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Trading-off volatility and distortions? Food policy during price spikes

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ABSTRACT

This paper analyses the trade-off between price distortions and reduced volatility when governments intervened in agricultural and food markets during the recent food price spikes. We develop a model to derive how much distortions a government would introduce when it cares about price stability in a situation with limited policy options. We show that there is a trade-off and identify the optimal combination of distortions and stability for given international price shocks and interest groups preferences for stability. We compare these theoretical findings with empirical indicators on actual government interventions in staple food markets. We find that several countries have been able to reduce (short run) price volatility in the domestic markets while at the same time allowing structural (medium and long term) price changes to pass through to producers and consumers. However, this is not the general case. For many countries, even when explicitly taking into account the trade-off (and the benefits of reducing volatility) government policies appear far removed from the optimal trade-off and there appears to be much room for policy improvement.

Introduction

The recent food price crisis has reopened the debate on the role of price policy interventions in agricultural markets (Timmer, 2010). The question that is often raised is to what extent one should rely on the international market or favor intervention to satisfy a country's food security objectives (Timmer, 1989, 2010, 2014).[1] One of the arguments in favor of policy interventions is that price volatility is undesirable as it causes inefficiencies and potentially reduces economic growth especially in the absence of insurance and credit markets (Dawe, 2001; Dawe and Timmer, 2012; Gouel, 2013). This is because unexpected price changes make it difficult for consumers and producers to make optimal decisions and it reduces their confidence in the market and investment levels. A typical example is the problem of farmers to plan their output if prices are volatile and uncertainty is large.

But food price volatility is not only an issue for producers and consumers but also for governments. As is well known, all over the world, politicians and governments are regularly under pressure from agricultural producers and food consumers to intervene in agricultural and food markets. In the longer run, this has led to a series of "patterns" of policy distortions in agricultural and food markets (Krueger et al., 1991; Anderson et al., 2013b). In recent years, many governments have intervened in an attempt to reduce short run price fluctuations with global food price spikes (Barrett, 2014; Naylor, 2014; Pinstrup-Andersen, 2014).[2] During the food price crisis many countries used trade policy measures to prevent price transmission from the international to the domestic market. Demeke et al. (2009) have shown that in 68 out of the 81 investigated countries governments used trade measures to counter price instability and to insulate the domestic market from the international price spikes. These government interventions have often been ad hoc – resembling what Swinnen (1996) called "fire brigade policy-making" when governments are confronted with shocks in the external environment.

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[1] The volatility issue is related, but still distinct from what Timmer et al. (1983) refer to as the "food policy dilemma". This dilemma reflects the conflict between the interests of the consumers and producers in the short and in the long run. In the short run, consumers prefer to have low food prices. But low food prices are detrimental for farmers and agricultural growth and will be detrimental for consumers as well in the longer run. Besides these welfare costs for consumers and producers, government interventions might also create other costs. For example, trade policies have been showed to increase disruptions in the international markets, to destabilize price expectations and to create financial costs (see Dawe and Timmer, 2012 for a more extensive discussion).

[2] Government interventions to counter market fluctuations are not unusual. To the contrary, they are a key 'stylized fact' of agricultural and food policies (Anderson et al., 2013b) and there is much evidence to document this for other periods and regions (e.g. Gardner, 1987; Swinnen, 2009).

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Many economists and policy advisors have been critical of these attempts, criticizing governments for (a) being ineffective, (b) causing distortions in the economy, and (c) reinforcing price fluctuations, etc. (Anderson et al., 2013a; Ivanic and Martin, 2014). However, at the same time many economists and advisors point at the importance of reducing price volatility based on efficiency gains (FAO, 2011; FAO and OECD, 2011; Prakash, 2011; World Bank, 2012). In fact, in environments with important market imperfections (e.g. in insurance and other factor markets) government interventions that reduce price instability could be efficiency enhancing. (After all that is why one uses various insurance-type instruments in private markets.)

Yet, the basic economic model with static supply and demand equations and perfect markets is not very adequate to capture and measure distortions and inefficiencies in such conditions of market imperfections and volatility.[3] In fact, studies which have explicitly modeled the effects of price volatility on consumer and producer welfare yield more nuanced conclusions than are most often expressed in the public debate. The extent to which consumers benefit from price stabilization is not obvious ex ante. Newbery and Stiglitz (1981) and Turnovsky et al. (1980) have shown that food price volatility fluctuations around the mean may actually benefit consumers if the price elasticity of demand is high, if their budget spend on food is rather small and/or if they are risk loving – a generalization of a basic argument made by Waugh (1944). Poor people in developing countries who spend a large amount of their budget on food and who are risk averse will be likely to benefit from stable prices. Producers, on the other hand, use less inputs and have less profits if the prices of the agricultural products are volatile and uncertain (Sandmo, 1971) – although they may also have positive effects from price volatility (Oi, 1961). In developing countries, however, many consumers in rural areas are at the same time also producing food. For these households, Barrett (1996) and Myers (2006) have shown that the impact of price stability on their welfare depends on their marketable surplus, risk aversion and income and price elasticities. If the household is a net-seller of agricultural products and is risk averse, the household is more likely to benefit from price stabilization.

The question we will address is to what extent governments have traded off price distortions for reduced volatility in intervening in agricultural and food markets taking into account these complex impacts of price interventions. In this paper, we model this trade-off and show how much distortions a welfare maximizing government would introduce when it cares about stability (i.e. if it wants to limit price volatility for domestic producers and consumers) in a situation with limited policy options and compare the theoretical findings with empirical evidence.[4]

The key findings of our paper are (a) that several countries have been able to reduce (short run) price volatility in the domestic markets while at the same time allowing structural (medium and long term) price changes to pass through to producers and consumers; (b) that there is a trade-off between volatility and distortions in situations with limited policy options for welfare maximizing governments; and (c) that even when explicitly taking into account this trade-off (and the benefits of reducing volatility) that many countries (governments) are far removed from the optimal distortion–volatility (DV) combination and that there is, thus, considerable room for policy improvement.

The paper is organized as follows. Section 'Trading-off volatility and distortions: Two examples' presents two cases of important staple food markets where governments have significantly reduced (short run) price volatility in the domestic markets while at the same time allowing structural (medium and long term) price changes to pass through. Section 'Conceptual framework' develops a conceptual model of the trade-off between distortions and volatility for a welfare maximizing government and links the theoretical framework to empirical indicators. Section 'Empirical indicators of the DV trade-off' presents empirical indicators of the distortions–volatility (DV) trade-off for staple food markets and develops three different indicators to measure "inefficiency". Section 'DV trade-off and inefficiency in staple food markets in developing and emerging countries' presents the empirical results on distortions in staple food markets in developing and emerging countries. Section 'Conclusion and future extensions' concludes.

Trading-off volatility and distortions: Two examples

To start, we will illustrate the key issue with two cases of government interventions in important food markets over the past decade. The first example is that of rice markets and prices in China; the second example is that of wheat markets and prices in Pakistan.

Fig. 1 illustrates the evolution of rice prices on global markets and in China. The graph illustrates two important observations. First, rice prices in China have been much less volatile than on global markets. The sharp global price fluctuations in 2008–2010 have not occurred in China. This was due to important policy interventions by the Chinese government, including trade policy measures and the strategic use of rice stocks (Yang et al., 2008).

The second observation is that, despite stabilizing prices, the Chinese government allowed rice prices to increase over the 2006–2013 period, thus passing on (apparently) structural changes in global rice markets (and food markets more general) to Chinese consumers and producers. Rice prices in China were very close to international prices both at the start and at the end of the 2006–2013 period. In fact, prices were close to the international prices throughout 2006 and 2007 and again since 2011. Hence they diverged only during the years of largest volatility on international markets: 2008–2010.

Fig. 2 illustrates wheat prices in Pakistan and on global markets. The story here is very similar. Domestic wheat markets have been much less volatile than wheat prices on international markets, due to extensive interventions of the Pakistan government in wheat markets and trade (Dorosh and Salam, 2008; Briones Alonso and Swinnen, forthcoming). Yet at the same time, the government has allowed structural price changes to be transmitted to its domestic producers and consumers. Also here the domestic prices in Pakistan were very close to international prices both at the beginning and at the end of the 2006–2013 period, and more precisely until mid-2007 and again since 2011. As with rice, in China, wheat prices in Pakistan diverged strongly from international prices only during the most volatile price period: from mid-2007 till end of 2010.

In summary, in their interventions in their most important staple food markets both the Chinese and Pakistani governments appear to have allowed (long run) structural changes in the global food markets to be transmitted to their producers and consumers – avoiding long run distortions – while stabilizing the markets in the presence of large (short run) global price volatility – thus (possibly) avoiding short run inefficiencies due to volatility and uncertainty.

[3] Of course, the more fundamental issue is one of the policy instrument choice and the (transaction) costs and capacity of governments to implement certain policy instruments.

[4] Barrett (1999) discusses the political economy of trade-offs between food price levels and price volatility. The author shows how food price policies are determined by heterogeneous preferences across households which are related to average price levels and food price variability. Our paper is related but distinct from Barrett (1999) as he links the coalition alignment and support for food policies with the endowments and preferences of the households.

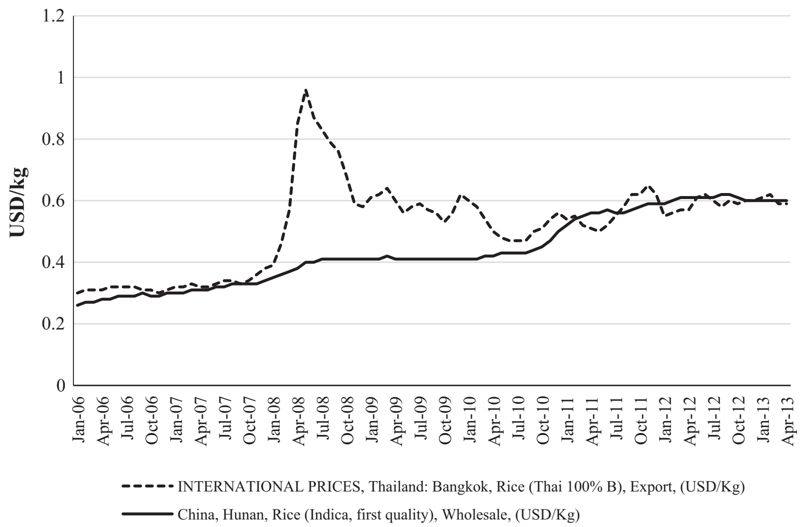

Fig. 1. Rice markets and prices in China (2006–2013).

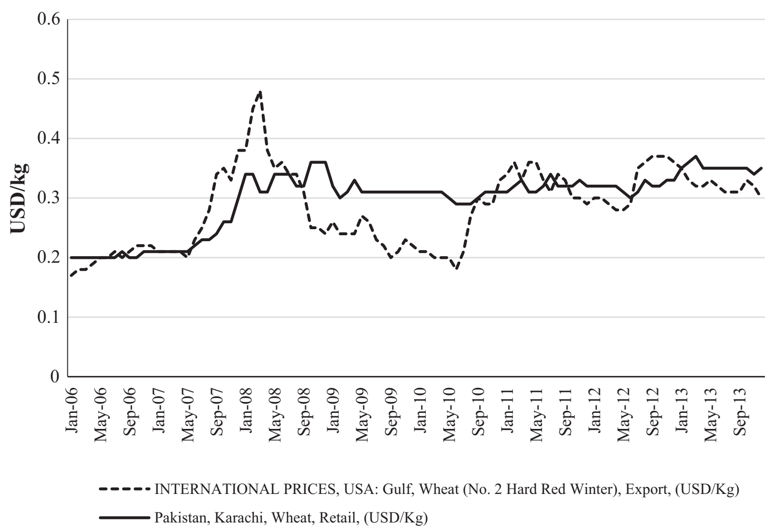

Fig. 2. Wheat markets and prices in Pakistan (2006–2013).

An obvious question is whether these two cases are exceptional cases or that they represent a larger pattern of government interventions in staple food crops in emerging and developing countries.[5] In the second part of the paper we will provide evidence from more countries using quantitative indicators of price distortions and volatility. However, before turning to the empirical indicators of price distortions and volatility and before putting the Chinese – rice and Pakistan – wheat policies into a broader comparative perspective, we first develop a conceptual framework to interpret the empirical observations.

Conceptual framework

Following Barrett (1996), we use a two-period model with product prices unknown when production decisions are made and with post-harvest prices announced before the consumer makes its decision. Even though consumers know the prices upfront, variations in prices may still leave consumers better or worse off than with stable commodity prices (Helms, 1985). This issue is especially important in the case where consumers are not able to fully insure themselves against variations in utility. As is standard in the literature, the impact of a price stabilization policy is assessed using expected utility since the policy decision is made before the realization of the price is known and the impact on consumer welfare is therefore done ex-ante (see e.g. Newbery and Stiglitz, 1981; Turnovsky et al., 1980; Helms, 1985; Barrett, 1996; Bellemare et al., 2013; Gouel and Jean, 2015).

Impact on the consumer

Assume that consumers derive their utility from the consumption two goods: food (F) and a composite index of nonfoods (N). A consumer's utility function $u^C(\cdot)$ is assumed to be concave in each individual argument. The consumer will choose its preferred consumption bundle according to the following expected utility maximization problem:

[5] Gulati and Dutta (2010) have shown that India also insulated in a successful way their domestic rice market to prevent the domestic price from rising. Another example is the case of Bangladesh, where the domestic rice price was more stable than the international price during the recent food price crisis (see Saifullah, 2010). Hoang and Meyers (2015) show that also the Indonesian government successfully stabilized the rice price during the food price crisis in 2008.

$$\max_{N,F} E[u^C(N,F)] \tag{1}$$

$$\text{subject to } p^N \cdot N + p^F \cdot F \leqslant y^T \tag{2}$$

where $E[\cdot]$ the expectation parameter, p^F and p^N the prices of food and nonfood commodities, respectively, and y^T income. This maximization problem can also be represented by an indirect utility function $\upsilon^C(\cdot)$ that is homogeneous in degree 0. Since the indirect utility function is independent of the unit of measurement, we define the price of the composite index of the nonfoods as the numéraire and let the domestic price p^D represent the ratio between the price of food and nonfood commodities and y is the real income in terms of nonfood prices. The maximization problem can thus be represented as

$$\max_{p^D} E[\upsilon^C(p^D, y)] \tag{3}$$

As is standard in the literature, we use the concept of equivalent variation to quantitatively measure the consumer benefits/losses of a price stabilization policy. The equivalent variation (EV) measures the necessary compensation for the consumer if the stabilization scheme is not introduced. In other words, it represents the required change in income/cash that would bring an equivalent change in the expected utility as the change in prices resulting from the government's price stabilization policy. The equivalent variation is the solution of the following equation:

$$E[\upsilon^C(p^W, y + EV)] = E[\upsilon^C(p^D, y)] \tag{4}$$

with p^W the price without the stabilization which could also be interpreted as the international price and p^D the price set by the government. Using a second-order Taylor expansion around the mean undistorted price $\bar{p}^W$, the equivalent variation can be approximated by (see e.g. Newbery and Stiglitz, 1981; Gouel and Jean, 2015):

$$EV \cong (\bar{p}^D - \bar{p}^W)\frac{\upsilon^C_p}{\upsilon^C_y} - \frac{\upsilon^C_{pp}}{\upsilon^C_y} \cdot \frac{\Delta\sigma^2_p}{2} \tag{5}$$

with $(\bar{p}^D - \bar{p}^W)$ the change in mean price and $\Delta\sigma^2_p$ the change in variance.[6] Using Roy's identity, we replace $\left(-\frac{\upsilon^C_p}{\upsilon^C_y}\right)$ by the demand for food $D(p, y)$. Following Turnovsky et al. (1980), the Arrow–Pratt coefficient of absolute price risk aversion for the consumer $\left(\frac{\upsilon^C_{pp}}{\upsilon^C_y}\right)$ can be defined as $\frac{D(p,y)}{p}[\beta(\eta - r) - \alpha]$ with β the budget share of food in total income (with $0 \leqslant \beta \leqslant 1$), r the relative income risk aversion (with $r \geqslant 0$), and η the income elasticity of food demand ($\eta \geqslant 0$) and α the price elasticity of demand for food (with $\alpha \leqslant 0$). The equivalent variation for consumers can thus be rewritten as follows:

$$EV \cong \left[-D(\bar{p}^W) \cdot (\bar{p}^D - \bar{p}^W) + [\beta(\eta - r) - \alpha]D(\bar{p}^W)\frac{\Delta\sigma^2_p}{2\bar{p}^W}\right] \tag{6}$$

The consumer will benefit from price stabilization around the undistorted mean price when EV is positive. From Eq. (6) it is obvious that the EV is more likely to be positive and consumers are more likely to gain from price stability if the budget share of food in total income is large, the relative income risk aversion is large, and the income elasticity of food demand is small.[7] On the other hand, if the relative income risk aversion and the budget share are small, the consumer is more likely to lose from a policy intervention to stabilize food prices.

In order to analyze in a more tractable and explicit way the impact of a price deviation from the mean undistorted price $\bar{p}^W$ on consumer welfare, we rewrite the equivalent variation such that the impact of a price stabilization can be split up in the effect of a downward sloping demand curve and an additional term that corrects for the negative welfare effect of price instability. Replace α by its definition $\left(D_p(\bar{p}^W)\frac{\bar{p}^W}{D(\bar{p}^W)}\right)$ and define the consumer surplus CS as $-\int_0^{\bar{p}^W} D(p)dp$ with $CS_p = \partial CS/\partial p = -D(p)$ and $CS_{pp} = -D_p(p)$. This yields:

$$EV \cong CS_p(\bar{p}^W)(\bar{p}^D - \bar{p}^W) + CS_{pp}(\bar{p}^W)\frac{\Delta\sigma^2_p}{2} - \delta \cdot \frac{\Delta\sigma^2_p}{2} \tag{7}$$

$$\text{with } \delta = [\beta(r - \eta)]\frac{D(\bar{p}^W)}{\bar{p}^W} \tag{8}$$

The first and second term of Eq. (7) measure the positive welfare effect of price instability and the third term represents the negative effect for the consumer of price instability. δ can be interpreted as the consumer's preference for price stability due to risk aversion. When $\delta = 0$, the equivalent variation is reduced to the welfare analysis of the Marshallian consumer surplus and with a downward sloping demand curve the consumer will lose from a policy of price stabilization (Waugh, 1944). Consumers will only benefit from price stabilization if their relative risk aversion r is sufficiently high. Otherwise, price stabilization will make consumers worse off. This is also the case if the budget share of food is small or when the relative risk aversion is close to the income elasticity. In rich countries, for example, price stabilization for food staples would be unfavorable for consumers because of the low budget share (Barrett, 1996).

In order to identify the social optimum, we follow Gouel et al. (2014) in using a more specific form of the expected indirect utility of Eq. (3) which is consistent with the equivalent variation in Eq. (7).[8] More specifically, we define:

$$\upsilon^C(p^D, y) = CS(p^D) - \frac{\delta}{2}\left[(p^D - \bar{p}^W)^2\right] \tag{9}$$

The first term is the consumer surplus and the second term represents the reduction in expected utility following from a deviation of the domestic price from the mean price, which is weighted by the consumer preference for price stability (δ).[9]

Impact on the producer

Analog to the specification of the equivalent variation for consumers, we calculate the equivalent variation of producers using the Arrow–Pratt coefficient of absolute risk aversion as defined by Barrett (1996):

$$EV \cong S(\bar{p})\left[(\bar{p}^D - \bar{p}^W) + [\lambda(g - r) + \varepsilon] \cdot \frac{\Delta\sigma^2_p}{2\bar{p}^W}\right] \tag{10}$$

with $S(\bar{p})$ representing the marketed surplus, λ is a parameter measuring the share of the food crop in total income (with $0 \leqslant \lambda \leqslant 1$ and $\lambda = 1$ with monoculture), r is the relative risk aversion of the producer (with $r \geqslant 0$), and g and ε representing the income and price elasticity of the marketable surplus (with $g \leqslant 0$ and $\varepsilon \geqslant 0$). In what follows, we rewrite the equivalent variation such that the first and second term account for the impact of changing food prices

[6] $\Delta\sigma^2_p$ is defined as $E[(p^D - \bar{p}^W)^2] - E[(p^W - \bar{p}^W)^2]$.

[7] If the government sets its domestic price p^D equal to the mean price $\bar{p}^W$ than the equivalent variation reduces to $EV \cong \left[[\beta(r - \eta) + \alpha]D(\bar{p}^W)\frac{\sigma^2_{pW}}{2\bar{p}^W}\right]$.

[8] In other words, the expected second order Taylor approximation should be equal to the equivalent variation in Eq. (7).

[9] As in Eq. (7), δ is equal to $[\beta(r - \eta)]\frac{D(\bar{p}^W)}{\bar{p}^W}$. The full derivation can be obtained from the authors.

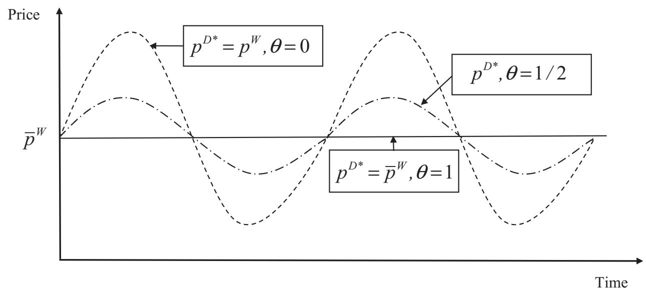

Fig. 3. Social optimum for different θ.

on the profit of the producer and the third term measures the producer's preferences for price stability:

$$EV \cong \pi_p(\bar{p}^W)(\bar{p}^D - \bar{p}^W) + \pi_{pp}(\bar{p}^W)\frac{\Delta\sigma_p^2}{2} - \tau \cdot \frac{\Delta\sigma_p^2}{2} \tag{11}$$

$$\text{with } \tau = \lambda(r - g)\frac{S(\bar{p}^W)}{\bar{p}^W} \tag{12}$$

where $\pi(\cdot)$ representing the profit of the net-producer and $\pi_p = \partial\pi/\partial p = S(p)$ and $\pi_{pp} = S_p(p)$ and τ representing the stability preference. As in the case for consumers, the EV can be positive or negative. Price stabilization will be more beneficial for producers involved in monoculture (λ higher) and/or when producers are income risk averse (r larger).

Similar as before, we use a more specific form of the general indirect utility function of producers with the specification consistent with the above defined equivalent variation (11):

$$v^P(p^D, y) = \pi(p^D) - \frac{\tau}{2}[(p^D - \bar{p}^W)^2] \tag{13}$$

Impact on the economy

Now consider a small open economy where the government can stabilize prices by intervening in domestic food markets. For simplicity we assume that the government will set the domestic price p^D (and that this is the only price that consumers and producers face) in combination with trade taxes or subsidies to sustain the price setting. For example, if the government wants to protect consumers against international food price surges, the policymakers will set the domestic price lower than the international price p^W which will be associated with export taxation (for an exporting country) or import subsidies (for an importing country). The cost related to the government intervention are the subsidies or tax revenues, T, of trade interventions and are presented by the following cost equation[10]:

$$T = (p^D - p^W)(D(p^D) - S(p^D)) \tag{14}$$

with $T > 0$ when the government imposes import or export taxes. $D(\cdot)$ and $S(\cdot)$ representing domestic demand and supply and $D(\cdot) - S(\cdot)$ the net imports. We assume that the government redistributes the revenues and taxes uniformly across the economic agents.

Social welfare is then the sum of the surplus of the different agents and the tax revenue or cost related to the government policy:

$$\max_{p^D}\left\{CS(p^D) - \frac{\delta}{2}(p^D - \bar{p}^W)^2 + \pi(p^D) - \frac{\tau}{2}(p^D - \bar{p}^W)^2 + (p^D - p^W)(D(p^D) - S(p^D))\right\} \tag{15}$$

A social welfare maximizing government will then set the optimal domestic price p^{D*} according to the following specification[11]:

$$(p^{D*} - p^W)(D'(p^{D*}) - S'(p^{D^*})) = (\delta + \tau)[(p^{D*} - \bar{p}^W)] \tag{16}$$

Balancing volatility and distortions in social welfare

As a benchmark let us first consider the optimum without volatility concerns. The optimality condition for p^{D^*}, the price which maximizes (16) when there is no volatility – or when nobody cares about volatility (i.e. when $\delta = 0$, $\tau = 0$) is:

$$(p^{D*} - p^W)(D'(p^{D*}) - S'(p^{D*})) = 0 \tag{17}$$

The difference between conditions (16) and (17) is the right hand side term of (16). Without volatility concerns the social welfare maximizing government will set the domestic price where it minimizes distortions, which are captured by the left hand side term of (16) and (17). This is at the world market price. Hence,

$$p^{D*} = p^W \tag{18}$$

However with volatility concerns there is a trade-off for the government. Only in the case that $p^W = \bar{p}^W$, i.e. when there is zero volatility, will the government choose $p^{D^*} = p^W$, the non-distortive price. In all other cases, it will chose a different price. More specifically,

$$\text{if } p^W > \bar{p}^W \Rightarrow p^W > p^{D*} > \bar{p}^W \tag{19}$$

$$\text{if } p^W < \bar{p}^W \Rightarrow p^W < p^{D*} < \bar{p}^W \tag{20}$$

This can also be seen from rewriting condition (16) as follows:

$$p^{D*} = \theta\bar{p}^W + (1 - \theta)p^W \tag{21}$$

with $\theta = \frac{\delta+\tau}{\delta+\tau+S'-D'}$ and $0 \leqslant \theta \leqslant 1$. Except in the extreme cases ($\theta = 0$ or 1), the social optimum will partially offset the price change. In other words, governments will raise domestic prices in response to global price rises, but because this increases distortions it only does so partially – and similarly for price declines.

This is illustrated in Fig. 3. Fig. 3 shows the optimal price setting for a given international price for 3 different levels of θ ($\theta = 0, \theta = \frac{1}{2}, \theta = 1$). In the extreme cases, the domestic price follows the world market price (if $\theta = 0$) or the price is set by the government such that there is zero-volatility ($\theta = 1$), i.e. $p^{D^*} = \bar{p}^W$. In the case where $\theta = \frac{1}{2}$, the socially optimal domestic price follows the trend of the world market price but is less volatile than the world market price.

The extent of the adjustment will depend on the marginal increase in production and consumption distortions caused by deviations of the price from the world market price (captured by $S' - D'$, which reflect the elasticities of supply and demand) and the preferences for stability $(\delta + \tau)$. Only when the preferences for stability are zero $(\theta = 0)$ there will be full price adjustments. When the marginal impact on distortions is larger ($S' - D'$ larger and thus θ smaller) adjustments will be larger – and vice versa.

The government will thus try to find a balance between the international price and the long term free trade price. To compensate producers and consumers for their potential welfare loss from

[10] The formulated cost equation does not take into account the distortionary effect related to the collection of the government's import or export revenues/subsidies.

[11] The first order condition can be expressed as: $CS_p(p^{D*}) + \pi_p(p^{D*}) - (\delta + \mu)(p^{D*} - \bar{p}^W) + (D(p^{D*}) - S(p^{D*})) + (p^{D*} - p^W)(D'(p^{D*}) - S'(p^{D*})) = 0$.

price instability, the government will set the domestic price higher or lower than the international price by imposing export or import taxes (subsidies). The higher the relative risk aversion and the dependence on food production, the higher the welfare loss of producers following from price volatility and the closer the government will set the domestic price to the mean price. Consumers, on the other hand, might benefit from price volatility if their budget share spend on food is relatively small and if their relative risk aversion is close to zero. In this case, the government will set the domestic price closer to the international price.

To relate these theoretical results to empirical indicators, we can express the equilibrium condition also as a relationship between price distortions and volatility. Condition (16) can be written as

$$(p^{D^*} - p^W) = \varepsilon(p^{D^*} - \bar{p}^W) \tag{22}$$

with $p^{D^*} - p^W$ measuring distortions and $p^{D^*} - \bar{p}^W$ measuring volatility around the mean and $\varepsilon = \frac{\delta+\mu}{D'-S'} (= \frac{\theta}{\theta-1})$ measuring the ratio of the preferences for stability over the marginal distortionary effects. The absolute size of ε is increasing with preferences for stability of consumers and producers and decreasing with the distortionary effects of price deviations from the world market price. As we will explain in the next section we can use data to develop empirical indicators of these variables.

Fig. 4 illustrates the government's distortions-volatility (DV) trade-off and shows the optimal combinations of the absolute values of the domestic volatility and distortions for different values of $\theta(\varepsilon)$ for a given price shock. The choice of the government will be more towards the North-West with a higher θ (lower ε). With lower θ (higher ε), i.e. higher marginal distortions and less preference for stability, the choice will be more towards the South-East of the line.[12]

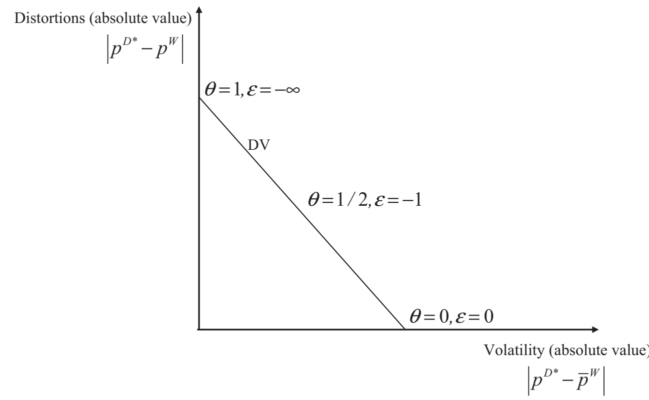

Fig. 4. Optimal combinations of observed volatility and distortions for a given price shock.

Empirical indicators of the DV trade-off

We now present empirical indicators of this trade-off for various countries over the past decade. In Section 'Trading-off volatility and distortions: Two examples' we discussed how the Chinese and Pakistani government appeared to have chosen a combination of limited domestic volatility with distortions. We now present comparative evidence from more countries using the conceptual framework we developed in Section 'Conceptual framework'.

Data on staple food prices

Our analysis uses monthly data for wheat, rice, and maize over the period from January 2007 to December 2013. For the selection of the international prices we follow Baltzer (2013) using the same prices of wheat (US Gulf, No. 2 Hard Red Winter, USD/kg), maize (US Gulf, No. 2, Yellow, USD/kg) and rice (Bangkok, Rice, Thai 100% B, USD/kg). The domestic food prices are also based on Baltzer (2013),[13] but we extend his sample to include all the African and Asian countries for which data was available from 2007 to 2013.[14]

The domestic and international prices we use for wheat, rice and maize are from the FAO's Global Information and Early Warning System (GIEWS) database.[15] We follow the same data approach as several studies in the price transmission literature that examine the response of domestic prices to changes in international prices (see e.g. Dawe et al., 2015; Zorya et al., 2015; Baquedano and Liefert, 2014; Baltzer, 2013).

Measuring volatility

Price volatility is measured as the standard deviation of the logarithm of prices (see e.g. Dawe et al., 2015; Gilbert and Morgan, 2010; Minot, 2014):

$$v = sd(r) = \left[\sum \frac{1}{T-1}(r_t - \bar{r})^2\right]^{0.5} \tag{23}$$

where $\bar{r} = \sum \frac{1}{T} r_t$ and $r_t = \ln\left(\frac{P_t}{P_{t-1}}\right)$.

Measuring distortions

The price distortion caused by the government policy is a measure of the deviation between the domestic price and the world market price. More specifically, the price distortion is calculated as the average of the absolute difference between the domestic and international price at each point in time.

$$d = \sum_{t=0}^{T} \frac{1}{T} \left| \frac{p_t^D - p_t^w}{p_t^w} \right| \tag{24}$$

As a "robustness check" on the distortions indicator we will also consider the Nominal Rate of Assistance (NRA) data (Anderson and Valenzuela, 2008). This alternative indicator for distortions is only available for a subset of countries.

The distortions–volatility frontier

To evaluate policy choices of the different countries in terms of their real outcomes in volatility and distortions, we will construct the empirical equivalent of the distortions–volatility (DV) trade-off frontier as developed in Section 'Conceptual framework' (see Fig. 4).[16] The DV frontier represents the optimal trade-off for the

[12] The trade-off line is a linear function between food price volatility and distortions. Appendix A shows how the curvature of demand and supply functions influences the optimum but not the linear relationship.

[13] Baltzer (2013) included the following countries in his analysis: Brazil, India, Egypt and South Africa for wheat; Brazil, Ethiopia, Kenya, Zambia, Nigeria, Mozambique, Malawi and South Africa for maize; and Brazil, China, India, Vietnam, Bangladesh, and Senegal for rice. The wheat prices of Egypt, the maize prices of Malawi, rice prices of Vietnam were not included in our sample because of a lack of data over the period from January 2007 and December 2013.

[14] More details on the countries included and their domestic prices can be found in the Appendix B.

[15] The data was retrieved from: http://www.fao.org/giews/pricetool/. The FAO GIEWS food price database makes use of the exchange rates sourced from the IMF International Financial Statistics.

[16] As in the theoretical model, we will assume that the distortion-volatility trade-off function follows a linear path and assume that the cost of the deviation from the international price will be compensated by the gains resulting from a more stable price.

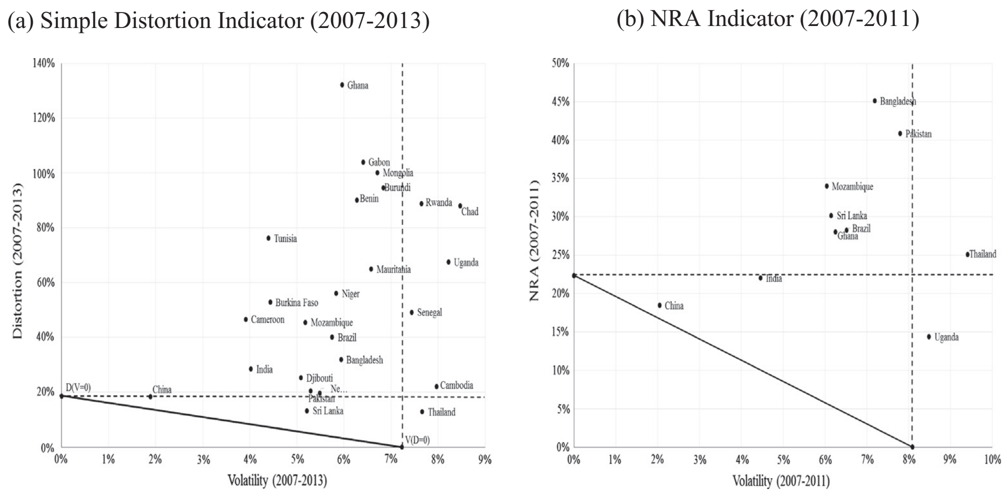

Fig. 5. Rice: distortions and volatility. (a) Simple distortion indicator (2007–2013). (b) NRA indicator (2007–2011). Note: $D(V = 0)$: Minimum distortions at zero volatility. $V(D = 0)$: Volatility at zero distortions (= world market price volatility).

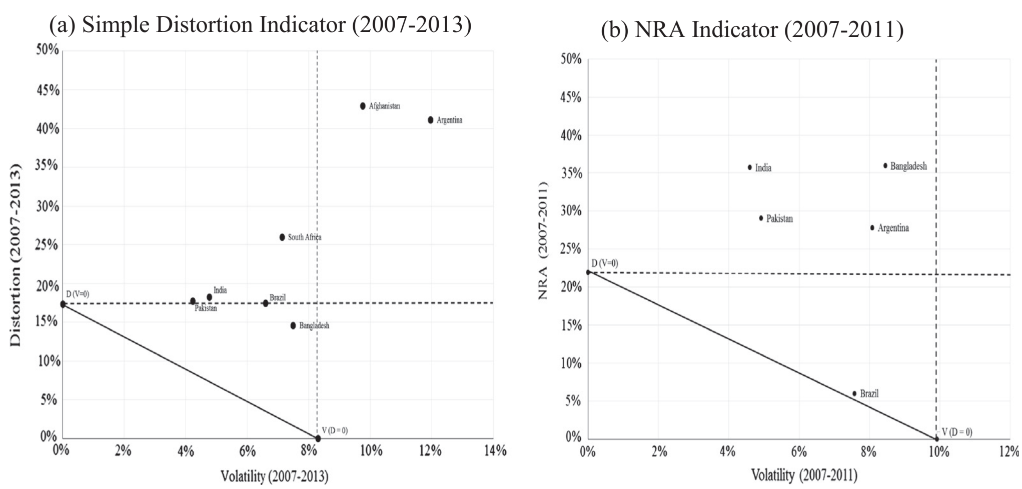

Fig. 6. Wheat: distortions and volatility. (a) Simple distortion indicator (2007–2013). (b) NRA indicator (2007–2011). Note: $D(V = 0)$: Minimum distortions at zero volatility. $V(D = 0)$: Volatility at zero distortions (= world market price volatility).

government between different levels of volatility and the degree of distortion in the absence of lobby groups and for a given world market price. If a country's trade-off between volatility and distortions is an element of the frontier, the government's policy is "efficient" from this DV perspective. If not, the distance between the outcome of the government policy and the frontier will represent possible efficiency improvements that can be made by the government.

The empirical DV frontier is constructed as the line between two extreme cases. The first point (on the horizontal axis) represents the volatility of the world market price when there are no distortions. This point is represented by $V(D = 0)$ in Figs. 5–7 and is the empirical equivalence of the point $(\theta = 0, \varepsilon = 0)$ on the theoretical DV line in Fig. 4. The second point (on the vertical axis) represents the minimum deviation from the world market price when there is no volatility. This point is represented by $D(V = 0)$ in Figs. 5–7 and is the empirical equivalence of the point $(\theta = 1, \varepsilon = -\infty)$ in Fig. 4.

Measuring inefficiency in a DV trade-off framework

The distance between the outcome of the government policy and the frontier represents the possible efficiency improvement that can be made by the government. This distance I between the closest point on the DV frontier (v_{DV}, d_{DV}),[17] and a country's actual policy decision (v_C, d_C) is an indicator of the inefficiency of the government policy in our DV framework (see Fig. 8). The inefficiency measure I is then calculated as:

$$I = \sqrt{(d_C - d_{DV})^2 + (v_C - v_{DV})^2} \tag{25}$$

To get a perspective of what the major component is of the inefficiency indicator, we also calculated the vertical and horizontal distances separately, as illustrated in Fig. 8. *VI* represents the "volatility inefficiency", which is the reduction in volatility that is possible for the same level of distortion, and is measured as:

$$VI = |v_C - v_{DV}| \tag{26}$$

DI is the "distortion inefficiency", i.e. the reduction in price distortions that are possible for the same level of volatility, and is measured as:

$$DI = |d_C - d_{DV}| \tag{27}$$

[17] The closest point on the DV frontier is defined by: $v_{DV} = \frac{v_C + m \cdot d_C - m \cdot k}{m^2+1}$ and $d_{DV} = m\frac{v_C + m \cdot d_C - m \cdot k}{m^2+1} + k$ with m and k representing respectively the slope and intercept of the DV trade-off frontier.

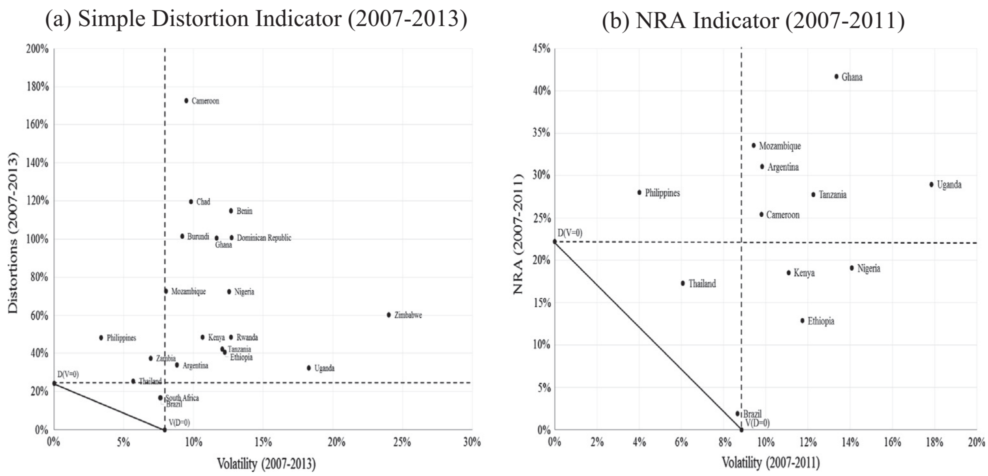

Fig. 7. Maize: distortions and volatility. (a) Simple distortion indicator (2007–2013). (b) NRA indicator (2007–2011). Note: $D(V = 0)$: Minimum distortions at zero volatility. $V (D = 0)$: Volatility at zero distortions (= world market price volatility).

DV trade-off and inefficiency in staple food markets in developing and emerging countries

DV trade-off and classification of countries

Figs. 5–7 illustrate the empirically measured trade-off between price distortions and volatility for wheat, rice and maize. Each point represents a country's choice between price distortions and stability.

As explained above, the zero distortion point "$V(D = 0)$" on the horizontal axis represents the volatility of the international price and the zero volatility point "$D(V = 0)$" on the vertical axis is the minimum distortion of the domestic price when there is no volatility. The line that connects both points in Figs. 5–7 is the empirical equivalent of the theoretical DV line in Fig. 4. The dotted vertical and horizontal lines on the figures go through the zero distortions and zero volatility points such that we get four quadrants.

There are two figures for each commodity. The first figure shows the country's choice when using the distortion indicator based on the FAO GIEWS database and the second figure gives the results when using the NRA's as a distortion indicator (see Section 'Empirical indicators of the DV trade-off'). The differences between the two figures and distortions indicators are due to different methodologies (e.g. the NRA indicator uses the border price

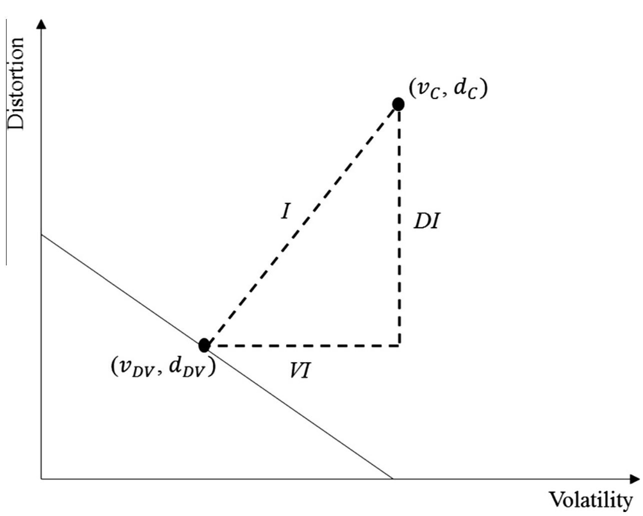

Fig. 8. Inefficiency indicators.

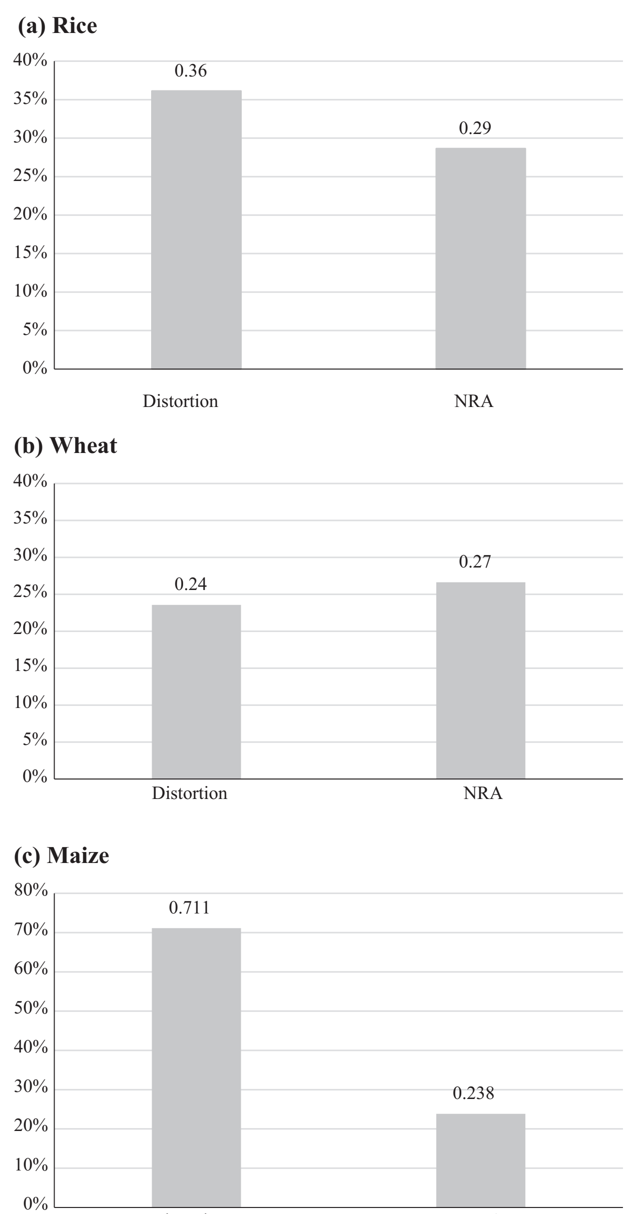

Fig. 9. Average distortions and NRA (2007–2011).

and the producer farmgate price; while the simple distortion indicator uses the international and domestic price; NRA includes other forms of taxes and subsidies), different time periods (the NRA indicator is only available until 2011) and different countries. Overall, the NRA indicators are lower than the simple distortion indicators, probably caused by a combination of different time periods and a (lack of) accounting for transport and freight costs (see Fig. 9).

The countries in the South-West quadrant have done better than the zero distortions point in terms of volatility and better than the zero volatility point in terms of distortions. The cost of the distortion caused by their divergence from the international price to reduce volatility is lower than the world price with no volatility. Figs. 5–7 show that several countries are in (or close to) the (best) South-West quadrant. This is the case for China, Sri Lanka and India for rice; for Brazil for wheat; for Thailand and Brazil for maize. However, it is also obvious that the majority of the countries is in the other quadrants.

In the North-West quadrant countries perform better in terms of volatility relative to the world market price but with higher distortionary costs than the efficiency trade-off when there is no volatility. In this case, countries apparently value stability more than the distortionary costs. It appears that there are only few countries, including the Philippines, in the North-West quadrant for maize. For wheat, India and Pakistan are in the North-West quadrant. For rice there are several countries located in the North-West quadrant with some of them close to the South-West quadrant such as Pakistan, Brazil and Mozambique.

Governments of countries in the South-East have followed a price policy that kept the price distortion between the domestic and the international price limited, but volatility was higher than volatility in the international market. In this quadrant countries value the cost of the distortionary effects more than the adjustment costs for consumers and producers resulting from higher volatility. However, according to our indicators there are only a few cases in this quadrant; and none of them is consistent for the two distortion indicators.

The worst situation is in the North-East quadrant where countries have performed worse both in terms of volatility and efficiency. In these cases it is possible to simultaneously reduce distortions and reduce volatility. There is a significant number of countries in this worst quadrant. Especially African countries are in the North-East quadrant, in particular for maize. This conclusion holds both for the NRA indicator and the simple distortion indicator. There may certainly be measurement problems but the consistent observations suggest that there may be structural factors behind this.

Figs. 10–12 present the inefficiency indicators for the government policy compared to the optimal distortion and volatility trade-off. The countries with the lowest scores on the inefficiency

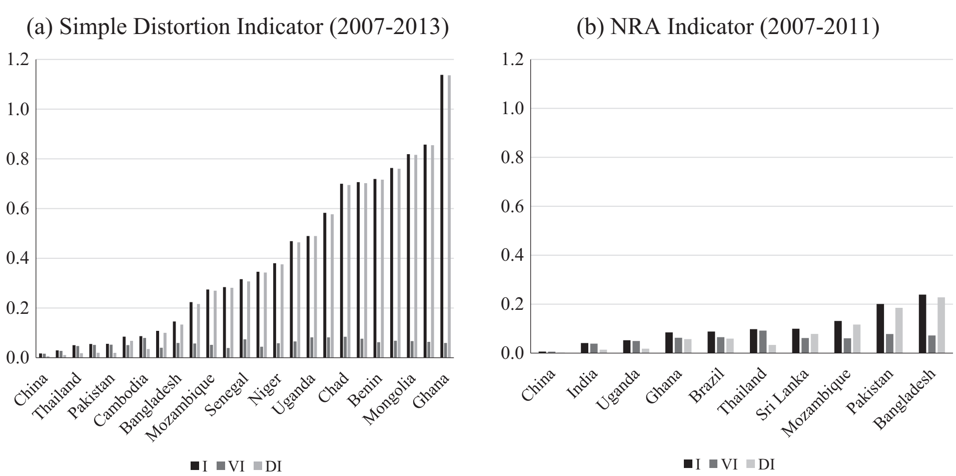

Fig. 10. Rice inefficiency relative to the DV frontier. (a) Simple distortion indicator (2007–2013). (b) NRA indicator (2007–2011).

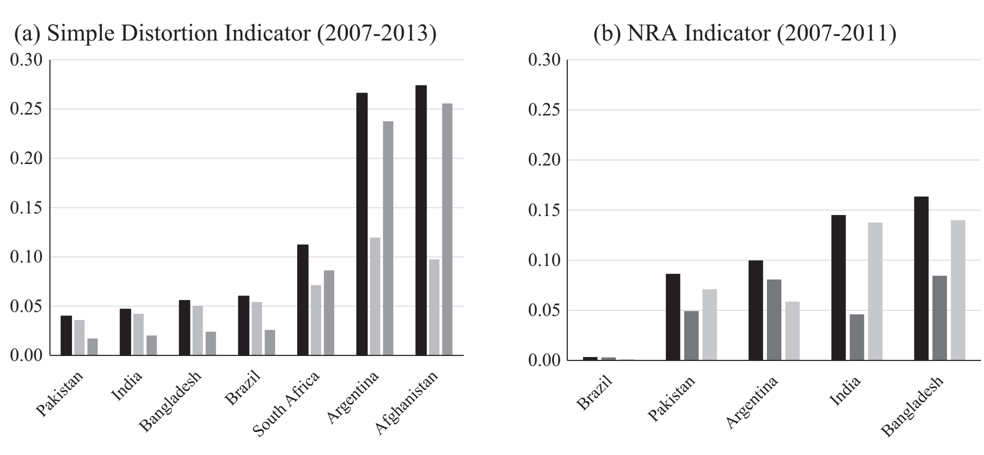

Fig. 11. Wheat inefficiency relative to the DV frontier. (a) Simple distortion indicator (2007–2013). (b) NRA indicator (2007–2011).

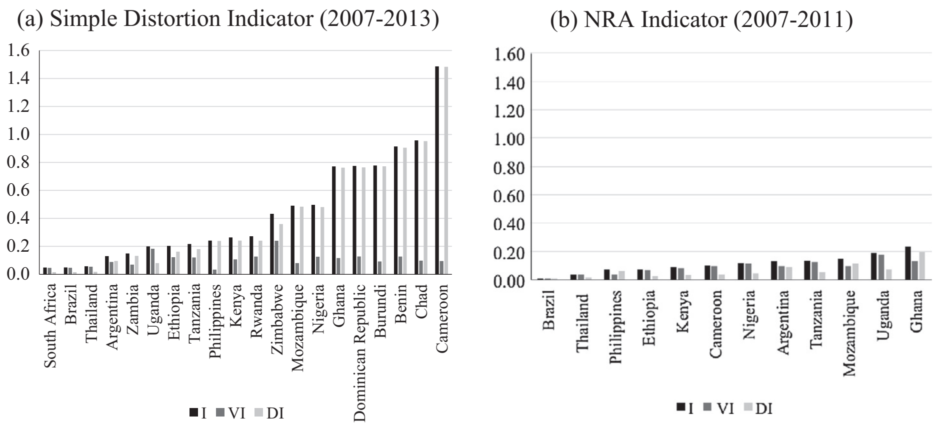

Fig. 12. Maize inefficiency relative to the DV frontier. (a) Simple distortion indicator (2007–2013). (b) NRA indicator (2007–2011).

indicator are located in the North–East quadrant in Figs. 5–7. While the countries in the South-West quadrant are the countries with the lowest inefficiency scores.

China's policy intervention in the rice market is closest to the (theoretically) best outcome measured in terms of all three inefficiency measures. Similarly, the best performers in the maize market are Brazil and Thailand in terms of a reduction of volatility and distortions over the 2007–2013 period.

The efficiency indicators in Figs. 10–12 confirm that there are a lot of countries with relatively low performance levels compared to the DV frontier but the results are depending on the distortions indicator used. In most of the cases, these inefficiencies are caused by very high price distortions. Compared to the best outcome these countries are confronted with large deviations from the international food prices for similar volatility levels.

There are only a few countries were the overall inefficiency is driven by high volatility rates compared to the optimal DV frontier. One example is Uganda's maize policy. In other words, Uganda faces relatively high price volatility rates in the maize sector compared to the closest point on the optimal DV trade-off.

In summary, our analysis indicates a large heterogeneity in the performance of countries in this DV trade-off framework. Some seem to have done well in this trade-off but others could have had much lower distortions in order to reduce volatility on the domestic markets. In fact, several countries have done worse in both distortions and volatility than could have been possible. Political concerns in these countries may have caused unnecessary distortions in the face of volatile markets.

Conclusion and future extensions

The question addressed in this paper is to what extent governments may have traded off price distortions for reduced volatility in intervening in agricultural and food markets. We developed a model to derive how much distortions a government would introduce when it cares about stability (i.e. if it wants to limit price volatility for domestic producers and consumers) in a situation with limited policy options. We showed that there is a trade-off between volatility and distortions in situations with limited policy options; and we identified a DV frontier as the optimal combination of distortions and stability for given international price shocks and various preferences.

We also showed that several countries have been able to reduce (short run) price volatility in the domestic markets while at the same time allowing structural (medium and long term) price changes to pass through to producers and consumers. One case is the Chinese rice market.

However, this is not the general (or average) case. The average "DV efficiency" is rather low. For many countries, even when explicitly taking into account this trade-off (and the benefits of reducing volatility) government policies appear far removed from the optimal distortion–volatility (DV) combination and that there appears to be, thus, much room for policy improvement.

There are several ways in which this analysis can be further refined, and several issues need to be taken into consideration when interpreting the results. One is to improve the empirical indicators by better correcting for differences in transportation costs, quality differences and other factors. A second is related to the conceptual model and the availability and costs of using alternative instruments. Our assumption was that in order to address the volatility governments would intervene in markets and did not

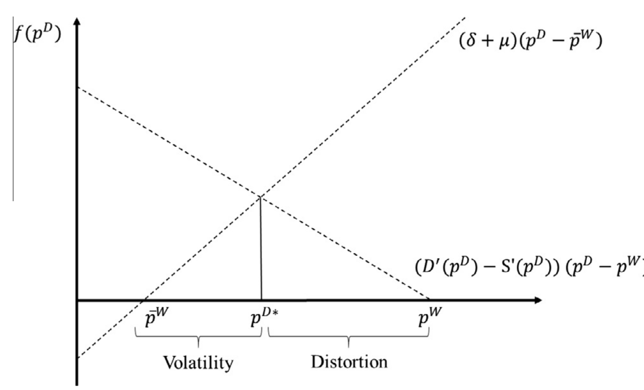

Fig. A.1. The optimal domestic price for a linear demand and supply curve.

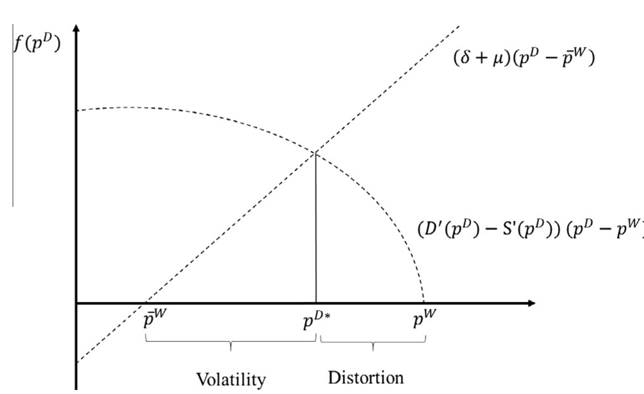

Fig. A.2. The optimal domestic price for a quadratic demand and supply curve.

have other instruments, such as income support as an alternative option. A more elaborate model with multiple policy instruments (and their respective implementation costs and distortions) would improve the conceptual analysis. In this respect, it may be important to point out that we have not explicitly taken into account the possible asymmetry in the food price series. For example, Williams and Wright (1991) and Deaton and Laroque (1992, 1996) show that there is a positive skewness in commodity price series – i.e. price spikes are more common than price collapses – due to storability and stock-out constraints. This asymmetry might have important implications for the costs of governments to stabilize prices. This aspect deserves a more extensive discussion in future research. A final issue that we ignored is the spillover effect (and potentially secondary price effects) of domestic policies on international markets, an issue emphasized by e.g. Ivanic and Martin (2014). Our analysis and results are complementary to the findings of these studies.

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Appendix A

The relationship between distortions and volatility as expressed in Eq. (16) and as illustrated in Figs. 4–7 is always linear, independent of the demand and supply functions. Condition (16) expresses the equilibrium condition as a relationship between price distortions and volatility and can be written as:

$$(p^{D^*} - p^W)(D' - S') = (\delta + \mu)(p^{D^*} - \bar{p}^W) \tag{A.1}$$

with $p^{D^*} - p^W$ measuring distortions and $p^{D^*} - \bar{p}^W$ measuring volatility around the mean, $(\delta + \mu)$ the preferences for stability and $D' - S'$ measuring the marginal distortionary effects. The curvature of the demand and supply functions $(D' - S')$ will affect the optimal domestic price, the deviation from the world market price and the volatility level. In what follows, we present a graphical analysis to show how demand and supply functions affect the equilibrium.

Fig. A.1 shows the results for a linear demand and supply curve (i.e. $(D' - S')$ is a constant). The left- and right-hand side of the equation can be plotted as a linear function of the domestic price. The equilibrium price is the intersection point between the two lines. As can be seen from the graph the optimal domestic price is thus a weighted average of the long-term target price and the international price and the distance regarding are representing, respectively, volatility and distortion.

Fig. A.2 shows the results for a quadratic demand and supply curve ((i.e. $(D' - S')$ is a function of p^D). The left-hand side of Eq. (A.1) is a quadratic function of the domestic price. The equilibrium price is the intersection point between the linear and quadratic function. The optimal domestic price is again a weighted average of the international price and the long-term target price. To conclude, the curvature of the demand and supply curve affects the position on the trade-off line, but it does not affect the linearity of the trade-off line since it is still a weighted average between the two extremes.

Appendix B

	Domestic price
Rice	
Bangladesh	Dhaka, Rice (coarse), Wholesale, (USD/kg)
Benin	Cotonou, Rice (imported), Retail, (USD/kg)
Brazil	National Average, Rice (paddy), Wholesale, (USD/kg)
Burkina Faso	Dori, Rice (imported), Wholesale, (USD/kg)
Burundi	Bujumbura, Rice, Retail, (USD/kg)
Cambodia	Phnom Penh, Rice (Mix), Wholesale, (USD/kg)
Cameroon	Douala, Rice, Retail, (USD/kg)
Chad	N'Djamena, Rice (imported), Retail, (USD/kg)
China	Hunan, Rice (Indica, first quality), Wholesale, (USD/kg)
Djibouti	Djibouti, Rice (Belem), Wholesale, (USD/kg)
Gabon	Libreville, Rice, Retail, (USD/kg)
Ghana	Accra, Rice (imported), Wholesale, (USD/kg)
India	New Delhi, Rice, Wholesale, (USD/kg)
Mauritania	Nouakchott, Rice (imported), Retail, (USD/kg)
Mongolia	Ulaanbaatar, Rice, Retail, (USD/kg)
Mozambique	Maputo, Rice, Retail, (USD/kg)
Nepal	Kathmandu, Rice (coarse), Retail, (USD/kg)
Niger	Niamey, Rice (imported), Wholesale, (USD/kg)
Pakistan	Karachi, Rice (basmati), Retail, (USD/kg)
Rwanda	Kigali, Rice, Wholesale, (USD/kg)
Senegal	Dakar, Rice (imported), Retail, (USD/kg)
Sri Lanka	Colombo, Rice (white), Retail, (USD/kg)
Thailand	Bangkok, Rice (5% broken), Wholesale, (USD/kg)
Togo	Lomé, Rice (imported), Retail, (USD/kg)

(*continued on next page*)

Appendix B (*continued*)

	Domestic price
Tunisia	National Average, Rice, Retail, (USD/kg)
Uganda	Kampala, Rice, Wholesale, (USD/kg)
Wheat	
Afghanistan	Kabul, Wheat, Retail, (USD/kg)
Argentina	Buenos Aires, Wheat, Wholesale, (USD/kg)
Bangladesh	National Average, Wheat, Wholesale, (USD/kg)
Brazil	National Average, Wheat, Wholesale, (USD/kg)
India	New Delhi, Wheat, Wholesale, (USD/kg)
Pakistan	Karachi, Wheat, Retail, (USD/kg)
South Africa	Randfontein, Wheat, Wholesale, (USD/kg)
Maize	
Argentina	Rosario, Maize (yellow), Wholesale, (USD/kg)
Benin	Cotonou, Maize (white), Retail, (USD/kg)
Brazil	National Average, Maize (yellow), Wholesale, (USD/kg)
Burundi	Bujumbura, Maize, Retail, (USD/kg)
Cameroon	Douala, Maize, Retail, (USD/kg)
Chad	N'Djamena, Maize, Retail, (USD/kg)
Dominican Republic	Santo Domingo, Maize, Wholesale, (USD/kg)
Ethiopia	Addis Ababa, Maize, Wholesale, (USD/kg)
Ghana	Accra, Maize, Wholesale, (USD/kg)
Kenya	Nairobi, Maize, Wholesale, (USD/kg)
Mozambique	Maputo, Maize (white), Wholesale, (USD/kg)
Nigeria	Kano, Maize, Wholesale, (USD/kg)
Philippines	National Average, Maize (yellow), Wholesale, (USD/kg)
Rwanda	Kigali, Maize, Wholesale, (USD/kg)
South Africa	Randfontein, Maize (white), Wholesale, (USD/kg)
Thailand	Bangkok, Maize, Wholesale, (USD/kg)
Uganda	Kampala, Maize, Wholesale, (USD/kg)
United Republic of Tanzania	Dar es Salaam, Maize, Wholesale, (USD/kg)
Zambia	National Average, Maize (white), Retail, (USD/kg)
Zimbabwe	Harare, Maize, Retail, (USD/kg)

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