of developing countries are in line with those obtained by those analysing the determinant international price volatility (staple commodity) (e.g. Tadesse et al. (2013), and Balcombe (2009)). However, we do find a bigger and opposite role for yields at the domestic level than the positive impact found by Balcombe (2009) at international level.



## 7 Conclusions

Since 2006, the international prices of several staple food commodities are unstable, often more than doubling within a few years. A surge in the price of food in the context of high level of instability is of special concern to the developing countries. Many impoverished people depend upon food production for their livelihood, and virtually all poor people spend large portions of their household income on food. Therefore, staple food price instability remains a major problem in developing regions. Many governments in developing countries attempt to stabilize food prices through pricing, marketing, and trade policy instruments.

This paper has provided measures of maize, wheat and rice domestic volatility in developing countries. Among the three commodities under scrutiny, maize is the most volatile and Africa is the most unstable region. Differences between wholesale and retail level were explored. Our research also estimated the level of volatility for traditional staple food commodities such as beans and cassava. Our analysis has also explored a set of volatility drivers by quantifying their impact by commodity or by continent. The mixed model estimates indicate significant effect of international volatility, oil volatility and yields on domestic prices stability.

Price volatility for rice was higher in Africa than in Asia which is a problem especially for some countries in western Africa where the rice is one of the most important staple foods. This phenomenon is exacerbated if we consider that the price levels for rice in Africa are usually higher than the price rice in Asian countries, with exemption of Philippines where the prices are quite high but the price volatility is low. Not only rice shows more volatile prices in Africa, the case of maize is similar and the region presents the highest volatility for maize.

The lack of data makes it difficult to elaborate a conclusion on the level of volatility of traditional staple food commodities (bean and cassava) and the connection with the volatility of internationally traded staple food as rice wheat and maize. But our partial information set suggest that volatility is higher for traditional staple food.

One main conclusion of this research is the importance of some macroeconomics variables such as international markets volatility, oil price instability or yields in the context of local price volatility. But we need to consider that the behaviour of the models is not the same across different commodities and would be interesting for a future research to understand the behaviour of the price volatility across a few numbers of countries in the same region like South Asian or Southern African countries.

Domestic markets of different countries have responded differently to this surge in international price volatility. The sources, size, and consequences of food price instability vary substantially across and within countries. The appropriate policy response to food price risk and instability will also vary across and within countries because of differences in geography, patterns of food production and consumption, and institutional capacity to implement alternative policies.

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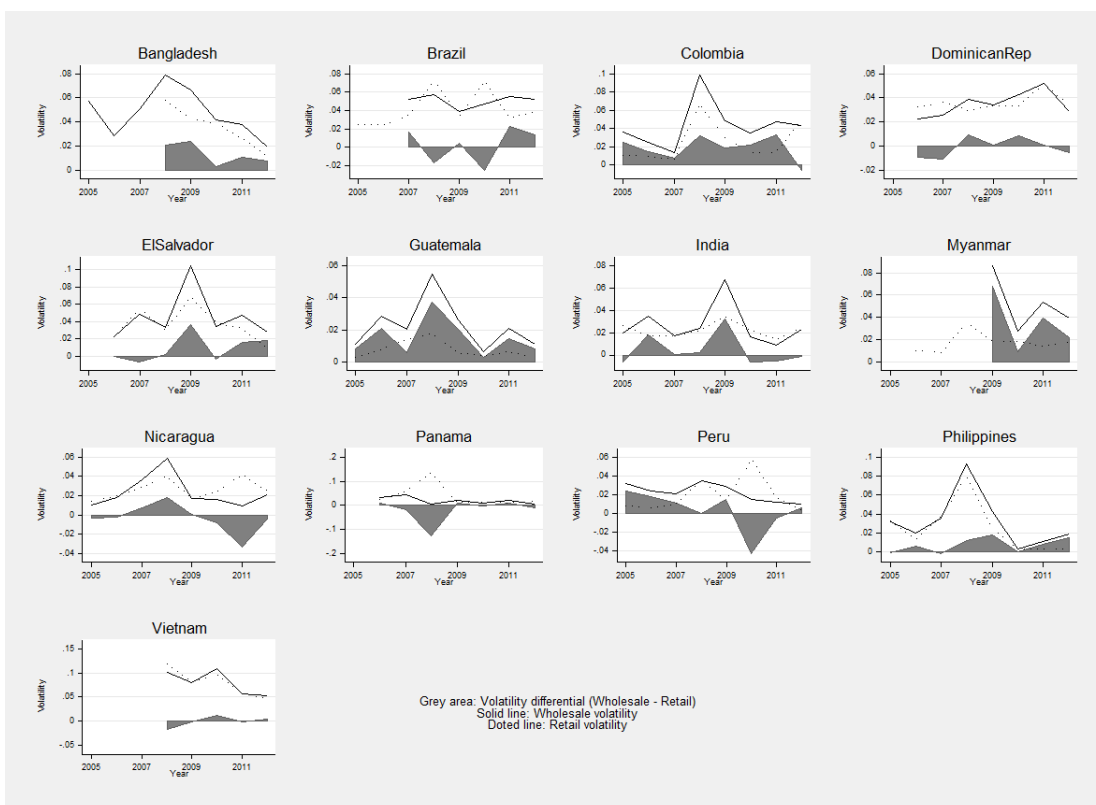
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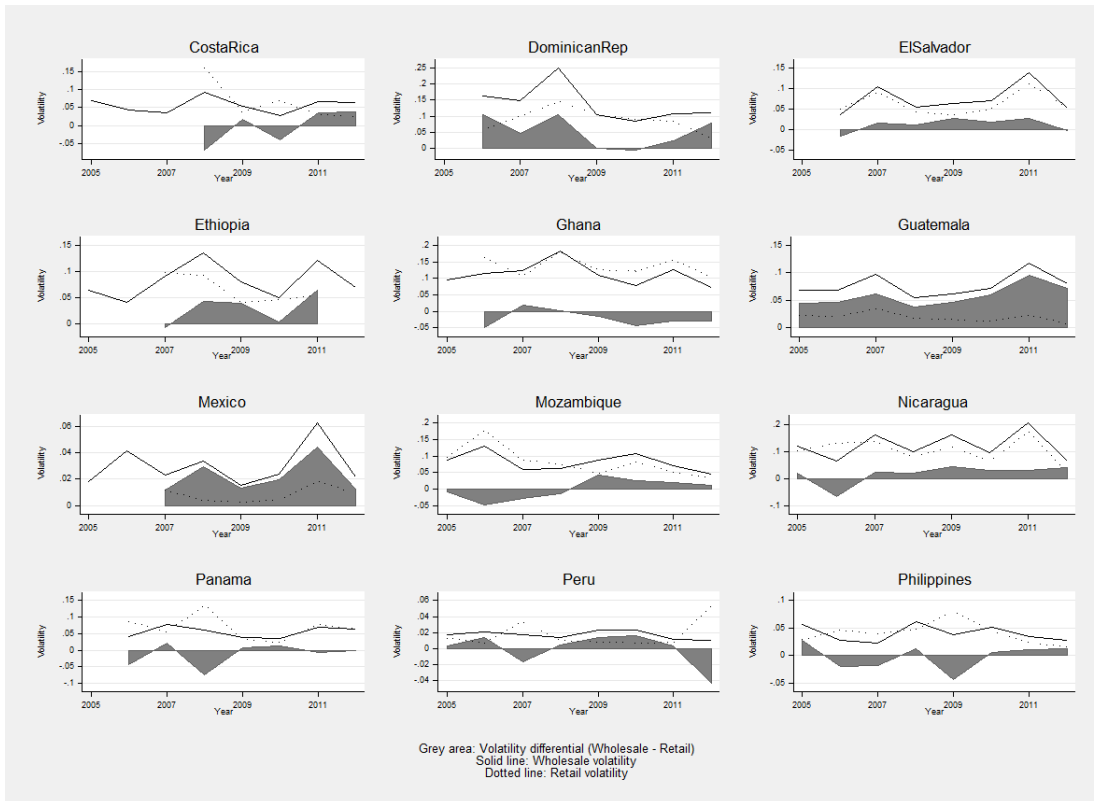
## Appendix

**Figure 7: Volatility differentials for Rice**

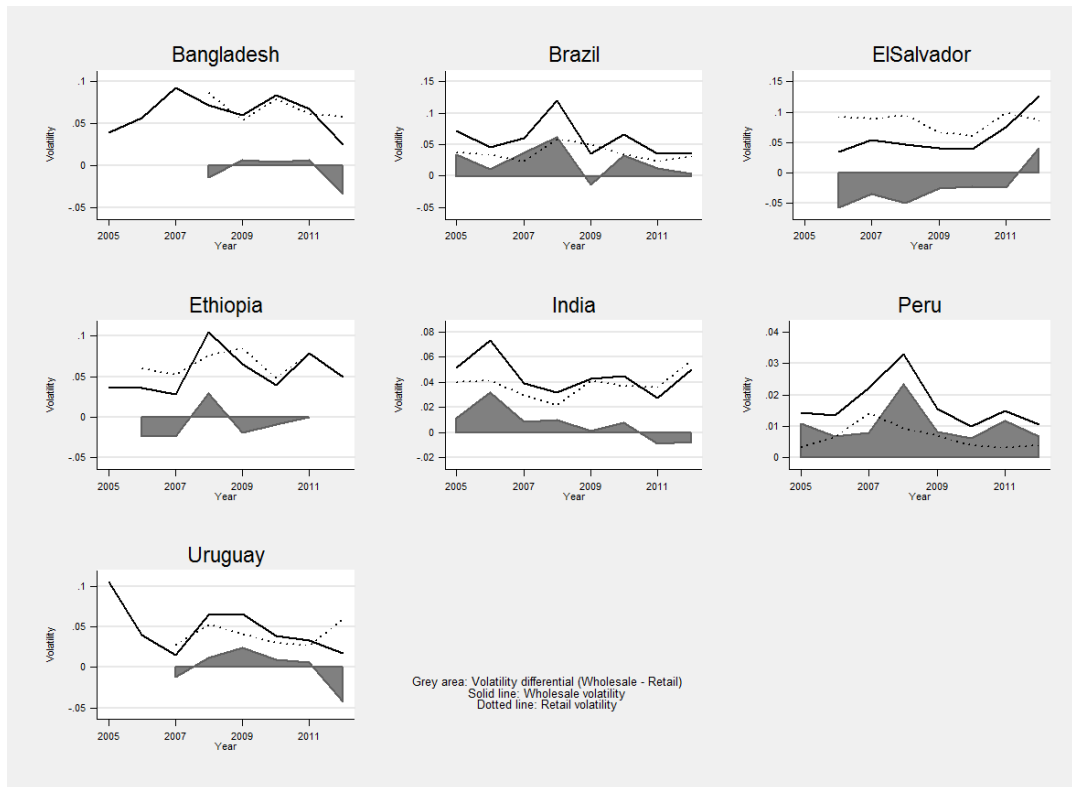




**Figure 8: Volatility differentials for Maize**



**Figure 9: Volatility differentials for Wheat**



**Table 7: Rice retail volatility**

	2005	2006	2007	2008	2009	2010	2011	2012	2005-2012
<b>Africa</b>	<b>8.77</b>	<b>5.19</b>	<b>7.63</b>	<b>6.13</b>	<b>8.21</b>	<b>4.98</b>	<b>4.65</b>	<b>5.87</b>	<b>6.43</b>
Burundi	.	4.38	5.75	4.62	8.12	10.05	7.20	6.90	6.72
Cameroon	2.73	4.92	6.48	3.37	2.15	1.50	0.76	3.30	3.15
Chad	19.25	6.56	7.47	10.25	4.84	4.18	6.78	11.01	8.79
DR Congo	.	.	14.93	11.24	.	5.63	4.78	9.80	9.28
Egypt	.	.	16.07	.	28.27	10.90	3.70	.	14.73
Gabon	.	.	4.14	6.09	5.40	4.13	5.47	5.02	5.04
Lesotho	.	.	.	.	.	2.26	5.51	1.99	3.26
Madagascar	7.23	5.60	9.54	3.61	3.90	2.62	5.71	3.40	5.20
Malawi	.	.	5.68	8.36	11.30	7.65	.	7.03	8.00
Mozambique	5.86	4.49	4.07	4.03	6.67	4.44	4.78	4.34	4.84
Zambia	.	.	2.14	3.61	3.23	1.46	1.79	.	2.45
<b>Asia</b>	<b>2.92</b>	<b>5.93</b>	<b>4.30</b>	<b>6.35</b>	<b>3.64</b>	<b>3.91</b>	<b>2.68</b>	<b>2.45</b>	<b>4.02</b>
Bangladesh	.	.	.	4.01	6.11	4.04	3.04	0.99	3.64
Bhutan	.	.	.	3.48	2.65	4.90	2.53	4.14	3.54
China	.	.	.	.	1.87	2.22	1.86	2.69	2.16
India	2.60	1.71	1.73	2.16	3.45	2.22	1.42	2.44	2.22
Indonesia	.	.	.	1.80	1.15	2.67	1.81	0.99	1.68
Lao	3.19	4.20	3.54	4.85	2.62	1.48	.	1.44	3.05
Mongolia	.	.	1.41	12.95	2.98	3.13	1.48	1.30	3.87
Myanmar	.	1.02	0.85	3.57	1.85	1.81	1.43	2.13	1.81
Nepal	2.96	11.34	10.02	6.28	6.24	6.73	2.14	4.63	6.29
Pakistan	.	17.05	5.85	15.35	3.99	1.55	2.97	1.33	6.87
Samoa	.	2.04	3.79	6.50	3.66	4.34	4.72	1.49	3.79
Sri Lanka	.	4.17	7.20	3.39	2.59	6.11	2.96	3.50	4.28
Vietnam	.	.	.	11.81	8.16	9.65	5.77	4.74	8.02
<b>LAC</b>	<b>2.46</b>	<b>2.29</b>	<b>3.26</b>	<b>6.47</b>	<b>3.52</b>	<b>4.55</b>	<b>2.28</b>	<b>1.95</b>	<b>3.35</b>
Brazil	2.46	2.42	3.51	7.35	3.38	7.20	3.24	3.85	4.18
Colombia	1.08	0.94	0.63	6.67	2.94	1.34	1.43	4.95	2.50
Costa Rica	6.16	5.11	2.85	8.70	9.73	9.38	0.50	2.80	5.65
Dominican Rep.	.	3.22	3.64	2.97	3.34	3.37	5.17	3.39	3.59
El Salvador	.	2.21	5.52	3.04	6.85	3.88	3.23	0.93	3.67
Guatemala	0.32	0.79	1.41	1.77	0.57	0.38	0.65	0.30	0.77
Haiti	4.22	3.93	3.30	11.70	7.25	18.27	4.45	0.99	6.76
Nicaragua	1.40	2.00	2.87	4.05	1.68	2.43	4.18	2.46	2.63
Panama	.	2.53	5.86	13.38	1.22	1.27	1.09	1.82	3.88
Peru	0.80	0.64	1.01	3.51	1.45	5.77	1.70	0.36	1.90
Philippines	3.24	1.38	3.74	8.07	2.50	0.29	0.35	0.31	2.48

Uruguay	.	.	4.83	6.38	1.29	1.03	1.30	1.26	2.68
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**Table 8: Rice wholesale volatility**

	2005	2006	2007	2008	2009	2010	2011	2012	2005-2012
<b>Africa</b>	<b>3.21</b>	<b>5.65</b>	<b>5.27</b>	<b>9.88</b>	<b>4.77</b>	<b>5.14</b>	<b>5.77</b>	<b>5.90</b>	<b>5.70</b>
Djibouti	3.21	2.97	5.22	7.27	5.00	5.16	2.70	3.66	4.40
Mali	.	4.93	3.38	12.88	5.09	8.60	8.40	6.06	7.05
Philippines	3.21	2.00	3.57	9.25	4.26	0.34	1.15	1.86	3.20
Rwanda	.	3.95	2.98	11.64	4.17	5.94	7.76	3.40	5.69
Tanzania	.	12.58	9.42	7.78	5.97	5.45	6.72	13.16	8.72
Uganda	.	7.47	7.02	10.47	4.13	5.37	7.88	7.28	7.09
<b>Asia</b>	<b>2.79</b>	<b>2.51</b>	<b>3.09</b>	<b>8.47</b>	<b>6.70</b>	<b>4.66</b>	<b>3.90</b>	<b>4.06</b>	<b>4.52</b>
Bangladesh	5.75	2.89	5.06	7.93	6.67	4.20	3.77	1.91	4.77
Cambodia	.	2.47	3.41	11.87	9.32	3.24	5.76	7.05	6.16
China	1.89	2.17	2.96	2.48	3.03	2.54	2.33	3.30	2.59
India	2.00	3.49	1.74	2.37	6.70	1.60	0.88	2.28	2.63
Thailand	1.50	1.54	2.26	16.02	6.47	5.45	4.96	4.58	5.35
Vietnam	.	.	.	10.13	8.01	10.94	5.70	5.24	8.00
<b>LAC</b>	<b>2.33</b>	<b>2.56</b>	<b>3.35</b>	<b>4.49</b>	<b>3.80</b>	<b>2.83</b>	<b>3.44</b>	<b>2.77</b>	<b>3.20</b>
Bolivia	.	2.81	4.55	4.59	2.98	4.00	8.49	3.85	4.47
Brazil	.	.	5.18	5.69	3.86	4.70	5.48	5.24	5.02
Colombia	3.59	2.46	1.34	9.83	4.84	3.54	4.70	4.38	4.34
Dominican Rep.	.	2.28	2.54	3.89	3.39	4.26	5.24	2.85	3.49
Ecuador	3.92	2.74	5.38	2.88	1.48	1.34	1.75	1.35	2.61
El Salvador	.	2.21	4.87	3.30	10.51	3.50	4.79	2.80	4.57
Guatemala	1.11	2.85	2.01	5.46	2.61	0.66	2.09	1.13	2.24
Honduras	.	.	3.20	4.07	2.28	5.20	1.32	2.11	3.03
Mexico	1.11	2.57	1.09	4.23	1.89	2.78	1.42	3.55	2.33
Myanmar	.	.	.	.	8.66	2.73	5.38	5.09	5.47
Nicaragua	1.05	1.79	3.65	5.86	1.75	1.66	0.90	2.08	2.34
Panama	.	3.45	4.26	0.63	2.28	0.91	1.97	0.68	2.03
Peru	3.23	2.41	2.10	3.47	2.91	1.48	1.22	0.96	2.22

**Table 9: Maize retail volatility**

	2005	2006	2007	2008	2009	2010	2011	2012	2005-2012
<b>Africa</b>	<b>11.43</b>	<b>10.61</b>	<b>9.18</b>	<b>13.69</b>	<b>10.85</b>	<b>10.49</b>	<b>9.82</b>	<b>10.10</b>	<b>10.77</b>
Benin	16.53	9.41	11.38	15.01	20.24	6.70	11.56	9.50	12.54
Burundi	.	5.97	7.11	5.77	12.66	13.88	10.93	6.09	8.92
Cameroon	2.21	4.06	3.32	1.91	7.62	4.15	3.52	5.40	4.03
Chad	16.74	9.61	10.06	9.12	7.61	9.47	7.49	7.37	9.69
DR Congo	.	.	12.47	33.60	.	16.70	18.58	11.75	18.62
Ethiopia	.	.	9.80	9.25	4.11	4.57	5.57	.	6.66
Ghana	.	16.33	10.64	18.15	12.59	12.20	15.66	10.15	13.68
Malawi	.	.	9.97	14.32	16.58	16.14	7.91	15.77	13.45
Mozambique	9.64	17.83	8.78	7.60	4.78	8.22	5.13	3.32	8.16
Niger	12.20	3.76	3.32	5.75	4.31	4.26	2.91	31.85	8.54
Somalia	14.81	14.10	8.86	25.71	19.09	20.21	27.06	10.05	17.49
Togo	12.17	12.30	17.67	23.37	12.80	12.69	5.44	5.59	12.76
Zambia	7.15	12.76	5.89	8.44	7.81	7.24	5.86	4.30	7.43
<b>Asia</b>	<b>2.91</b>	<b>4.61</b>	<b>4.02</b>	<b>4.85</b>	<b>8.03</b>	<b>4.53</b>	<b>2.35</b>	<b>1.61</b>	<b>4.11</b>
Philippines	2.91	4.61	4.02	4.85	8.03	4.53	2.35	1.61	4.11
<b>LAC</b>	<b>5.89</b>	<b>5.55</b>	<b>6.69</b>	<b>7.25</b>	<b>3.88</b>	<b>3.80</b>	<b>6.30</b>	<b>3.03</b>	<b>5.30</b>
Cape Verde	.	2.95	8.64	6.39	0.63	2.11	4.10	0.87	3.67
Costa Rica	.	.	.	16.03	3.82	6.91	3.10	2.50	6.47
Dominican Rep.	.	5.76	9.99	14.58	10.51	9.01	8.42	3.23	8.79
El Salvador	.	5.08	8.96	4.35	3.56	5.09	11.12	5.35	6.22
Guatemala	2.29	2.08	3.48	1.76	1.53	1.22	2.33	0.77	1.93
Haiti	9.71	5.95	5.33	6.36	2.40	3.88	6.09	2.52	5.28
Mexico	.	.	1.19	0.39	0.26	0.46	1.86	0.92	0.85
Nicaragua	10.25	13.17	13.72	8.00	11.85	6.34	17.49	2.41	10.40
Panama	.	8.68	5.57	13.60	3.37	2.30	7.71	6.40	6.81
Peru	1.32	0.72	3.36	1.03	0.85	0.72	0.79	5.31	1.76

**Table 10: Maize wholesale volatility**

	2005	2006	2007	2008	2009	2010	2011	2012	2005-2012
<b>Africa</b>	<b>8.72</b>	<b>10.54</b>	<b>10.54</b>	<b>12.69</b>	<b>10.02</b>	<b>11.34</b>	<b>11.74</b>	<b>9.56</b>	<b>10.64</b>
Ethiopia	6.44	4.07	9.02	13.54	7.96	4.99	12.07	6.89	8.12

Ghana	.	11.52	12.45	18.35	10.98	7.76	12.63	7.23	11.56
Kenya	10.46	9.41	5.53	9.28	8.80	12.98	12.81	7.40	9.58
Mozambique	8.89	12.98	6.04	6.29	8.88	10.65	7.16	4.54	8.18
Niger	6.62	7.85	15.32	15.62	15.06	9.57	7.66	12.71	11.30
Nigeria	6.62	7.85	15.32	15.62	15.06	9.57	7.66	12.71	11.30
Rwanda	6.99	11.94	9.72	16.77	8.03	19.59	13.25	8.05	11.79
South Africa	11.50	6.72	10.47	4.79	6.40	8.68	5.18	9.92	7.96
Tanzania	7.60	13.94	11.13	11.19	6.10	9.64	11.55	8.88	10.00
Uganda	13.37	19.13	10.41	15.49	12.90	19.98	27.46	17.25	17.00
<b>Asia</b>	<b>3.59</b>	<b>3.91</b>	<b>3.55</b>	<b>6.54</b>	<b>5.14</b>	<b>3.97</b>	<b>4.33</b>	<b>3.53</b>	<b>4.32</b>
Philippines	5.65	2.73	2.29	6.10	3.74	5.17	3.46	2.81	4.00
Thailand	1.52	5.09	4.81	6.99	6.54	2.77	5.20	4.25	4.65
<b>LAC</b>	<b>6.85</b>	<b>6.80</b>	<b>8.94</b>	<b>8.92</b>	<b>6.89</b>	<b>6.96</b>	<b>9.13</b>	<b>6.05</b>	<b>7.57</b>
Bolivia	7.87	8.66	7.81	10.39	8.57	11.61	10.82	9.56	9.41
Brazil	4.90	8.86	10.43	6.24	6.09	6.32	3.35	7.15	6.67
Colombia	10.67	6.04	10.67	9.62	7.12	9.89	7.53	1.83	7.92
Costa Rica	6.83	4.25	3.48	9.21	5.43	2.86	6.67	6.38	5.64
DominicanRep	.	16.27	14.71	24.91	10.46	8.47	10.81	10.95	13.80
Ecuador	4.04	6.26	6.30	5.36	4.80	10.59	3.41	6.36	5.89
El Salvador	.	3.57	10.44	5.38	6.30	6.90	13.80	5.19	7.37
Guatemala	6.76	6.80	9.64	5.57	6.25	7.27	11.83	8.03	7.77
Honduras	11.72	10.81	14.88	18.27	10.43	8.81	15.46	7.12	12.19
Mexico	1.85	4.17	2.35	3.35	1.57	2.43	6.28	2.17	3.02
Nicaragua	12.13	6.40	16.06	10.06	16.36	9.46	20.65	6.61	12.22
Panama	.	4.18	7.68	6.12	3.95	3.50	6.92	6.28	5.52
Peru	1.69	2.06	1.72	1.44	2.28	2.37	1.11	1.01	1.71

**Table 11: Wheat retail volatility**

	2005	2006	2007	2008	2009	2010	2011	2012	2005-2012
<b>Africa</b>	<b>4.50</b>	<b>2.83</b>	<b>4.97</b>	<b>8.16</b>	<b>7.03</b>	<b>4.36</b>	<b>5.71</b>	<b>3.93</b>	<b>5.19</b>
Burundi	.	1.78	1.50	13.14	7.15	2.71	4.78	.	5.18
Cameroon	.	1.08	5.97	8.94	2.09	4.08	4.32	0.21	3.81
DR Congo	.	.	.	14.60	.	4.34	3.51	2.86	6.33
Egypt	.	.	.	10.74	16.70	.	11.12	.	12.86
Ethiopia	.	5.97	5.23	7.64	8.47	4.86	7.89	.	6.68
Gabon	.	.	9.87	5.77	7.47	10.26	10.02	12.33	9.29
Lesotho	.	.	.	.	.	3.38	2.81	3.57	3.25
Mauritania	4.50	0.76	4.42	2.16	2.06	0.90	1.23	0.67	2.09
Zambia	.	4.56	2.83	2.28	5.28	4.39	.	.	3.86
<b>Asia</b>	<b>2.70</b>	<b>2.78</b>	<b>6.42</b>	<b>5.86</b>	<b>4.15</b>	<b>5.12</b>	<b>2.62</b>	<b>3.07</b>	<b>4.09</b>
Afghanistan	2.77	1.32	5.97	17.59	6.73	7.06	2.05	2.10	5.70
Azerbaijan	.	1.69	6.67	5.98	3.61	2.29	2.24	2.78	3.61
Bangladesh	.	.	.	8.62	5.39	7.87	6.16	5.82	6.77
Bhutan	.	.	.	1.24	8.89	8.37	1.56	0.00	4.01
China	.	.	.	.	1.59	2.31	1.61	2.44	1.99
India	4.01	4.14	2.98	2.18	4.11	3.68	3.60	5.72	3.80
Indonesia	.	.	.	1.11	1.14	0.73	0.99	0.40	0.87
Kyrgyzstan	1.62	0.99	12.04	4.08	1.93	5.72	4.52	4.14	4.38
Mongolia	.	.	4.67	5.46	1.87	9.16	1.43	1.33	3.99
Nepal	2.42	5.51	6.96	8.99	2.12	3.28	1.59	1.80	4.08
Pakistan	.	2.92	5.10	7.51	2.18	4.53	4.48	2.99	4.24
Sri Lanka	.	3.06	5.99	3.34	1.34	7.24	1.41	4.38	3.82
Tajikistan	.	2.63	7.42	4.17	13.12	4.31	2.40	6.06	5.73
<b>LAC</b>	<b>2.04</b>	<b>4.42</b>	<b>5.71</b>	<b>5.52</b>	<b>4.36</b>	<b>3.10</b>	<b>4.05</b>	<b>4.27</b>	<b>4.18</b>
Brazil	3.73	3.37	2.32	5.85	5.00	3.37	2.38	3.18	3.65
Costa Rica	.	.	13.15	6.06	5.27	2.65	5.01	3.18	5.89
El Salvador	.	9.22	8.88	9.47	6.69	6.08	9.84	8.62	8.40
Peru	0.34	0.66	1.42	0.93	0.70	0.39	0.32	0.40	0.64
Uruguay	.	.	2.77	5.28	4.12	3.00	2.68	5.98	3.97

**Table 12: Wheat wholesale volatility**

	2005	2006	2007	2008	2009	2010	2011	2012	2005-2012
<b>Africa</b>	<b>5.37</b>	<b>7.20</b>	<b>7.61</b>	<b>10.47</b>	<b>8.13</b>	<b>4.93</b>	<b>7.66</b>	<b>7.08</b>	<b>7.31</b>
Djibouti	2.28	5.02	6.98	8.93	10.46	2.93	7.75	11.46	6.98



Ethiopia	3.69	3.56	2.87	10.53	6.50	4.00	7.93	4.91	5.50
Soudan	11.06	12.86	12.24	13.69	10.50	8.78	9.06	7.16	10.67
SouthAfrica	4.45	7.35	8.34	8.74	5.06	4.02	5.89	4.79	6.08
<b>Asia</b>	<b>4.52</b>	<b>6.28</b>	<b>5.74</b>	<b>5.08</b>	<b>6.88</b>	<b>6.35</b>	<b>4.65</b>	<b>3.70</b>	<b>5.40</b>
Bangladesh	3.90	5.63	9.28	7.20	6.00	8.36	6.81	2.47	6.21
India	5.15	7.29	3.87	3.16	4.26	4.47	2.72	5.00	4.49
Israel	.	5.92	4.08	4.87	10.39	6.22	4.42	3.63	5.65
<b>LAC</b>	<b>5.13</b>	<b>3.13</b>	<b>4.33</b>	<b>7.58</b>	<b>3.94</b>	<b>3.72</b>	<b>3.52</b>	<b>3.85</b>	<b>4.40</b>
Bolivia	.	0.64	3.82	10.66	1.70	3.36	2.76	2.80	3.68
Brazil	7.20	4.51	5.96	12.04	3.62	6.67	3.60	3.61	5.90
Colombia	1.34	4.71	6.97	8.41	6.09	3.49	2.45	1.15	4.33
ElSalvador	.	3.55	5.50	4.60	4.12	3.87	7.53	12.69	5.98
Peru	1.44	1.35	2.21	3.28	1.54	1.00	1.50	1.06	1.67
Uruguay	10.54	4.02	1.53	6.48	6.56	3.91	3.29	1.77	4.76

**Table 14: Volatility differentials**

<b>Maize (pts of %)</b>												
	Costa Rica	Dominican Rep.	El Salvador	Ethiopia	Ghana	Guatemala	Mexico	Mozambique	Nicaragua	Panama	Peru	Philippines
2005						4.5		-0.7	1.9		0.4	2.8
2006		10.5	-1.5		-4.8	4.7		-4.8	-6.8	-4.5	1.4	-1.9
2007		4.7	1.4	-0.8	1.8	6.1	1.1	-2.8	2.4	2.1	-1.7	-1.7
2008	-6.8	10.3	1	-0.3	0.2	3.8	3	-1.3	2.1	-7.5	0.4	1.2
2009	1.6	0	2.7	3.9	-1.6	4.8	1.3	4.1	4.5	0.5	1.4	-4.3
2010	-4	-0.5	1.8	0.4	-4.4	6.1	1.9	2.5	3.2	1.2	1.7	0.7
2011	3.6	2.4	2.7	6.5	-3.1	9.5	4.4	2.1	3.2	-0.8	0.3	1.1
2012	3.9	7.8	-0.1	6.9	-2.9	7.2	1.3	1.2	4.2	-0.1	-4.3	1.2
<b>Rice (pts of %)</b>												
	Bangladesh	Brazil	Colombia	Dominican Rep.	El Salvador	Guatemala	India	Myanmar	Nicaragua	Panama	Peru	Philippines
2005			2.5			0.8	-0.6		-0.4		2.4	0
2006			1.6	-0.9	0	2.1	1.8		-0.2	1	1.8	0.6
2007		1.7	0.7	-1.1	-0.6	0.6	0		0.8	-1.6	1.1	-0.1
2008		-1.7	3.1	0.9	0.3	3.7	0.2		1.8	-12.8	0	1.1
2009	0.6	0.5	1.9	0.1	3.6	2	3.2	6.8	0	1.1	1.4	1.8
2010	0.2	-2.5	2.2	0.9	-0.4	0.3	-0.6	0.9	-0.7	-0.4	-4.3	0
2011	0.8	2.3	3.3	0	1.6	1.4	-0.5	4	-3.3	0.9	-0.5	0.7
2012	0.9	1.3	-0.6	-0.6	1.9	0.8	-0.1	3	-0.4	-1.1	0.6	1.6
<b>Wheat (pts of %)</b>												
	Vietnam											
	Bangladesh	Brazil	El Salvador	Ethiopia	India	Peru	Uruguay					
2005												
2006			3.5		1.1	1.1						
2007			1.1	-5.7	-2.4	3.2	0.7					
2008	-1.7		3.7	-3.4	-2.3	0.9	0.8	-1.3				
2009	-0.2		-1.4	6.2	-4.9	2.9	1	2.4	1.2			
2010	1.3		0.6	-1.4	-2.6	-2	0.2	0.8	2.5			
2011	-0.1		0.5	3.3	-2.2	-0.9	0.8	0.6	0.9			
2012	0.5		0.6	1.2	-2.3	0	-0.9	1.2	0.6			
			-3.3	0.4	4.1	4.9	-0.7	0.7	-4.2			