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Lukas Kornher
Matthias Kalkuhl
Irfan Mujahid

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Food price volatility in developing countries - the role of trade policies and storage

Lukas Kornher[a,1], Matthias Kalkuhl[b], Irfan Mujahid[c]

[a] *University of Kiel, Department of Food Economics and Consumption Studies, Olshausenstrasse 40, Kiel, Germany*
[b] *Mercator Research Institute on Global Commons and Climate Change (MCC), Torgauer Str. 12-15, 10829 Berlin, Germany, and University of Potsdam, Faculty of Economic and Social Sciences, Germany*
[c] *University of Bonn, Center for Development Research (ZEF), Walter-Flex-Str. 3, Bonn, Germany*

Abstract

The work at hand contributes to the ongoing discussion on drivers of food price volatility and closes the gap with respect to the impact of trade and storage policies. A dynamic panel is estimated to account for country fixed effects and the persistence of volatility. Findings underline the importance of international price volatility and transactions costs, while international volatility spill-overs are significantly higher in countries with high imports. New evidence is provided with respect to the impact of anti-cyclical trade policies: Accordingly, both exporters and countries that switch between net-importer and net-exporter successfully stabilize domestic prices by insulating themselves from international markets. On the other hand, regional market integration, as a tool to reduce reliance on (unstable) international trade and to improve stable regional trade relations, reduces volatility at domestic markets.

Keywords: Commodity price volatility, storage, trade policies, dynamic panel

Email addresses: lkornher@food-econ.uni-kiel.de (Lukas Kornher), kalkuhl@mmc-berlin.net (Matthias Kalkuhl), imujahid@uni-bonn.de (Irfan Mujahid)

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1. Introduction

The world has experienced two major food crises within the past 10 years. Prior to the global food crisis in 2007/2008 low prices of agricultural commodities were the long-standing concern of the development community, while this has diametrically changed thereafter (Aksoy and Hoekmann, 2011). However, this is not a contradiction since the poor are usually both consumers and producers and are impaired by price changes in both ways. On the other hand, price instability and unpredictability has unambiguously adverse consequences on their livelihood (Timmer, 1989). Moreover, price uncertainty also endangers macroeconomic stability and economic growth for importing and exporting countries (Myers and Jayne, 2012) as well as it impedes the achievements of the Millennium Development Goal (MDG) on the eradication of hunger inducing costly policy reactions.

The quest for the causes of this volatility has produced a large body of literature examining whether financialization of commodity markets, the new nexus with energy markets, or restrictive trade policies prompted food prices to change so quickly (Abbott et al., 2011; Serra and Gil, 2012; Tadesse et al., 2013). Increasing volatility in international markets are a real concern for developing countries. However, surprisingly, there are not many new insights on the causes of food price instability at domestic markets in developing countries. Several papers have analyzed the transmission of international price changes to domestic markets finding mixed evidence for strong inter-linkage between international and national level (Minot, 2011; Baquedano and Liefert, 2014). In contrast to pure time-series approaches, reduced form equation models that control for market fundamentals and policy variables consistently find a positive volatility spillover from international to national markets (Lee and Park, 2013; Kornher and Kalkuhl, 2013; Pierre et al., 2014). This literature also provides evidence on the impact of prominent supply and demand factors as well as the importance of transaction costs and governance indicators.

In response to increasing international volatility, national governments imposed anti-cyclical trade and storage policies to stabilize domestic markets (Demeke et al., 2009). Policy reactions have their domestic justification, but are accompanied by negative externalities as export restrictions limit supply at international and regional markets (Martin and Anderson, 2012; Laborde et al., 2013). Similar to anti-cyclical trade policies, stocks can be used to stabilize domestic prices. Sufficiently large stocks guarantee adequate supply and prevent post-harvest prices from spiking, while they also offset inter-annual supply shocks (Deaton and Laroque, 1992; Tadesse and Guttormsen, 2011). State involvement in storage increases national carry-over stocks and can thereby contribute to price stabilization (Jayne et al., 2008; Mason and Myers, 2013; Kozicka et al., 2015). Thus, policies play a crucial role to control price instability. However, there is no study available that shows the theoretical or empirical link of anti-cyclical trade and storage polices on volatility. Closely related to this, the trade regime is not considered when analyzing the effects of these policies.

In this paper, we refine and expand the analysis in Kornher and Kalkuhl (2013) by providing a stylized theoretical model describing the link between transaction costs, several price stabilization policies, and price volatility as well as by incorporating additional variables in the empirical model. The work contributes to the existing literature on food price volatility and is part of the growing research on the impact of public intervention on food markets (Maitre d'Hotel et al., 2012; Martin and Anderson, 2012; Porteous, 2012; Gouel, 2013a; Gouel and Jean, 2013). A particular focus of the study is to address the impact of anti-cyclical trade and storage policies also in considerations of the effects of different trade regimes. The paper differs from Martin and Anderson (2012) by modeling volatility rather than price levels and by the fact that we explain observed price variation through crop specific trade policy changes instead of an index for the nominal rate of assistance.

The empirical analysis employs a dynamic panel, estimated by system GMM that successfully accounts for changes in volatility over time (Serra and Gil, 2012) and potentially endogenous variables by using moment based instruments as well as a two step estimator to identify the effect of time-invariant regressors (Hoeffler, 2002). The remainder of the paper is organized as follows. Section two reviews existing empirical literature by listing potential determinants for price variation and by discussing anti-cyclical policies to offset volatility spill-overs. Then, section three presents our theoretical model and catalogues its prediction with respect to the sign and magnitude of the effect. Section four deals with the empirical strategy and describes data set and variables, followed by the discussion of the results in section five. Section six concludes.

2. Food price volatility and public stabilization policies

2.1. Causes for food price instability

While the determinants of international food price volatility were subject to a great number of significant publications in the course of the past years, few research attempted to screen domestic price volatility in developing countries at a global scale. This is surprising since several of the identified drivers of price volatility in international markets are unlikely to affect prices in developing countries unless through their impact on international prices. Research on the topic of financialization of commodity markets in the form of increasing non-commerical speculation has attracted most of the academic concentration without being able to generate consensus among scholars (Irwin et al., 2009; Algieri, 2012; Tadesse et al., 2013). By contrast, broad conformity prevails with regard to the impact of increasing market demand from emerging economies and the energy sector (Serra and Gil, 2012).

Nevertheless, there are notable similarities in price formation at international vis-à-vis national level. Supply shocks remain to be the major source of instability, while contemporaneous market conditions including a high concentration of exports make food markets prone to these shocks (Tadesse et al., 2013). In addition, changes in trade policy regimes hit both domestic markets of food importers and international markets. During the 2007/2008 price surges, the impact of these policies on international prices is estimated to be between 30 percent for wheat and 45 percent for rice, respectively (Martin and Anderson, 2012). The matter can be characterized as a classic collective action failure when an increase in prices causes the reaction of more and more countries fueling price rise.

At the domestic level, several other factors play a role for price determination and its instability. The theory of storage describes the underlying theoretical model for price dynamics of storable commodities (Williams and Wright, 1991; Deaton and Laroque, 1992). Due to the seasonality of production, commodity prices in developing countries exhibit strong seasonal patterns that contribute to overall price volatility (Kaminski et al., 2014; Kornher, 2014). Stocks can absorb production shortfalls by increasing available supply, and thus mitigate price instability between and within marketing years. On the same account, stock-outs cause price spikes by the inability to absorb these shocks (Shively, 2001; Osborne, 2004; Tadesse and Guttormsen, 2011). On the other hand, greater supply at the beginning of the marketing year guarantees higher supply in the course of the whole year and dampens price increases towards the end of the season. Therefore, a higher production level can reduce volatility (Shively, 1996; Durevall et al., 2013).

Likewise storage, trade allows to stabilize prices in both directions. The clear theoretical link is proven by numerous empirical contributions (e.g. Makki et al., 1996). Indeed, the substitutability between imports and stocks, offers a great flexibility through an optimal combination of both (Gouel and Jean, 2013). In consequence, tradeable commodities are largely driven by supply and demand in export countries and international markets (Minot, 2011). Therefore, international price instability can spill-over into national markets. With the notable exemption of a few studies, the literature focus lies on the transmission of price levels or changes instead of volatility. contributions on volatility transmission find throughout a significant positive spill-over from international to national markets (Lee and Park, 2013; Kornher and Kalkuhl, 2013; Pierre et al., 2014), while Rapsomanikis and Mugera (2011) report great heterogeneity among study countries. Similar to the latest, conventional price transmission analysis often finds mixed evidence for market integration with great discrepancy across countries (Greb et al., 2012; Baquedano and Liefert, 2014; Kalkuhl, 2014). However, taking into account large transaction costs, transmission within a range between 20 to 30 percent should be considered substantial. A number of countries are not interlinked with international commodity markets but trade extensively within the region. Proximity plays a critical role for the extent of spatial price adjustments between geographical nearby markets (e.g. Mengel and von Cramon-Taubadel, 2014a,b). The reliance on international and regional trade also involves the exposure to trade regime changes of trading partners that significantly affect the price adjustment between countries (Myers and Jayne, 2012; Stephens et al., 2012). When taking into account trade between countries, exchange rate variability also becomes an important component to instability of import prices and has been identified as an important price driver (e.g. Durevall et al., 2013).

Moreover, trade induces costs of transaction. This is of particular importance when goods are shipped from one country (region) to another. Hence, transaction costs are a critical factor to the price formation of spatially traded commodities. Changes in transaction costs are passed on to market prices until the new price equilibrium is reached. In addition to that, institutional economics emphasizes the importance of transaction costs to the general functioning of markets, in particular in developing countries (e.g. Rujis et al., 2004). With regard to food markets, efficiency can be gained in facilitating fast and costless contacts between buyers and sellers (Overa, 2006; Aker, 2010) as well as enforcing liability of contractors (Gabre-Madhin, 2001). The ease of doing business in consequence of low transactions costs reflects in the ability of market participants to quickly react in order to eliminate imbalances between supply and demand (e.g. Jensen, 2007). Other than the determinants listed so far, demand side shocks such as income, general inflation, and the growth rate of money complete the enumeration of factors that drive price volatility (Durevall et al., 2013; Lee and Park, 2013). Not to forget are policy related influences which are discussed in the subsequent section.

2.2. Public price stabilization policies

Since the global food crisis in 2007/2008, the public debate on agricultural markets in developing countries is dominated by the discussion on possible policy options to combat food price instability. Two of the possible policy tools appear to stand out: trade and storage policies. This explains the work's focus on the two.

Public storage is a traditional policy instrument to manage agricultural price levels and stability. Two distinct forms of public storage are evident. Buffer stocks try to mitigate price movements in both directions by permanently intervening in the market to affect prices. Unlike buffer schemes, strategic reserves are created to overcome supply shortage in markets as result of harvest failures or unavailability of international supply. However, they can also be used to mitigate price spikes (Galthier, 2013). Usually, the level of interventions is much lower than in the case of a buffer regime. In reality, the mandate of national food companies is often unclear and the difference between strategic reserves and buffer stocks blur (Deuss, 2014). Inadequate stock levels carried by the private sector represent the most frequently cited rationale for public stocks. Possible reasons are high costs of capital and transactions resulting in large costs of storage. In this instance, consumers' risk aversion and incomplete insurance markets call for state intervention (Timmer, 1989; Gouel, 2013a).

Partial equilibrium analysis shows strong stabilizing effects of public stabilization programs (Miranda and Helmberger, 1988). Empirically, the gains from public storage with regard to price stabilization are difficult to identify, given that a with-without comparison is not possible, since high volatility countries are also more prone to undertake price stabilization programs (Minot, 2014). Nevertheless, country level evidence supports the conjecture of price stabilizing effects for Zambia's Food Reserve Agency (FRA) and Kenya's National Cereals and Produce Board (NCPB) (Jayne et al., 2008; Mason and Myers, 2013). Similarly, India that runs one of the largest public storage programs has been very successful in guaranteeing price stability for rice and wheat (Kozicka et al., 2015). Against this, market liberalization is found to diminish market volatility by increasing competition and creating an incentives for private investments (Shively, 1996; Chavas and Kim, 2006).

The effects of trade policies, namely import taxes, export taxes and quotas, and export subsidies on prices are standard cases in economic textbooks.[2] Generally, trade policies are often motivated by revenue generation and protection of

[2]Price impacts depend on a country's share in international trade. Textbook cases: small country vs. large country.

domestic producers. Export quotas and taxes also control export quantities with the aim to regulate domestic supply. In this paper, we do not engage in the general discussion on trade policies but look at their specific role in controlling price stability. Indeed, in order to control domestic price levels and stability, changing the status quo trade regime is the most common policy option (Demeke et al., 2009). Thereby, trade policies are used in an anticyclic manner. Importers reduce import taxes, a de facto subsidy for consumers, to offset the effect of high international volatility. By contrast, exporting countries ban trade or limit quantities designated for trade by imposing quotas in order to limit high international price instability to conquer domestic markets. These policies have been found to be a successful means during the recent price surges for major exporters (Martin and Anderson, 2012) but not for regional traders that often switch between net-importer and net-exporter (Porteous, 2012).

Apart from the positive effects on domestic food price stability, export restrictions are associated with externalities for food importers and geographical neighbors (Martin and Anderson, 2012). For this reason, the most recent WTO meeting in Bali in 2013 put special emphasize on the possibility to suppress ad hoc restriction to international trade. However, WTO rules allow exemptions when countries face domestic supply shortage, a term not clearly defined (Konandreas, 2012). Trade liberalization can reduce agricultural price volatility through the intensification of trade between member countries. Yet, Rose (2004) finds little evidence that WTO membership effectively enhances bilateral trade. Moreover, it does not stabilize trade flows and predictability of trade flows by diminishing temporary trade restrictions (Rose, 2005). As opposed to this, trade liberalization between few trading partners, commonly referred to as regional trade agreements (RTA), effectively enhances agricultural trade and significantly reduces trade policy unpredictability (Baier and Bergstrand, 2007; Mansfield and Reinhardt, 2008; Cadot et al., 2009; Sun and Reed, 2010). On this account, amplified regional trade integration stabilizes agricultural commodity price volatility as countries within RTAs refrain from implementing short-term trade distortions against partners to maintain good political and economic relations. RTAs are therefore to be interpreted as a tool to reduce exposure to volatility-increasing anti-cyclical trade policies of trading partners.

Apart from a policy's immediate effect on price stability, public intervention is often evaluated with respect to its impact on overall welfare. This is related to the fact that policies come at high fiscal and economic costs. For instance, no intervention carry-over stocks are considered to achieve maximum welfare (Williams and Wright, 1991). At the same time, this has to be weighed against the adverse impacts of price instability (in short and long term) on a variety of welfare indicators such as health and nutrition status (von Braun and Tadesse, 2012). This is mentioned for the sake of completeness, but an assessment of this aspect is not within the scope of this study.

3. Theoretical model

The starting point of our theoretical model on domestic price volatility is the spatial trade equilibrium approach which links domestic prices p_t^D to international prices p_t^G and transaction costs for importing or exporting goods, τ_t, via the arbitrage condition (Samuelson, 1952; Fackler and Goodwin, 2001). High transaction costs can impede arbitrage possibilities and thus trade; in this case, domestic prices are determined by an inverse demand function $D^{-1}(X_t, Y_t)$ depending on total domestic consumption X_t and income Y_t. Hence, the spatial price equilibrium can be formally described by:

$$p_t^D = \begin{cases} p_t^G + \tau_t & \text{if } D^{-1}(X_t, Y_t) \geq p_t^G + \tau_t \quad \textit{(import regime)} \\ p_t^G - \tau_t & \text{if } D^{-1}(X_t, Y_t) \leq p_t^G - \tau_t \quad \textit{(export regime)} \\ D^{-1}(X_t, Y_t) & \text{else} \quad \textit{(no trade)} \end{cases} \tag{1}$$

In the following, we will analyze the structural and policy-related determinants of price volatility, measured by the variance of the price, for the different regimes.

3.1. Trade policies and transaction costs in the trade regime

First, we consider the role of domestic trade policies that influence transaction costs τ_t.[3] We conceptualize this by decomposing transaction costs into a stable base component (which includes also transportation and insurance costs and other fees and taxes that are constant) and variable component: $\tau_t = \tau^{base} + \tau_t^{pol}$. Hence, the variance of domestic prices in any of the trade regimes equals:

$$Var(p_t^D) = Var(p_t^G + \delta\tau_t^{pol}) = Var(p_t^G) + Var(\tau_t^{pol}) + 2\delta Cov(p_t^G, \tau_t^{pol}) \tag{2}$$

where $\delta = 1$ in case of the import regime and $\delta = -1$ for the export regime.

Proposition 1. *For any of the two trade regimes and assuming a marginal change in trade policy that does not lead to a regime switch, the variance of domestic prices is affected by trade policy as follows:*

[3] While we model only price-based trade policies in our analysis, it is easy to see that quantity-based policies like export quotas are equivalent to an export tax at the level of the quota price.

i *for a constant trade policy, the variance of domestic prices equals the variance of international prices;*

ii *domestic trade policies can reduce domestic price variance below international price variance if* $Var(\tau_t^{pol}) + 2\delta Cov(p_t^G, \tau_t^{pol}) < 0$*;*

iii *a linear trade policy response function where* $\tau_t^{pol} = \delta\alpha p_t^G$ *reduces domestic variance below international variance if and only if* $-1 < \alpha < 0$*;*

iv *the variance of domestic prices is not affected by the mean of the transaction costs* $E[\tau_t]$*; the normalized volatility of domestic prices, measured as coefficient of variation, decreases (increases) in* $E[\tau_t]$ *for importers (exporters). The response of the coefficient of variation to international price volatility is higher for exporters than for importers.*

Proof. The proofs of (i) and (ii) follow directly from Eq. (2). For (iii), substituting $\tau_t^{pol} = \delta\alpha p_t^G$ into (2), gives $Var(p_t^D) = (1 + \alpha)^2 Var(p_t^G)$. For (iv), it follows from Eq. (2) that $E[\tau_t]$ has no impact on the variance and from (1) that $\partial E[p_t^D]/\partial E[\tau_t] = \delta$. Hence, the coefficient of variation changes in $E[\tau_t]$ according $\partial CV(p_t^D)/\partial E[\tau_t] = -\delta Var^{1/2}(p_t^G)/(E[p_t^G + \delta E[\tau_t]])^2$. □

The findings from Proposition 1 can be described as follows: In order to reduce domestic variance, an importing country needs to employ an anti-cyclical tariff policy (i.e. $Cov(p_t^G, \tau_t^{pol}) < 0$) where tariffs (subsidies) decrease (increase) in global prices while an exporting county has to increase export taxes or quantitative restrictions when global prices increase (i.e. $Cov(p_t^G, \tau_t^{pol}) > 0$). In case of linear response functions, the change in tariffs, subsidies or taxes needs to be less pronounced than the change in global prices ($|\alpha| < 0$). While the mean level of transaction costs does not affect the price variance, high transaction costs reduce the coefficient of variation in importing countries due to higher mean price levels and increase the coefficient of variation in exporting countries due to lower mean price levels.

Proposition 1 can easily be transferred to the case of anti-cyclical trade policies of *trade partners* that may alter their respective price p_t^G by $\tilde{\tau}_t$. As follows from Proposition 1, exporters will have an incentive to intervene with $Cov(p_t^G, \tilde{\tau}_t^{pol}) > 0$ contrary to importers with $Cov(p_t^G, \tilde{\tau}_t^{pol}) < 0$ in order to stabilize prices. Hence, anti-cyclical trade policy of *trade partners* results in the opposite effects on domestic variance than own anti-cyclical trade policy.

3.2. Storage in the no-trade regime

As trade binds domestic prices to international prices via the costs of arbitrage, domestic supply and demand factors like income shocks, production shortfalls or stock releases do not affect prices in a small open economy within one of the trade regimes. If no trade occurs, however, these factors become important determinants of domestic price variability. Assuming a linear inverse demand function in consumption X_t and income Y_t, we have $D^{-1}(X_t, Y_t) = A - BX_t + CY_t$ with $B, C > 0$. Using (1), the variance of domestic prices in the no-trade regime is

$$Var(p_t^D) = Var(D^{-1}(X_t, Y_t)) \tag{3}$$
$$= B^2 Var(X_t) + C^2 Var(Y_t) - 2BC\, Cov(X_t, Y_t) \tag{4}$$

As it can be easily seen, the variance of domestic prices increases in the variance of domestic consumption as well as in the variance of domestic income. To better understand the causes of price fluctuations and the role of storage, we analyze inter-annual price variability and intra-annual (seasonal) price variability separately. The former is driven by the variability of production while the latter is caused by the fact that production takes place typically only few months per year.

Inter-annual price variability. For the inter-annual analysis we consider the time subscript t to represent years. The inter-annual variance of domestic consumption, in turn, is strongly affected by grain stocks. We can substitute $X_t = Q_t - \Delta S_t$ where Q_t is the domestic production and $\Delta S_t = S_{t+1} - S_t$ the supply from changes in the beginning year's grain stocks S_t. For countries with large and effective grain storage, releases $\Delta S_t < 0$ from the grain stock at the beginning agricultural year S_t occur when production is low; likewise, excess production is transferred to the stock $\Delta S_t > 0$. In both ways, domestic supply is stabilized and $Var(X_t) = Var(Q_t + \Delta S_t)$ decreases.

While it is in general not possible to model neither competitive storage nor optimal public storage with closed-form solutions (see Newbery and Stiglitz, 1982, for a very specific case where a closed-form solution exists), a linear storage rule can provide a rough approximation of storage behavior. This rule describes ending stocks (i.e. beginning stocks at the next period) S_{t+1} as a function of domestic supply, thus $S_{t+1} = \gamma(Q_t + S_t)$ with $0 \leq \gamma < 1$ being the marginal propensity to store.

Proposition 2. *Given a linear storage rule for the annual ending stocks $S_{t+1} = \gamma(Q_t + S_t)$ and Q_t i.i.d., the variance of inter-annual domestic supply is in the long-run $Var(X_t) = \psi(\varsigma)Var(Q)$ with $\varsigma = E[S_t]/E[Q_t]$ the mean stock-to-use ratio and $\psi(\cdot) > 0, \psi'(\cdot) < 0$ a decreasing function in ς. The coefficient of variation of inter-annual domestic supply decreases in mean stock-to-use ratio ς as well.*

Proof. See appendix. □

The insight from Proposition 2 is that higher stock-to-use ratios effectively reduce supply variability.

Intra-annual (seasonal) price variability. For the intra-annual analysis we consider the time subscript to represent alternating harvest and lean season: Even indices $2t$ represent harvest periods at year t and odd indices $2t+1$ lean periods at year t where no production occurs and consumption is satisfied from intra-annual stocks. Thus, intra-annual storage ΔS_{2t} smooths consumption between harvest and lean season according to

$$X_{2t} = Q_{2t} - \Delta S_{2t} \tag{5}$$

$$X_{2t+1} = \Delta S_{2t} \tag{6}$$

The fundamental behavioral equation for understanding seasonal price variability is the inter-temporal arbitrage equation

$$p_{2t} = \frac{1}{1+r} E[p_{2t+1}] \tag{7}$$

Prices at harvest p_{2t} have to equal discounted expected prices at the lean season $E[p_{2t+1}]$ with the interest rate r as discount factor.[4] For the seasonal analysis, we neglect storage carry-over from one marketing year to the other (which is covered by the inter-annual analysis and Proposition 2). In the absence of intra-annual income shocks Y in the inverse demand function, (7) becomes:

$$p_{2t} = \frac{p_{2t+1}}{1+r} \tag{8}$$

We measure seasonal price variability as sample-variance over the two prices at harvesting and lean season, thus

$$V_{2t} := (p_{2t} - \bar{p}_{2t})^2 + (p_{2t+1} - \bar{p}_{2t})^2 = \frac{1}{2}(p_{2t} - p_{2t+1})^2 \tag{9}$$

with $\bar{p}_{2t}$ the intra-annual mean price $\bar{p}_{2t} := (p_{2t} + p_{2t+1})/2$ prevailing at year t. Normalizing the sample variance by the mean price gives the coefficient of variation

$$CV_{2t} := \frac{\sqrt{V_{2t}}}{\bar{p}_{2t}} \tag{10}$$

[4]For the sake of simplicity, we assume that storage costs can be all subsumed into the discount factor $1/(1+r)$.

Proposition 3. *Under the absence of intra-annual income shocks, the following holds:*

i *the coefficient of seasonal price variation is* $CV_{2t} = \frac{r}{2+r}$*;*
ii *the coefficient of seasonal price variation increases in storage costs* r*;*
iii *the coefficient of seasonal price variation decreases in intra-annual storage levels* ΔS_{2t}*.*

Proof. (i) Substituting (9), $\bar{p}_{2t} = (p_{2t} + p_{2t+1})/2$ and $p_{2t+1} = (1 + r)p_{2t}$ from (8) into (10), we obtain the result. (ii) $\frac{\partial CV_{2t}(r)}{\partial r} = \frac{2}{(2+r)^2} > 0$. For (iii) substitute the linear inverse demand function into (8) gives

$$(1 + r)(A - BX_{2t} - CY_{2t}) = A - BX_{2t+1} - CY_{2t+1} \tag{11}$$

Let g be the growth rate of income such that Y_{2t+1} can be substituted by $(1+g)Y_{2t}$. Inserting this and the intertemporal budget equation (5-6) into (11) gives after rearranging $\Delta S_{2t} = -\frac{rA+(g-r)cY_{2t}-(1+r)BQ_{2t}}{B(2+r)}$. The partial derivative of stocks after the discount rate r is then $\frac{\partial \Delta S_{2t}(r)}{\partial r} = \frac{-2A+BQ_{2t}+c(2+g)Y_{2t}}{B(2+r)^2}$. As prices are positive, i.e. $p_{2t}, p_{2t+1} > 0$, for the linear inverse demand function follows that $A > BX_{2t} - CY_{2t}$ and $A > BX_{2t+1} - CY_{2t+1}$. After substituting (5-6), this implies that $-2A + BQ_{2t} + c(2 + g)Y_{2t} < 0$ and, thus, $\frac{\partial \Delta S_{2t}(r)}{\partial r} < 0$. With the finding from (ii) we finally get $\frac{dCV_{2t}}{d\Delta S_{2t}} = \frac{\frac{\partial CV_{2t}(r)}{\partial r}}{\frac{\partial \Delta S_{2t}(r)}{\partial r}} < 0$ □

Similar to inter-annual storage, Proposition 3 shows that higher intra-annual storage (which can, among others, be increased by low interest rates) reduces intra-annual (seasonal) price variability.

3.3. Variance with regime switching

So far, we study the impact of storage and trade policies on domestic volatility within either trade ($T \neq 0$) or no-trade ($T = 0$) regime. These policies, if large enough, can also alter the trade regime or, more general, the probability of being in one of the trade regimes. The variance of domestic prices with regime switch is

$$Var(p_t^D) = \text{Prob}[T \neq 0]Var[p_t^G + \delta\tau_t | T \neq 0] + \tag{12}$$
$$(1 - \text{Prob}[T \neq 0])Var[D^{-1}(X_t, Y_t) | T = 0] \tag{13}$$

In this general form, it is not possible to analyze how changes in policies affect the variance of domestic prices. High transaction costs τ increase the probability of the no-trade regime. This can decrease domestic volatility if $Var(D^{-1}(X_t, Y_t))$ is very low which can in particular be the case for countries with large storage programs or low variability in production. On the other hand, variance of domestic prices can be higher in small countries with substantial fluctuations in production and low institutional or fiscal capacity to run storage programs.

Comparing the variances of domestic prices in the trade and in the no-trade regime gives another important conclusion regarding the role of transaction costs: If the variance of the international price is smaller than the variance of the domestic price in the no-trade regime and trade policy is constant, then trade always reduces the domestic price variance. Therefore transaction and trade costs, including tariffs, τ_t must be sufficiently small to allow the possibility of trade. Thus, a reduction of τ_t can reduce domestic price variability if it induces a regime switch from the no-trade to the trade regime. The implications and predictions of the theoretical model and its correspondence to the empirical model described below are listed and evaluated in Table 1.

[Table 1 here]

4. Empirical strategy and data

4.1. The model

The empirical model is inspired by Lee and Park (2013) and extents their analysis by including a larger set of explanatory variables and expanding the analysis to crop specific estimates. Availability of the data allows an estimation on annual base only. Therefore, volatility is computed as the price variation within a particular calendar year. Price volatility exhibits clustering implying that periods of high volatility follow periods of high volatility and low volatility episodes periods of low volatility, respectively (Serra and Gil, 2012). In order to control for these clusters, a dynamic model is chosen allowing the inclusion of lags of the dependent variable.[5]

The observation period is restricted to the time between 2000 and 2012. This leaves us with only few observations per country. On that account, the unit of

[5] The empirical approach is similar to the one described in more detail in Kornher and Kalkuhl (2013). One important difference is the consideration of calendar year observations instead of marketing year periods for reasons of better data consistency (most trade data is reported on calendar year basis and the majority of starting months of marketing years in the FAO GIEWS database is January); furthermore, we have integrated more trade policy related explanatory variables in the empirical analysis.

analysis is crop-country-year within a panel of more than 70 countries and a maximum of thirteen years per unit.

$$\sigma_{ij,t} = \beta\sigma_{ij,t-1} + \gamma X'_{ij,t} + \theta I'_{i,t} + \eta I'_{j,t} + u_{ij,t} \tag{14}$$

where i and j represent countries and crops and t is the time subscript. σ_{ijt} stands for the price volatility and X' and I' are vectors of time-varying and time-invariant but observable regressors. u_{ijt} is the error term. The estimation is associated with methodological challenges from omitted variable bias (OVB) and dynamic panel bias (Nickell, 1981). The endogeneity problem between price volatility and our policy variables can also be resolved by instrumenting public interventions by their first difference or orthogonal deviations as done by GMM estimation. The estimation is implemented in Stata 13 using Rodman's xtabond2 (Roodman, 2009a).

The identification of causal effects of time-invariant regressors in cross country data sets, in particular in a dynamic setting, adds complexity to the model. Therefore, most independent variables are designed as time variant. Yet data availability and frequency of updates do not permit to observe all determinants on an annual base. Besides, country characteristics, such as net trade position, do hardly change over time; others are naturally constant (geography).

As a matter of fact, it is very likely that observed time-invariant country characteristics are correlated with the fixed effect (Hoeffler, 2002). As a result, the system GMM estimator is inconsistent. Among others, Cinyabuguma and Putterman (2011) and Kripfganz and Schwarz (2013) apply a two stage estimation approach. In this instance, only time-variant regressors are included in the first stage using either difference or system GMM. Thus, GMM estimates are not biased through the inclusion of endogenous time-invariant regressors. From the GMM regression, u_{ijt} is obtained containing observed and unobserved time-invariant effects as well as the normally distributed regression error ϵ_{ijt}. In the second stage, the errors (u_{ijt}) are regressed on the time-invariant regressors within a cross sectional regression framework:

$$u_{ijt} = \theta_1 F'_{ij} + \theta_1 f'_{ij} + \alpha_{ij} + e_{ijt} \tag{15}$$

where F'_{ij} contains strictly exogenous time-invariant regressors and f'_{ij} contains endogenous time-invariant regressors. Both constitute to I'_{ij} from above. Equation (15) can be estimated using two stage least squares (2SLS). The difficulty in the estimation is to find feasible instruments that are sufficiently correlated with the endogenous time-invariant variables f'_{ij}, but not correlated with the fixed effect.

As in any instrumental variable regression, the quality of the first step GMM estimator depends on the relevance and validity of its instruments. The exclusion restriction can be tested using Hansen J-Test or the Sargan Test of overidentifying restrictions. Both difference and the system GMM potentially suffer from inconsistency as a consequence of too many instruments. Alongside, results on Hansen's J-Test may be compromised by a large number of instruments (Roodman, 2009b).

4.2. Description of the data

Principally, the model allows to include a large variety of potential drivers of volatility discussed in the literature review section. Yet the selection of explanatory variables for the analysis at hand is largely based on the theoretical model and the literature review section. In addition to most of the existing work, an attempt is undertaken to account for trade and price stabilization policies in a quantitative manner. The full set of independent variables is provided in Table 2.

The data set used in this analysis combines several sources that are public with the exemption of the FAO CBS data set. Normalized price instability is measured as the standard deviation of log returns as suggest by most of the existing literature.[6] In order to achieve a normal distribution of residuals, which is required for inferences testing, the standard deviation of returns is logarithmized. The price data to construct the volatility measure consists of national retail prices which can be found in the following databases: FAO GIEWS, FEWS.NET, and WFP VAM.[7]

[Table 2 here]

To assess the transmission of volatility from international to domestic markets, and to account for spatial price adjustment, international volatility is a main variable of interest. It is computed over an annual period in the manner of the dependent variable. So, international volatility is not weighted by national trade activities. Exchange rate volatility represents national currency fluctuations towards the USD. It controls for price adjustment which does not affect real prices. For exporters, exchange rate volatility also captures their trade competitiveness.

[6]Consult Piot-Lepetit and M'Barek (2011) for a detailed summary and discussion on measures of price volatility.

[7]In some instances, if they are not accessible, then the national average is constructed from available market level price data. In some rare cases, wholesale price data is used. The difference should not be of concern within the panel framework that is applied.

Growth rate of money supply accounts for demand shocks and inflation pressure. Both lead to an import of volatility into the food sector. The overall score of Kaufmann's World Governance Indicator (*WGI*) is included to control for political stability and governance effectiveness. Production shocks are controlled for by the relative deviation of production from its trend.

In order to consider transaction costs, we construct a variable that measures institutional quality. This is captured by an index that represents the quality of market institutions. It comprises of road infrastructure, economic freedom, mobile phone penetration rate, and the presence of an agricultural exchange to hedge price risk and to gain better price information.[8] Then, they are equally weighted evolving into a single index. One main advantage is the time-variant structure of the index which cannot be achieved for all variables composing the index, but for the index as a whole. The combined index is then multiplied by -1 to achieve an intuitive interpretation. So, if the coefficient for transaction costs is positive, an increase in transaction costs is associated with higher price instability.

We consider two related storage policies, beginning stock-to-use ratios observed in the market and the existence of a public storage program.[9] Noteworthy, empirical analysis is aggravated by difficulties to adequately measure public interventions since release and sales data is rarely available. Therefore, *high intervention* is a dummy variable which is 1 if the country runs an important price stabilization program. This information comes from extensive desk research. The country classification is presented in Table 3.

[Table 3 here]

Trade policies are captured by three different variables. They are constructed from annual bilateral trade flow data for individual agricultural commodities published by UN COMTRADE. Data until 2013 is available only for trade values, but not for quantities. In order to make quantities comparable over time,

[8] Mobile phone penetration and economic freedom are measured relative to penetration and freedom in the US. Road infrastructure is measured as the percentage of paved roads, while years of missing values are linearly interpolated. If a commodity exchange exists a country gets 100 percent and zero if no commodity exchange exists. Institutional quality is an equal weighted average.

[9] To the knowledge of the authors the FAO CBS stock data is the best and most comprehensive data set available with respect to developing countries. FAOSTAT only provides stock changes. USDA provides reliable data for big importers but generally little or bad data for sorghum and millet. Notably, there is still legitimate doubt on the precision of the data, as it is also constructed from commodity balance sheets.

trade values are divided by the annual international grain price index that is also used to compute international price volatility. National anti-cyclical trade policies are represented by protectionist behavior (*insulation*), while *reg trade* represents the ratio of trade with partners in regional trade agreements (RTAs) over the total amount of trade of the respective commodity.[10] In contrast, anti-cyclical policies of trade partners (*int exp res*) are measured by endured protectionism. Comprehensive data on bilateral trade barriers is not available, therefore anti-cyclical policies are approximated by the deviation of trade values from its trend value:

$$insulation_{ijt} = -\frac{\text{Exp}_{ijt} - \widetilde{\text{Exp}}_{ijt,2000-2013}}{\widetilde{\text{Exp}}_{ijt,2000-2013}} \tag{16}$$

$$int\ exp\ res_{ijt} = -\frac{\sum_1^5 \text{Imp}_{ijt} - \sum_1^5 \widetilde{\text{Imp}}_{ijt,2000-2013}}{\sum_1^5 \widetilde{\text{Imp}}_{ijt,2000-2013}} \tag{17}$$

where the subindex ijt indicates that trade shocks do vary across commodities and $\widetilde{\text{Exp}}_{j,2000-2013}$ as well as $\widetilde{\text{Imp}}_{j,2000-2013}$ represent the median export and import values over the period from 2000-2013. *Insulation* represents deviations of exports (Exp) from country j to other countries. Multiplying the quotient by -1 allows to interpret the variable as follows: a negative sign of *insulation* states a price depressing export policy, while a positive sign is associated with high exports (implying high domestic prices). By contrast, restrictions endured by country j are measured by the negative deviations in trade values of the five main trading partners of country j. Hence, the negative quotient induces the interpretation that higher restrictions are associated with a positive sign of *int exp res*.

The strategy is to estimate the econometric model for the whole sample and distinct country groups, namely importers, non-importers, trade-switchers, and high and low intervention countries.[11] Further, the two-step estimation allows to test for difference in the level of volatility between these groups of countries. The elaboration of heterogeneity between countries is an innovative approach with no comparable application in empirical research. The classification according to the trade regime is also included in Table 3.

[10]Data on regional trade agreements is collected by Mujahid and Kalkuhl (2015).

[11]The number of observations for exporters is relatively small. Therefore, non-importers are exporters plus trade-switchers. Differences between non-importer and trade-switchers should be carried by exporters; Exporters are countries that exported throughout the whole period of observation. Importers are defined as countries that imported in each year of the observation period with a median import-to-consumption ratio greater than 15 percent.

Countries and crops that are part of the data set are selected based on availability of price data from existing commodity price databases and national publicly open sources. Table 4 summarizes the number of country-crop groups by continent, country type, and commodity.[12]

[Table 4 here]

5. Results

5.1. Pooled data

Table 6 presents four different specifications of the model. The motivation is twofold. First, some explanatory variables reduce the sample size substantially. And second,*transaction costs* is highly correlated with other explanatory variables which may distort test statistics with regard to these variables. The correlation among all explanatory variables can also be found in Table 5. All specification tests, as well as the number of instruments, are reported beyond the regression output. Table 6 also displays specification tests for dynamic panel models. First, the Arellano-Bond test for autocorrelation in the idiosyncratic disturbances is used to test the validity of all lags as instruments (Roodman, 2009a). Second, Sargan and Hansen test for instrument exogeneity are performed. The first is not robust, whereas the second weakens with too many instruments. Following the suggestion of Roodman (2009b), the number of GMM type instruments is collapsed. Both Sargan and Hansen accept the null hypothesis of instrument validity. The difference-in-Sargan test confirms the validity of GMM type instruments. Test results do not reveal a general problem with instrument validity although some test statistics are not sufficient to conclude on this for a single regression. On a general note, there are numerous possibilities to choose the number of instruments and regression options. It is preferable to estimate all models with equal options and assumptions with regard to endogeneity and predetermination of explanatory variables in order to make results comparable. The details are also noted at the end of the regression outputs. Overall, it is concluded, that the specifications chosen, pass standard testing procedures.

[Table 5 here]

[Table 6 here]

[12] The detailed list of countries and the full country classification is available from the authors upon request.

Throughout all specifications, significant variables exhibit the sign predicted by the theoretical model and summarized in Table 1. Nevertheless, one should keep in mind that the theoretical model is very stylized and simplified, neglecting, for example, substitution effects, differences in quality between international and domestically traded commodities or limited domestic market integration of local commodity markets. International food price volatility, measured as the weighted average of most prominent export prices, exhibits a strong significant impact on domestic volatility in each specification. Due to the log-log nature, the coefficient represents an elasticity. Thus, in the short run, around 30 percent of international price volatility is transmitted to domestic markets. This estimate is of similar size as in Pierre et al. (2014), but larger than in Lee and Park (2013). A comparison with findings from price transmission analysis based on vector error correction models is not reasonable as they measure transmission of price levels instead of volatility spill-overs.

Fundamental supply factors are significant when excluding transaction costs from the regression.[13] To be precise, volatility reduces by 2.5 percent given an increase in the stock-to-use of one percentage point. This coefficient is much larger as compared to estimates on the impact of stocks on international price volatility. Hence, enhanced storage reduces price instability. Similarly, when national production rises by 10 percentage points, the impact on domestic volatility is between 1.8 and two percent. This effect is of similar size as the one for yield found by Pierre et al. (2014). In contrast, the evidence on impacts of production and yield on international price volatility is mixed (Balcombe, 2009; Ott, 2014a). Considering the stochasticity of production shocks, 10 percent is not much.

Furthermore, transaction costs and money growth rate are found to significantly impact on price volatility. Transaction costs are represented by an index that lies between 0 and -1. Thus, an increase of 10 percentage points would lead to an increment of price volatility of around 10 percent. The impact of transaction costs is ambivalent in the theoretical model and depends on the trading regime. Low transaction costs are a necessary condition for international as well as within-country trade which can lower domestic volatility.[14] The negative relationship predicted for importers gains relevance only when a trade relationship already exists. Money growth rate is also given as a ratio and is to be interpreted in the same way as transaction costs. Thus, an increase in money supply by 10

[13]This can be explained by relatively high correlation between stock-to-use and institutions, but also by the increment in degrees of freedom.

[14]Note again that the theoretical model is stylized and abstracts, for example, also from within-country trade that is affected by transaction costs.

percentage points induces price volatility to rise by only three percent. On the contrary to money supply and transaction costs, political stability is not significant in any specification. Exchange rate volatility is also not found to be an important driver of domestic price dynamics.

A particular interest of this analysis is the impact of anti-cyclical trade policies on domestic price dynamics. The regional share of total trade is significantly negatively associated with price volatility. Hence, higher regional market integration and trade liberalization successfully stabilizes market prices. These results are robust across all specifications. Conversely, price insulation through export restrictions is found to have a dampening effect on price volatility, however, to a smaller extent. An enlargement of regional trade and a restriction of exports by 10 percentage points lead to a reduction of volatility by eight and four percent, respectively. Export restrictions by the five largest trading partners are significant in specification (2) and (3) of Table 5 only, but hardly in any other specification tested.[15] This finding could be explained by simultaneous implementation of anti-cyclical trade policies by importers and exporters that partially offsets volatility impacts (Martin and Anderson, 2012). Therefore, the insignificance of export restrictions of trading partners to domestic price may also confirm the effectivity of anti-cyclical import policies to reduce price volatility.

Lastly, the impact of the lagged dependent variable is positively significant at the one percent level with a magnitude between 0.25 and 0.35 across specifications. This implies high persistence of domestic food price volatility. Due to the inclusion of the lagged dependent variable, long run effects of other explanatory variables are obtained by dividing the respective estimated coefficient by one minus the autoregressive parameter.[16] Hence, long term effects exceed short term effects by approximately 45 percent.

A detailed overview on short and long run impacts is given in Table 7. Significance of variables alone is not much enlightening with respect to their relevance on food price volatility. Therefore, and to improve readability, explanatory variables are shocked by one standard deviation. This is equivalent to normalizing a variable by dividing it by its standard deviation. In doing so, the relative importance of each explanatory variable can be assessed. The procedure is very similar to standardized coefficients but yields a more intuitively interpretable number. The percentages given in Table 7 are to be understand as the change in domestic price volatility if the explanatory variable of interest changes by one standard deviation. Accordingly, marginal effects of stocks and share of regional

[15] This also holds when excluding international price volatility.

[16] $\gamma/(1-\beta)$.

trade are considerably higher than for all other explanatory variables, while the effect of regional trade is more stable across specifications. Impacts of international prices, transaction costs, and insulation policies are of medium magnitude, but robust across specifications. Changes in national production, money supply, and export restrictions of trading partners have relatively little consequences on domestic volatility. Worth to note, an increase (decrease) of explanatory variables by standard deviation may not be equally realistic. On the other hand, it is difficult to a priori determine a realistic variation in explanatory variables. Thus, the estimated marginal effects should be interpreted with the usual caution.

5.2. Regression by trade regime

The impacts of some explanatory variables are suspected to be highly nonlinear as suggested by Table 1. Therefore, the regressions are performed for subsets of the full data set to test for differences originating from the trade regime as shown above. Specifications chosen are synonymous to (1) and (2) from Table 6, but exclude insulation and international export restrictions for importers and non-importers, respectively. The results with respect to trade status are presented in Table 8.

[Table 8 here]

First, results with regard to trade status are discussed. Lagged domestic price volatility is positive and significant in all specification in Table 8 with no notable difference in the size of the effect. Similarly, international price volatility remains strongly significant at the one percent for all types of countries. Yet the coefficient for importers is almost twice the size of the one for non-importers. Hence, the rise of international price volatility hits importers particularly hard, since almost 50 percent of the volatility is transmitted to domestic markets. Heterogeneity in the magnitude of volatility spill-overs is also evident in Rapsomanikis and Mugera (2011) who use BEKK conditional variance models for several countries. Besides, transaction costs remain highly significant with a greater impact in countries with limited integration in international markets which is in line with the negative relationship between mean transaction costs and price instability for importers as part of Proposition 1iv.

The segmentation of the data set yields to the insignificance of production shocks for all countries. This is in line with the literature on international price volatility (Ott, 2014b). On the contrary, the stock-to-use ratio remains significant in the specification without transaction costs. Interestingly, the price stabilizing effect of stocks is much higher in importing countries, while the effect for exporters and trade-switchers has the same magnitude. The gap between importers and non-importers may be caused by the inability of importers to effectively manage price stability through trade because imports are indispensable to satisfy consumption needs.

With respect to regional trade integration, no difference between different types of countries can be observed, while the effects remain significant and at similar relevance as compared to the full model. Export restriction remain insignificant. Lastly, exporters and trade-switchers successfully stabilize domestic prices through export regulations. This is in line with the state of research regarding insulation policies. While Martin and Anderson (2012) base their conclusions on theoretical consideration on the formation of prices and transmission mechanisms as well as changes in nominal assistance coefficients, here the impact on price volatility is directly observed. Hence, the findings provide empirical evidence for the predictions with regard to welfare impacts of importing and exporting countries made by Martin and Anderson (2012). Moreover, price stabilizing effects are also found for trade-switching countries which contradicts Porteous (2012) who finds no positive effect of insulation policies for regional exporters in Africa.

Variability in the USD exchange rate and growth rate of money supply are both insignificant in all but one specification. WGI is significantly positively associated with price volatility for non-importers only. Counter-intuitively, the sign implies that better governance increases volatility. Since the coefficient is positive and significant only in the specifications for non-importers, this should not be attached with great importance.

5.3. Regression by interventions status

Table 9 concentrates on differences between countries that are characterized by high state involvement through price stabilization programs. Among countries with high public involvement, the coefficient of lagged domestic volatility is roughly 0.1 greater than in any other specification. It implies higher persistence of volatility with public storage. This is theoretically convincing because storage enhances autocorrelation of commodity prices. The impact of international volatility remains at similar size.

[Table 9 here]

Stocks are more important in determining domestic price dynamics for low intervention countries than for high intervention countries. Production is insignificant for both types of countries, albeit the effect of production changes is close to reach significance for low intervention countries. Regional market integration is significant across all specifications, but the effect is considerably larger for low intervention countries. Furthermore, money growth rate is significant with the expected sign in specification (2) of Table 9. Lastly, the coefficient for transaction costs is significantly greater in the specification for low intervention countries. All these differences take the same line. Market forces, such as supply and demand, market integration, and transaction costs are of less importance in a system in which governmental institutions dominate and affect private sector decision making. Exchange rate volatility and governance are not significant in any specification.

Both anti-cyclical trade policy variables, namely *int exp res* and *insulation* are significant for low intervention countries only. A possible explanation is that countries with public storage generally control exports in order to prevent the outflow of subsidized stock releases and do not adjust this policy during food crises. It could also hint at a specialization of governments to either control prices by storage or trade policies. Conversely, a number of high intervention countries like India, Thailand, and Vietnam use both storage and trade policies to steer domestic pries.

5.4. Two step estimation: public storage

In the last part of the empirical analysis, we test whether a portion of the country-crop fixed effect can be attributed to time-invariant country characteristics. Again, the focus lies on trade status and public intervention. Table 10 depicts a priori differences in volatility without controlling for further explanatory variables and differences in residuals after controlling for explanatory variables. The residuals of the system GMM estimation are obtained by subtracting the fitted values from the actual volatility values. From this, high intervention countries have lower volatility than countries without intervention before controlling for observable counterfactuals. With regard to the trade regime, most importers exhibit lower volatility as compared to exporters and trade-switchers but the average volatility is higher for importers than for non-importers, indicating that some importers show very volatile prices. The finding that importers have lower volatility is unambiguous and even more pronounced when controlling for other explanatory variables.

[Table 10 here]

Yet, mean comparison alone is not sufficient to conclude on these differences. Causality is established only when the effect is properly identified. Following the two-step estimation procedure described above, the estimation requires relevant instruments that are not correlated with the country-crop fixed effects. As possible instruments geographical variables are discussed in the literature (Cinyabuguma and Putterman, 2011). On the other hand, it is also possible that geographical characteristics implicitly determine parts of the fixed effect through agro-ecological country characteristics.

Three external instruments for high intervention are identified: per capita gdp, financial freedom, and the share of rural population.[17] It is assumed that they are not correlated with the country-crop fixed effect, but strongly correlated with the endogenous variable.[18] The relevance of the instruments is revealed by the first stage of the 2SLS regression in which the endogenous variable is regressed on its instruments. The results are presented in Table 11.

[Table 11 here]

Table 12 shows the results of the second stage. Geographical variables are included and treated as exogenous in specifications (3)-(5). But results change when they are also instrumentalized by the available instruments as in specifications (6)-(8). For the sake of comparison, specification (1) presents a simple OLS regression. A conclusive assessment of the impact of geographical variables is not feasible. The coefficient for high intervention is positive in each specification with values between 0.1 to 0.6 which is equivalent to a marginal effect between 10 and 80 percent.[19] Significance at usual levels of significance is only found in specifications with an exogenous treatment of geographical dummies.[20]

[Table 12 here]

More importantly, no evidence can be found that intervention is associated with lower price volatility. This finding indicates that stocks decrease volatility rather than market intervention which is consistent with empirical evidence that market liberalization, implying the absence of public storage or similar intervention tools, reduces price volatility (Shively, 1996; Chavas and Kim, 2006). One

[17]Per capita gdp and share of rural population are part of the WDI. Financial freedom is an indicator generated by the Fraser Institute.

[18]An instrument is always disputable. The correlation between residuals and instruments was tested and found to be -0.0066, -0.0495, and 0.0143, for gdp financial freedom, and share of rural population, respectively. Nevertheless, the instruments can be correlated with the fixed effects. One can only argue that inherent or natural volatility is independent from the instruments, instead it is rather correlated with geographical and climate conditions.

[19]In a semi-log functional for the marginal effect of a dummy variable is equal to $e^{\beta} - 1$.

[20]But estimates are significant at 15 percent in specification (1)(7)(8).

important explanation of this finding refers to the unpredictability of interventionist policy actions (Maitre d'Hotel et al., 2012; Gouel, 2013b). On the other hand, positive effects on the level of stocks through public storage need to be considered and weighed against against the costs of intervention. A possibility could be to implement market friendly policies that encourage private storage without creating additional risk for private businesses.

External instruments could be found only for high intervention. GDP, financial freedom, and share of rural population are not relevant to determine the trade regime. Thus, the discussion needs to be based on Table 10. But differences are also conclusive. Importers exhibit lower intra-year price volatility since supply is less concentrated within the year due to continuous imports. In contrast, exporters and trade-switchers mostly rely on seasonal supply which leads to strong intra-year price variation.

6. Conclusion

This paper discusses the determinants of food price volatility and fills a gap in the literature with respect to the empirical evidence from developing countries. The study develops a stylized theoretical model which is used to design the empirical analysis with respect to transaction costs as well as trade and storage policies also accounting for distinct trade regimes. We employ a comprehensive data set with great country coverage across Africa, Asia, and Latin America.

The empirical model chosen is a dynamic panel estimated by system GMM. The significant coefficient of lagged price volatility confirms the choice of the model to account for persistence of volatility. A great number of instruments can lead to an overidentification of endogenous variables and distort common test statistics. For this reason, the number of instruments was limited and the exclusion restriction was successfully accepted.

The regression results support evidence that international price volatility strongly influences domestic volatility. The estimate is in line with existing studies which use a similar approach (Lee and Park, 2013; Pierre et al., 2014), but do not account for heterogeneity across countries. Furthermore, high transaction costs, as consequence of poor institutional quality of agricultural markets, are positively associated price instability. Among supply and demand drivers, stocks and change in production significantly impact on volatility. An increase in the stocks-to-use ratio by one percent reduces price variability by 2.5 percent. The effect of production is weak and appears to be less robust across specifications.

Most insightful are the findings with respect to trade policies and regional integration. Using a unique data set on bilateral trade agreements, regional trade appears to have a dominant role in stabilizing national food prices across all types of countries. This contributes to the literature that emphasizes the positive effect of regional integration on trade flows and trade policy volatility (Cadot et al., 2009; Sun and Reed, 2010; Mujahid and Kalkuhl, 2015).

Distinguishing by types of country provides striking results in multiple ways. First, volatility spillovers from international to domestic markets are almost twice as large for importers as compared to exporters and trade-switchers. Second, insulation policies are found to be a successful price stabilization tool not only for large exporting countries, but also for regional traders. Third, transaction costs are particularly important in countries that are hardly involved in international trade. The price stabilizing effect of stocks is notably high in importing countries. Last, market forces, such as supply and demand, exhibit less impact on price volatility in countries that are characterized by public price stabilization programs. Using a two-step estimation procedure to properly identify the effect of high public intervention, no positive effect on market stability is established.

Our analysis gives valuable insights in the effectiveness of policies to reduce domestic volatility. It does not, however, assess the costs and the benefits of these policies which need a broader consideration of fiscal costs, welfare benefits from stabilization as well as potential efficiency losses due to high state-intervention. The most important policy implications refer to the role of trade for domestic price stability: trade and improved quality of market institutions – the latter providing an important determinant for the feasibility and extent of trade through transaction costs – provide an important tool to moderate domestic supply and demand shocks. Admittedly, it makes a country simultaneously prone to international price risks. Over long time periods, international markets are less volatile than in most developing countries (Kornher, 2014) and importers exhibit lower price volatility than non-importers (Table 10). In rare events of excessive price spikes at international markets, policy makers are tempted to use anti-cyclical trade policy to insulate domestic price increases at the expense of their trading partners. Regional trade agreements provide a vehicle to stabilize regional markets and to reduce domestic volatility substantially. Hence, recent developments to create or enhance regional trade in Asia or Africa provide a promising approach to reduce food price volatility in these countries without additional market distortions.

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Appendix

Proof of proposition 2

Using the linear storage rule

$$S_{t+1} = \gamma(Q_t + S_t) \tag{18}$$

gives $\Delta S_t = S_{t+1} - S_t = (\gamma - 1)S_t + \gamma Q_t$. With $X_t = Q_t - \Delta S_t = (1-\gamma)(Q_t + S_t)$ we obtain

$$Var(X_t) = (1-\gamma)^2(Var(Q_t) + Var(S_t)) \tag{19}$$

because $Cov(Q_t, S_t) = 0$ (Q_t is i.i.d. and S_t depends only on past values of Q_t and S_t). Calculating the variance of (18), we get $Var(S_t) = \gamma^2(Var(Q_{t-1}) + Var(S_{t-1}))$. With $Var(S_t) = Var(S_{t-1})$ for large t and Q_t i.i.d., we obtain $Var(S_t) = \gamma^2/(1-\gamma^2)Var(Q_t)$. Substituting this into (19) gives:

$$Var(X_t) = \frac{1-\gamma}{1+\gamma}Var(Q_t) = \tilde{\psi}(\gamma)Var(Q_t) \tag{20}$$

with $\tilde{\psi}(\gamma) = (1-\gamma)(1+\gamma)$. Using again (18) and $E[S_t] = E[S_{t+1}]$ for large t, we find $E[S_t] = \gamma/(1-\gamma)E[Q_t]$ and, thus, for the mean stock-to use ratio $\varsigma = E[S_t]/E[Q_t] = \gamma/(1-\gamma)$ with $\partial\varsigma/\partial\gamma > 0$. As $\partial\tilde{\psi}(\gamma)/\partial\gamma < 0$, we can rewrite (20) as $Var(X_t) = \psi(\varsigma)Var(Q_t)$ with $d\psi(\varsigma)/d\varsigma = \frac{\partial\tilde{\psi}(\gamma)/\partial\gamma}{\partial\varsigma/\partial\gamma} < 0$.

Calculating the coefficient of variation of X_t, we get with (20)

$$CV(X_t) = \frac{\sqrt{Var(X_t)}}{E[X_t]} = \frac{\sqrt{\psi(\varsigma)Var(Q_t)}}{(\varsigma+1)E[Q_t]} = \frac{\sqrt{\psi(\varsigma)}}{(\varsigma+1)}CV(Q_t) \tag{21}$$

with $dCV(X_t)/d\varsigma < 0$.

q.e.d.

Tables

Table 1: Description of variables

Parameter in theoretical model	Impact on Variance	Impact on Coefficient of Variation	Associated variable in regression
Mean transaction costs			transaction costs, WGI
Permanent importer	0	–	
Permanent exporter	0	+	
Trade switcher...			
...with low domestic volatility †	–		
...with high domestic volatility †	+		
No-trader	0	0	
International volatility			vol int price
Permanent importer	+	+	
Permanent exporter	+	++	
No-trader	0	0	
Stock-to-use ratio			stocks, high intervention
Permanent importer or exporter	0	0	
No-trader	–	–	
Anticyclical domestic trade policy			
Permanent importer	–	–	
Permanent exporter	–	–	insulation
No-trader	0	0	
Anticyclical trade policy of trade partners			reg trade
Permanent importer	+	+	int exp res.
Permanent exporter	+	+	
No-trader	0	0	
Domestic income shocks			M1, vol exchange rate
Permanent importer or exporter	0	0	
No-trader	+		
Domestic production shocks			production
Permanent importer or exporter	0	0	
No-trader	+		

Note: Signs hold for small countries (no effect on global prices assumed). †'domestic volatility' is determined by variability of domestic production and domestic stock-to-use ratios in the no-trade regime. The impact on trade switcher is in most cases unclear.

Table 2: Description of variables

Name	Description	Source
Dependent variable		
vol dom price	volatility of domestic commodity prices †	ZEF Commodity
L.vol dom price	lagged volatility of domestic commodity prices †	Price Database
Anti-cyclical trade policies		
insulation	export restrictions by home country	UN Comtrade
int exp res.	export restrictions by main trading partners	UN Comtrade
reg trade	share of trade with RTA partners	UN Comtrade
Storage policies		
stocks	annual beginning stock-to-use ratio	FAO CBS
high intervention	dummy equals 1 if country i runs influential public stockholding	desk research
Controls		
vol int price	weighed international export prices †	IGC
vol exchange rate	LCU/USD exchange rate †	IMF
production	relative annual production	FAO CBS
M1	average annual growth rate in money supply	WDI
WGI	Kaufmann's World Governance Indicator	WGI
transaction costs	measure for market performance	ITU, WDI, Fraser Institute
Country type		
importer	dummy equals 1 if country i is an importer of commodity j	FAO GIEWS
exporter	dummy equals 1 if country i is an exporter of commodity j	FAO GIEWS
non-importer	dummy equals 1 if country i is not an importer of commodity j	FAO GIEWS
trade switcher	dummy equals 1 if country i is neither importer nor exporter	FAO GIEWS

Note: †Measured as standard deviation of log returns.

Table 3: Country classification

	countries	N
importers	Afghanistan[bd], Armenia[d], Azerbaijan[d], Bangladesh[d], Benin[b], Bhutan[bd], Bolivia[d], Brazil[d], Burkina Faso[b], Burundi[ad], Cameroon[bd], Cape Verde[ab], Chad[b], Colombia[a], Congo, D.R.[bd], Costa Rica[abd], Cote d'Ivoire[b], Dem. Republic[a], Djibouti[bd], Dominican Republic[a], Equador[a], Egypt[d], El Salvador[abd], Ethiopia[d], Gambia, the[b], Gabon[ab], Georgia[d], Ghana[b], Guinea [b], Guatemala[abd], Haiti[bd], Honduras[ab], Indonesia[d], Kenya[cd], Kyrgyzstan[bd], Mauritania[ab], Mexico[ab], Malawi[b], Mauritania[abd], Mongolia[bd], Mozambique[b], Namibia[a], Nicaragua[ab], Niger[abd], Nigeria[bd], Panama[ab], Peru[ad], Russia[b], Rwanda[ab], Senegal[b], Somalia[abc], Sudan[d], Sri Lanka[d], Togo[b], Tajikistan[d], Tunisia[bd], Turkey[b], South Africa[bd], Zambia[b], Zimbabwe[ad]	92
trade-switchers	Burundi[bc], Benin[c], Burkina Faso[ce], Bangladesh[b], Bolivia[ab], Brazil[b], China[bd], Cote d'Ivoire[a], Congo, D.R[a], Colombia[b], Dominican Republic[b], Egypt[b], Ethiopia[ace], Ghana[ace], Haiti[ac], Indonesia[b], India[d], Kenya[ae], Lao, PDR[b], Sri Lanka[b], Moldova[ad], Madagascar[b], Mali[ab], Mozambique[a], Mauritania[c], Malawi[a], Namibia[e], Niger[ce], Nigeria[a], Nepal[bd], Pakistan[d], Peru[b], the Philippines[ab], Sudan[ce], Senegal[ce], El Salvador[c], Chad[a], Togo[c], Tajikistan[ab], Turkey[d], Tanzania[abc], Uganda[ce], South Africa[a], Zambia[a]	66
exporters	Argentina[ad], Benin[a], Burkina Faso[a], Cameroon[a], India[b], Cambodia[b], Mali[ce], Myanmar[b], Nigeria[c], Pakistan[b], Russia[d], Chad[e], Togo[a], Thailand[b], Uganda[a], Uruguay[bd], Vietnam[b]	21
high intervention	Burkina Faso, Bangladesh, Brazil, China, Egypt, Ethiopia, India, Indonesia, Kenya, Cambodia, Mali, Myanmar, Malawi, Nepal, Pakistan, Philippines, Russia, Thailand, Turkey, Vietnam, Zambia, Zimbabwe	47

Note:[a]maize,[b]rice,[c]sorghum,[d]wheat,[e]millet; non-importers are exporters plus trade-switchers.

Table 4: Number of groups in sample

	maize	rice	sorghum	wheat	millet	Total
Africa	26	29	17	16	11	99
Asia	2	19	-	16	-	37
Latin America	14	14	2	9	-	39
Europe	1	1	-	2	-	4
landlocked	14	17	7	15	6	59
importer	19	38	2	33	0	92
exporter	6	7	3	3	2	21
non-importer	24	25	17	10	11	87
trade switcher	18	18	14	7	9	66
high intervention	7	19	4	13	4	47
All	43	63	19	43	11	179

Table 5: Correlation of variables in model

	vol dom price	L.vol dom price	vol int price	production	stocks	insulation	int export res.	reg trade	M1	vol exchange rate	transaction costs	WGI
vol dom price	1											
L.vol dom price	0.6158	1										
vol int price	0.2576	0.1945	1									
production	0.0361	0.0377	0.0315	1								
stocks	-0.0927	-0.0643	0.0464	-0.0578	1							
insulation	-0.0464	-0.017	-0.0545	-0.0119	-0.0843	1						
int export res.	0.1499	0.1443	0.1771	0.0413	0.0061	-0.0142	1					
reg trade	-0.1097	-0.0973	-0.0502	-0.0067	-0.0832	-0.0315	-0.0385	1				
M1	0.167	0.1634	0.0509	0.0428	-0.0202	0.0109	0.0579	-0.0665	1			
vol exchange rate	0.0482	0.0646	0.1396	0.0294	-0.0663	-0.0013	0.0616	-0.0085	-0.038	1		
transaction costs	0.2968	0.2692	-0.0276	-0.0075	-0.2107	0.0406	0.1725	-0.1086	0.037	-0.0519	1	
WGI	-0.2259	-0.1819	-0.0553	0.0185	0.0957	0.0937	-0.1408	0.2308	-0.077	0.0965	-0.3969	1

Table 6: System GMM results

	(1)	(2)	(3)	(4)
L.vol dom price	0.262***	0.357***	0.355***	0.328***
	(5.17)	(6.35)	(6.19)	(6.30)
vol int price	0.291***	0.280***	0.271***	0.354***
	(6.18)	(5.93)	(5.84)	(6.83)
production	-0.0757	-0.202**	-0.176*	-0.0867
	(-1.03)	(-2.20)	(-1.89)	(-1.00)
stocks	-1.200	-2.544***	-2.575***	-1.326*
	(-1.65)	(-3.66)	(-3.56)	(-1.92)
insulation	-0.417**	-0.402*	-0.409*	
	(-2.10)	(-1.66)	(-1.81)	
int export res.	0.0566	0.240*	0.238*	
	(0.41)	(1.70)	(1.70)	
reg trade	-0.858***	-0.880***	-0.926***	
	(-3.94)	(-3.66)	(-3.66)	
M1	0.141	0.327*	0.302*	0.305
	(0.61)	(1.78)	(1.88)	(1.55)
vol exchange rate	0.0169	0.0301	0.0380	0.0397
	(0.54)	(1.14)	(1.59)	(1.23)
transaction costs	0.956***			1.23***
	(2.77)			(3.74)
WGI	0.115	0.0617		-0.0104
	(1.18)	(0.61)		(-0.14)
N	996	1270	1323	1020
N groups	140	155	157	144
N instruments	67	72	72	46
AR(2)	0.397	0.994	0.828	0.736
Sargan Test	0.171	0.015	0.388	0.000
Hansen Test	0.664	0.428	0.570	0.022
Diff.Sargan(gmm)	0.792	0.601	0.124	0.164

t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Note: stocks, reg trade, and insulation are treated as endogenous, production is considered to be predetermined. Regressions use orthogonal deviations instead of first differences as instruments. Years are included as exogenous instruments.

Table 7: Relative importance of explanatory variables

	short term		long term	
	min	max	min	max
vol int price	17%	22%	25%	32%
production	-2%	-7%	-4%	-10%
stocks	-22%	-48%	-33%	-70%
insulation	-14%	-15%	-21%	-22%
int export res.	1%	4%	1%	5%
reg trade	-35%	-38%	-51%	-55%
M1	2%	5%	3%	7%
transaction costs	17%	22%	25%	32%

Note: The autoregressive term is averaged across the four specifications which yields $\beta = 0.3135$. Min and max represent minimum and maxium value of specifications shown in Table 6.

Table 8: Regression results by trade regime

	importer		non-importer		trade switcher	
	(1)	(2)	(3)	(4)	(5)	(6)
L.vol dom price	0.244**	0.340***	0.215***	0.352***	0.232***	0.386***
	(2.47)	(3.00)	(3.60)	(4.97)	(3.54)	(5.59)
vol int price	0.437***	0.420***	0.268***	0.271***	0.261***	0.270***
	(4.43)	(4.91)	(6.72)	(5.50)	(4.45)	(4.81)
production	-0.0817	-0.113	0.0529	-0.0805	0.0203	-0.0269
	(-1.00)	(-1.27)	(0.43)	(-0.65)	(0.11)	(-0.20)
stocks	-2.091	-3.497**	-0.623*	-1.530***	-0.832	-1.599**
	(-1.38)	(-2.49)	(-1.78)	(-3.31)	(-0.76)	(-2.61)
insulation			-0.413**	-0.370*	-0.393*	-0.459*
			(-2.24)	(-1.97)	(-1.70)	(-1.95)
int expo res.	-0.213	-0.0286			-0.105	0.0475
	(-0.37)	(-0.06)			(-0.83)	(0.29)
reg trade	-0.763***	-0.713*	-0.797***	-0.631***	-0.503***	-0.737***
	(-3.09)	(-1.87)	(-4.41)	(-2.68)	(-2.86)	(-3.08)
M1	0.421	0.504	-0.249	0.0367	0.108	0.145
	(1.10)	(1.46)	(-1.11)	(0.19)	(0.35)	(0.77)
vol exchange r.	0.000890	0.0129	0.0571*	0.0504	0.0588	0.0340
	(0.02)	(0.38)	(1.95)	(1.50)	(1.52)	(1.17)
transaction c.	0.844*		0.978***		1.44***	
	(1.75)		(3.42)		(3.30)	
WGI	-0.0973	-0.297	0.224**	0.183*	0.0833	0.104
	(-0.47)	(-1.43)	(2.17)	(1.75)	(0.70)	(0.84)
N	429	561	567	709	420	533
N groups	65	73	75	82	55	81
N instruments	57	61	66	71	67	72
AR (2)	0.346	0.061	0.091	0.178	0.149	0.224
Sargan Test	0.139	0.091	0.082	0.003	0.364	0.001
Hansen Test	0.364	0.201	0.724	0.428	0.894	0.837
Diff.Sargan(gmm)	0.797	0.610	0.939	0.746	0.979	0.990

t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Note: stocks, reg trade, and insulation are treated as endogenous, production is considered to be predetermined. Regressions use orthogonal deviations instead of first differences as instruments. Years are included as exogenous instruments.

Table 9: Regression results by level of public intervention

	low intervention		high intervention	
	(1)	(2)	(3)	(4)
L.vol dom price	0.228***	0.370***	0.356***	0.439***
	(3.29)	(4.97)	(3.35)	(4.17)
vol int price	0.351***	0.293***	0.281***	0.283***
	(4.78)	(4.12)	(6.95)	(3.88)
production	-0.0712	-0.137	0.0144	0.0159
	(-1.16)	(-1.43)	(0.08)	(0.09)
stocks	-0.781	-1.982**	-0.556	-1.252*
	(-1.31)	(-2.42)	(-0.84)	(-1.68)
insulation	-0.620***	-0.526*	-0.217	-0.266
	(-2.66)	(-1.88)	(-1.41)	(-1.16)
int exp res	0.146	0.338*	-0.235	-0.00492
	(0.74)	(1.95)	(-0.86)	(-0.01)
reg trade	-0.741***	-1.049***	-0.639**	-0.607**
	(-3.18)	(-5.04)	(-2.03)	(-2.30)
M1	0.354	0.449**	-1.14*	-0.224
	(1.39)	(2.15)	(-1.72)	(-0.71)
vol exchange rate	0.0257	0.0309	0.00479	0.0124
	(0.59)	(0.80)	(0.16)	(0.26)
transaction costs	1.19***		0.723**	
	(3.04)		(2.64)	
WGI	0.00500	-0.0178	0.210	0.224
	(0.04)	(-0.17)	(1.32)	(0.89)
N	673	876	323	394
N groups	75	82	55	61
N instruments	66	71	67	72
AR(2)	0.091	0.178	0.149	0.224
Sargan Test	0.082	0.003	0.364	0.001
Hansen Test	0.724	0.428	0.894	0.897
Diff.Sargan(gmm)	0.939	0.746	0.977	0.990

t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Note: stocks, reg trade, and insulation are treated as endogenous, production is considered to be predetermined. Regressions use orthogonal deviations instead of first differences as instruments. Years are included as exogenous instruments.

Table 10: Volatility by country characteristics

	sd return				u_{ijt}			
	yes		no		yes		no	
	mean	median	mean	median	mean	median	mean	median
high interv.	6.0%	4.1%	8.9%	6.0%	-0.022	-0.007	-0.050	-0.029
importer	8.3%	4.6%	7.9%	6.4%	-0.189	-0.180	0.071	0.058
exporter	8.5%	6.6%	8.1%	5.4%	0.167	0.138	-0.077	-0.067
trade-swit.	7.7%	6.2%	8.3%	4.9%	0.037	0.029	-0.098	-0.085

Note: Residuals are obtained from the full regression model reported in Table 6 column (1). The standard deviation of returns was logarithmized for the regression.

Table 11: First stage regression results for IV estimation

	(1)
	high intervention
per capita gdp	0.0000503***
	(8.49)
financial freedom	-0.00498***
	(-6.48)
share of rural population	0.00872***
	(11.13)
_cons	-0.0770
	(-1.05)
N	1664

t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Results for two step IV estimation on residuals for high intervention

	OLS	2SLS - IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
africa	0.129*			0.0706			-0.0870	
	(1.78)			(1.06)			(-0.31)	
landlocked	-0.0536		-0.148**	-0.0818	-0.0545	-0.0277	-0.0410	-0.0456
	(-0.90)		(-2.01)	(-1.31)	(-0.93)	(-0.07)	(-0.11)	(-0.13)
latin	0.141				0.156			0.104
	(1.62)				(1.62)			(0.31)
high_intervention	0.0902	0.208	0.602*	0.191	0.516*	0.0373	0.382	0.453
	(1.54)	(1.30)	(1.93)	(1.27)	(1.96)	(0.03)	(1.57)	(1.49)
asia			-0.435**			0.490		
			(-2.32)			(0.31)		
_cons	-0.149**	-0.105*	-0.0892	-0.104	-0.209**	-0.124	-0.0859	-0.181
	(-2.14)	(-1.83)	(-1.40)	(-1.35)	(-2.02)	(-1.29)	(-0.92)	(-0.71)
N	892	991	888	888	888	888	888	888
N instruments	-	3	3	3	3	3	3	3
Underidentification Test	-	0.0000	0.0000	0.0000	0.0000	0.1359	0.0000	0.0000
Sargan Test	-	0.9672	0.5113	0.3863	0.8035	-	-	-

t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Note: Residuals are obtained from the full regression model reported in Table 6 column (1). Columns (3),(4), and (5) treat geographical variables as exogenous to the fixed effect. (6),(7), and (8) treat them as endogenous. All regressions apply robust standard errors.

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FOODSECURE

FOR POLICIES THAT MATTER

The FOODSECURE project in a nutshell

Title	FOODSECURE – Exploring the future of global food and nutrition security
Funding scheme	7th framework program, theme Socioeconomic sciences and the humanities
Type of project	Large-scale collaborative research project
Project Coordinator	Hans van Meijl (LEI Wageningen UR)
Scientific Coordinator	Joachim von Braun (ZEF, Center for Development Research, University of Bonn)
Duration	2012 - 2017 (60 months)
Short description	In the future, excessively high food prices may frequently reoccur, with severe impact on the poor and vulnerable. Given the long lead time of the social and technological solutions for a more stable food system, a long-term policy framework on global food and nutrition security is urgently needed. The general objective of the FOODSECURE project is to design effective and sustainable strategies for assessing and addressing the challenges of food and nutrition security. FOODSECURE provides a set of analytical instruments to experiment, analyse, and coordinate the effects of short and long term policies related to achieving food security. FOODSECURE impact lies in the knowledge base to support EU policy makers and other stakeholders in the design of consistent, coherent, long-term policy strategies for improving food and nutrition security.
EU Contribution	€ 8 million
Research team	19 partners from 13 countries

FOODSECURE project office
LEI Wageningen UR (University & Research centre)
Alexanderveld 5
The Hague, Netherlands

T +31 (0) 70 3358370
F +31 (0) 70 3358196
E foodsecure@wur.nl
I www.foodscecure.eu

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SEVENTH FRAMEWORK PROGRAMME