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The use of organized commodity markets to manage food import price instability and risk

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Abstract

The article explores the possibility of insuring the price risks of wheat and maize imports of low-income food-deficit countries (LIFDCs). Optimal strategies for an importing agent, who hedges with futures and options are derived, based on the objective of minimizing the unpredictability of import bills. *Ex post* simulations for a set of LIFDCs are run on wheat and maize imports hedged with futures and options in the Chicago Board of Trade, to explore the extent to which hedging reduces the unpredictability in import bills. Simulations encompass both periods of normal price behavior, as well as the period of global upheaval that occurred in 2007 and 2008. Results show that hedging with futures alone affords agents considerable opportunities for reducing import cost unpredictability, and the same holds with options, albeit, to a lesser extent. However, during the recent price spike of 2007–2008, hedging with options would have increased the unpredictability of some countries' maize import bills, due to the combination of erratic import patterns and pronounced market uncertainty.

JEL classification: Q13, Q17, Q18

Keywords: Food import bill unpredictability and instability; Commodity price insurance; Hedging developing country food import bills

1. Introduction

An important long-term development in world agricultural trade has been the shift of developing countries from a position of net exporters—up to the early 1990s—to that of net agricultural importers. Projections to 2030 indicate a deepening of this trend (Bruinsma, 2003), due to the projected decline in the exports of traditional products, such as tropical beverages and bananas, combined with a projected large and growing deficit of basic foods, such as cereals, meat, dairy products, and oil crops. Among developing countries, those classified as least developed countries (LDCs) and low-income food-deficit countries (LIFDCs) have witnessed a rapid worsening of their agricultural trade balance in the last 15 years. Since 1990, the food import bills of LDCs have not only increased in size, but also in importance, as they typically amounted to more than 50% of total merchandise exports. The global food crisis of 2007–2008 brought this problem to the fore. The basic food import bills of LIFDCs increased by 37.5% between 2007 and 2008, from US$88 billion to US$121 billion, before declining to an estimated US$93 billion in 2009 (FAO, 2009a).

A study by Gürkan et al. (2003) indicated that the need to import food determined economic stress in LDCs between the mid1980s and 1990s; by the end of the millennium, the value of imported food reached in these countries an average of about 12% of apparent consumption. While this is not necessarily a negative outcome, as it may be due to domestic production restructuring along comparative advantages, the study showed that the growth in these countries' food import bills consistently outstripped that of GDP, as well as total merchandise exports. Changes in import unit costs of many important food commodities accounted for about two-thirds of the variation in food import bills. That same study also revealed that LDCs faced large and unanticipated price "spikes" that exacerbated their already precarious food security situation. Coupled with substantial declines in food aid over the same period, these developments have brought about a significant increase in the vulnerability

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Data Appendix Available Online

A data appendix to replicate main results is available in the online version of this article. Please note: Wiley-Blackwell, Inc. is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

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of developing countries. In light of the above developments, it seems that the problem of managing the risks of food imports has increased in importance, and is already a major issue for several LIFDCs. The main problem is not price or quantity variations *per se*, but rather unforeseen and undesirable departures from expectations on food import needs, such as those that affected many countries during the 2007–2008 period. The purpose of this article is to explore one way in which vulnerable developing countries can manage some of these risks, in particular those arising from unpredictable behavior of import prices for staple food commodities.

The issue of food import risk for LIFDCs has been discussed extensively especially after the commodity crisis of the early 1970s, when several proposals for international food insurance schemes were put forward.[1] The issue of financing food imports by LIFDCs featured prominently in the discussions leading to the World Trade Organization (WTO) Uruguay Round Agreement on Agriculture (URAA), and gave rise to the so-called "Marrakesh Decision."[2] In that document, Ministers recognized "that as a result of the Uruguay Round certain developing countries may experience short-term difficulties in financing normal levels of commercial imports and that these countries may be eligible to draw on the resources of international financial institutions under existing facilities, or such facilities as may be established, in the context of adjustment programmes, in order to address such financing difficulties."

Food import risk emerged again as a prominent issue during the 2007–2008 price spike. The combined increase of basic food prices, such as of wheat, maize, and rice, with that of petroleum price, created a "double squeeze" in many LIFDCs, which are large importers of both food and oil. African countries were most deeply affected (FAO, 2008; FAO, 2009b).

While opinions may differ on the causes of such market turmoil and its persistence, many elements suggest that the need to manage food import risks may loom large in the future, as several LIFDCs are still struggling to meet food import demands. In addition, given the simultaneous dependence of many of these countries on commodity markets both on the import and export side, price instability is becoming a problem. As different commodity prices do not move together, at least within a season, the likelihood of high import prices, together with low export prices, is real, and presents new challenges for policy. Moreover, international food price volatility has not declined, and, if anything, has remained at high levels (Sarris, 2009).

It thus becomes imperative to explore possible national strategies to deal with food import risks. A recent review of policy options (Byerlee et al., 2006) highlighted the difficulties that many governments face in disengaging from direct interventions, such as stabilization stocks, or discretionary measures such as export bans, but also highlighted the opportunities of using innovative organized market-based instruments. Indeed, the proliferation of international risk management instruments, such as futures and options for basic food commodities, may present opportunities for managing the risks that LIFDCs face. This article examines how a number of LIFDCs would have fared in the past, had they adopted market-based risk management strategies for their wheat and maize imports.

There is scant literature on this topic. An early paper by Faruqee et al. (1997) explored hedging Pakistan's wheat imports with futures. The analysis was based on data for one year only, and this opens it to the criticism that the positive results (which favored the use of futures) could have depended on the specificity of the particular year, or the particular import pattern of that country. Furthermore, Faruqee et al. (1997) explored only one particular hedging rule. A volume edited by Claessens and Duncan (1994) discussed a number of issues relevant to this work. More recently, Dana et al. (2006) examined the issue of hedging maize imports for Malawi and Zambia using futures and options, and showed that hedging led to a small cost reduction in maize imports.

In this article, we consider wheat and maize imports of several of the major LIFDCs, and examine, within a counterfactual scenario, the benefits or losses that would have been incurred had they combined their cash imports with simple and transparent hedging strategies based on futures and options. The assessment is made in terms of changes in the variance of unpredictable foreign exchange costs for cereal imports, over a past period of time, which includes the recent price spike period.

The next section briefly reviews the institutions and the type of agents that may be involved in managing risk associated with food imports in vulnerable developing countries. Section 3 presents the methodology followed in the analysis, as well as the data employed. In Section 4, we describe the empirical implementation of the exercise, and the simulated hedging rules, as well as the relationship among import prices in the countries selected, international reference prices, and prices in the Chicago Board of Trade (CBOT). Section 5 presents the results of the simulations, while the last section summarizes the results and offers conclusions and policy implications.

2. Issues relevant to food imports of LIFDCs

Food imports take place under a variety of institutional arrangements in developing countries. A recent study on the present structure of food trade in developing countries (FAO, 2003) notes that while in some LIFDCs state institutions still play a very important role in the export of basic foods, food imports have been mostly privatized in recent years. State agencies mostly operate alongside with private importers.

A public sector food importer, namely a manager of a food importing or a relevant food regulatory agency, each year faces the problem of determining the requirements that the country will need to satisfy the various domestic policy objectives, such as domestic price stability, satisfaction of minimum amount of

[1] A review is in Konandreas et al. (1978)

[2] This is the "*Decision on measures concerning the possible negative effects of the reform programme on least-developed and net food-importing developing countries"* reported in article 16.1 of the URAA.

supplies, demands to keep prices at high levels to satisfy farmers, or low to satisfy consumers, and others relevant to domestic welfare. Once domestic requirements have been estimated, the problem is how to fulfill them, namely through imports, or by reductions in publicly held stocks, if stock holding is part of the agency's activities. A related problem is the risk of nonfulfillment of the estimated requirements, which may result in domestic social problems and food insecurity. The third problem of such an agent is how to minimize the overall cost of fulfilling import requirements, given uncertainties in international prices and international freight rates, and how to manage the risks of unanticipated cost overruns. Last, but not least, the agent must finance the transaction, either through own resources, or some financing mechanisms.

The problems of private import agents are not much different from those of public agents. A private importer must assess with a significant time lag the domestic production situation as well as the potential demand, just like a public agent, and must plan to order import supplies so as to make a profit by selling in the domestic market. As far as unpredictability of domestic production, international prices, and domestic demand are concerned, the private importer faces risks similar to those of the public agent. Moreover, s(he) faces an additional risk, namely that of unpredictable government policies that may change the conditions faced when the product must be sold domestically. During the recent food price spike of 2007–2008, surveys documented the adoption of many short-term policies in response to high global prices of staple foods, which created considerable additional risks for private agents (Demeke et al., 2009). Furthermore, the private agent may be more credit- and finance-constrained than the public agent. In fact, the study by FAO (2003) indicated that the most important problem of private traders in LIFDCs is the availability of import trade finance.

Given the focus of this article on hedging strategies, we will not be concerned with the particular institutional character of the agent that imports. Rather, we will refer to an "agent" as the institution, public or private, that does both the actual importing as well as the hedging without specifying the institutional arrangements in the importing country. The assumption is that such an agent will need to plan for imports, in physical or financial terms, ahead of the actual time when imports need to be ordered.

Under the institutional arrangements currently in place in most countries, it is unrealistic to imagine that one single agent would manage all imports. However, the analysis that follows applies to any agent that accounts for a fixed share of the total imports, whether it operates on a private or public basis. While it is clear that there will be no agent that imports a fixed share of the total amount for any country unless there is a monopoly on imports, the fixed share assumption is adopted both because the market information requirements and actions of both private and public agents are the same; and because data for the empirical *ex post* simulations are available only for total commodity imports. Nevertheless, the analysis presented also holds for an agent that would have imported consistently only a "unit" of imports. In any case, the objective is to explore whether hedging with futures and/or options offers advantages over simply importing on the spot market.

3. Theoretical framework

Consider again the above mentioned agent who needs to plan imports of some basic food for a LIFDC. The present analysis focuses on wheat and maize, which are widely traded cereals, characterized by well-established cash, futures and options markets, and are imported by many LIFDCs.[3] The problem posed is the following. In the course of a year, the agent will need to import certain amounts of wheat and/or maize for delivery to the country's border in a given month. We shall assume that in any given month the agent has imperfect information on the amounts to be imported several months ahead. In most countries, total import requirements will be broadly known some time in advance by traders and other market participants, since domestic production conditions normally become clear several months before the onset of marketing. However, we consider the case in which future import requirements are uncertain.

In order to simplify the theory behind the hedging rules, assume initially that the agent estimates that at time 1, which is some months ahead of the present time, s(he) will need to import m_1^e units of wheat or maize. The superscript e denotes that this amount is the current expectation of import needs at time 1, conditioned on information available at time 0. The price the agent will pay when ordering m_1^e at time 1 will be denoted as p_1. Define the following variables:

- f_0 is the futures price of the commodity observed in a relevant organized commodity market in the current period (denoted by a subscript 0) for the futures contract expiring at, or nearest after, period 1, at which the actual order for imports is placed;
- f_1 is the price of the same futures contract at time 1;
- x is the amount of futures contracts (in units of the quantity of the commodity) purchased at the current period;
- z, is the amount of call options contracts purchased also at the current period. The call option contract is written on the same underlying futures contract expiring at or soonest after period 1, and stipulates that if the futures price f_1 at time 1 is higher than a strike price s, determined at the time of the purchase of the option, then the owner of the call option can "exercise" the option, and receive the difference $f_1 - s$ between the futures price at period 1 and the strike price s.
- The price of the option in the current period is denoted by r_0, whereas the profit from the option in period 1 is denoted

[3] Most countries in this group do in fact import more than just wheat and maize: rice, other cereals, as well as other staples are also common import items. While some short-term substitution may take place between the various foods imported—an issue on which we have no information—we will examine wheat and maize imports only and separately, assuming implicitly that hedging would not affect the short-term import demand of either wheat or maize. Exploring the possibility that risk management affects the volumes of food imports is beyond the objectives of this article.

by π_1. This profit will be equal to the difference $f_1 - s$ if the option is exercised, and zero otherwise. The profit of the option can be written succinctly as $\pi_1 = (f_1 - s)l$, where $l = 1$ if $f_1 \geq s$ and $l = 0$ if $f_1 < s$.

Given the above definitions, the foreign exchange cost to the agent at time 1 can be written as follows:

$$\begin{aligned} M_1 &= p_1 m_1 - (f_1 - f_0)x - (\pi_1 - r_0)z \\ &\equiv p_1(m_1^e + \mu_1) - (f_1 - f_0)x - (\pi_1 - r_0)z, \end{aligned} \tag{1}$$

where μ_1 denotes the zero mean prediction error of the current estimate of import needs. It shall be postulated that the agent wishes to minimize the conditional variance of M_1, conditioned on information Ω_0 available at the current time 0. This is written as

$$W = \min E\{Var[M_1]|\Omega_0\} \equiv Var_0[M_1], \tag{2}$$

where the second identity above defines the notation for the conditional variance.[4] The first order conditions for this problem can be written as follows:[5]

$$E\left\{\frac{\partial Var_0[M_1]}{\partial x}(f_1 - f_0)\right\} = 0, \tag{3}$$

$$E\left\{\frac{\partial Var_0[M_1]}{\partial z}(\pi_1 - r_0)\right\} = 0. \tag{4}$$

To characterize the solution, it is necessary to make assumptions about the relationship between the cash and the futures price. Following Benninga et al. (1984), the cash price is written as a linear function of the nearest futures price

$$p_1 = \alpha + \beta f_1 + \theta_1, \tag{5}$$

where θ_1 (the basis risk at time 1) is independently distributed from f_1, and has zero mean.

The problem will be solved under the additional assumption that the current futures price is unbiased, namely that the currently observed futures price f_0 is the (conditional) expected value of f_1, and that the options are fairly priced, in the sense that the current option price r_0 is the expected value of π_1. Finally, it is assumed for the time being that the eventual adjustment to imports μ_1 is only a function of domestic revisions to requirements, due to improved domestic information, and is not correlated with p_1, which is the prevailing international price at time 1. In principle, this is not entirely correct, since at time 1, when the order is placed, world prices may call for additional adjustment of planned imports. For instance, prices may be high enough to require a reduction regardless of the conditions prevailing in the domestic market. Such adjustments are usually the consequence of financial constraints or considerations; they will initially be assumed away for simplicity. In other words, *ex ante* adjustments of imports to expected world prices are incorporated into m_1^e and subsequent last-minute adjustments are ignored for the time being. We will discuss such *ex post* adjustments later.

Given the above assumptions, we can write the conditional variance as a quadratic expression in x and z. The minimization of this expression using straightforward algebra yields the well-known results $x = \beta m_1^e$ and $z = 0$ (Benninga et al., 1984; Rolfo, 1980).

It could be hypothesized that the importer only has call options available as a hedging instrument, instead of futures, and explore the optimal hedging rule for this case. This is a possible scenario in the real world, as over-the-counter options are available for commodity traders in absence of organized futures markets. It can then be easily derived from the above equations that in such a case the optimal hedge ratio with call options only is equal to the following expression:

$$z = \beta m_1^e \frac{Cov(f_1, \pi_1)}{Var(\pi_1)}. \tag{6}$$

As the covariance of f_1 and π_1 as well as the variance π_1 are conditional on values of f_1 greater than s (the strike price), it can be easily shown that the covariance in the numerator in Eq. (6) is equal to the variance of π_1. Hence the coefficient that multiplies the optimal futures only hedge ratio βm_1^e above is equal to 1. When only options are allowed, the optimal options hedge ratio is equal to the optimal futures hedge ratio, and is equal to β times the expected import level. Note that these results do not depend on the fact that the *ex post* imports m_1 is stochastic, since the welfare criterion is equal to the variance of M_1. If the welfare criterion was a concave utility of M_1, then the resulting optimal policy would be a combination of futures and options (Sakong et al., 1993). Notice also that the results do not depend on the magnitude or the variance of the basis at time 1, namely parameter α and the variance of θ_1 in our notation.

The above results pertain to the case in which the stated objective of the agent is to minimize the unanticipated two-sided variability of the import bills. It may, however, be the case that the agent is interested in minimizing only the unanticipated positive deviations of the import bills, since these deviations are the most detrimental from a food security standpoint as well as a cost perspective. We can deal with this problem by assuming a narrower objective, namely that the agent wishes to minimize the truncated variance of the unanticipated import bill. Given the assumptions made about the efficiency of the futures and options markets, and if it is assumed that the truncation level is the mean of the underlying distribution of imports, it can be shown using the formulas in Greene (2000, p. 899) that both the truncated mean and the truncated variance of M_1 are functions

[4] In principle, it would be possible to consider a more general concave utility function *u(.)* over *M*; but this would complicate matters without adding much to the argument. Our objective in this article is to discuss how to reduce the unpredictability of imports; choosing the variance helps focus the argument on the existence of benefits from hedging, rather than on the shape of the utility function, which was the object of several other contributions, such as Benninga et al. (1984) and Lence and Hayes (1994). Analyses using more general utility functions include Lapan et al. (1991), and Sakong et al. (1993).

[5] The second-order conditions hold because of the convexity of *W*.

only of the conditional variance of M_1. Hence, if the assumed objective of the agent is to minimize the truncated mean of the import bill deviations, it can be shown that this objective corresponds to the minimization of the variance of M_1. The same point holds if the objective of the agent is to minimize only the truncated variance of M.

Assume now that there are *ex post* adjustments to the estimated import requirements m_1^e. To simplify the discussion, assume a simple form of linear *ex post* import adjustment as follows:

$$m_1 = m_1^e - e\left(p_1 - p_1^e\right) + \mu_1. \tag{7}$$

Compared with the simpler formula for the import rule indicated in Eq. (2), this incorporates adjustments following from deviations of the *ex post* price p_1 from the *ex ante* expected price p_1^e, by introducing a parameter e. Minimization of the conditional variance of the food import bill M_1, through long but straightforward algebra, implies that the optimal futures hedge is smaller than the previously estimated one, while now the optimal amount of options hedge is nonzero. The relevant formulas are the following:

$$x = \beta\left(m_1^e - ep_1^e\right) - e\beta^2 \frac{A - B}{Var f_1 - Cov(f_1, \pi_1)}, \tag{8}$$

$$z = -e\beta^2 \frac{-A\ Cov(f_1, \pi_1) + B\ Var f_1}{Var\pi_1[Var f_1 - Cov(f_1, \pi_1)]}, \tag{9}$$

where

$$A = E_0(f_1 - f_0)^3, \tag{10}$$

$$B = E_0[(f_1 - f_0)^2(\pi_1 - r_0)]. \tag{11}$$

For an "at-the-money option," namely when the strike price s is equal to the expected futures price f_0, it can be seen that $A = B$. For an "out-of-the-money" call option, where $s > f_0$, then $A > B$. As the denominators in Eqs. (8) and (9) are positive, the conclusion is that when there are financial constraints or other considerations, which dictate *ex post* adjustments of import plans, then the optimal futures hedging rule suggests an amount of futures purchases smaller than the amount dictated by the simple hedge ratio β, and at the same time the purchase of some call options.

The above discussion indicates that even with the simple variance criterion, the optimal hedge can involve a combination of futures and options. Earlier research concluded that a mixed hedging strategy was optimal under two conditions, namely when there is uncertainty in the *ex post* imports; and when the objective function involves a concave utility (Sakong et al., 1993). We have shown that a combined rule is also optimal when there are budget constraints that may imply *ex post* adjustments. Such conditions are relevant in LIFDCs that face constraints in the availability of foreign exchange. In practice, however, it is very difficult, if not impossible, to estimate the *ex post* adjustment parameters e: even for a monopolistic import agent, it is difficult to obtain information on *ex ante* and *ex post* import transactions. Hence in the *ex post* simulations described below in the article, we will assume that e is equal to zero.

Another possibility is for the importer to buy at time t, k months ahead of when delivery is required, and store the commodity until time $t + k$. An agent following such a strategy would need to decide whether to store the physical commodity in the country of destination or in the country of origin. Either way, s(he) will incur storage cost, and deal with price uncertainty at the time of the sale. Futures prices reflect the market-determined cost of storage of a commodity between the time the future is bought and the later physical transaction time (periods t and $t + k$ in our discussion), albeit this cost can be negative because of backwardation.[6] Hence buying futures can be considered as an alternative to inventory holding, albeit the market-determined cost of storage in Chicago may have little to do with the cost of storage—and any implicit backwardation—in local markets. If the agent is well aware of the domestic storage situation, and thinks that the domestic price of storage (including any convenience yield) is lower than the market price of storage as determined in the hedging market, then it may indeed be appropriate for her/him to order the commodity now at time t, and then store it in the country of destination and sell it later. However, there is no information available on this issue, and we do not pursue it further in this article.

4. Empirical implementation

The empirical analysis presented here is based on monthly import data; therefore, the choice of the countries included in our sample was restricted by the availability of information at this frequency over a reasonably long time span. Out of the LIFDCs group, we selected 11 countries that have engaged in large wheat imports over the past 25 years. For maize, data were available for six LIFDCs only (Table 1).

For wheat, the sample of importers accounted for 58% of total LIFDCs' wheat imports in the period 1980–2008, and for 23% of world imports of this product. For maize, the selected LIFDC importers accounted for 49% of total LIFDC maize imports and for 6% of world imports of the product in the same period. It is worth noting the high share of wheat and maize in the countries' total cereal imports, the percentages reported in the last column, indicate that wheat is the most important cereal imported, while maize is the second most important; the two products together account for the vast majority of cereal imports. Moreover, with the exception of large countries like China, India, and Pakistan, wheat imports account for a large share of the total wheat consumed domestically, while this is not the case in any of the countries analyzed for maize.

The countries included in our sample encompass significant diversity in terms of cereal import requirements. They include

[6] See Considine and Larson (2001) on risk premiums and backwardation.

Table 1
Countries selected for the empirical analysis

Wheat importers	Average country wheat imports (1980–2008) *(000 tonnes)*	Share in LIFDC wheat imports (1980–2008) *(. . . . .*	Share in world wheat imports (1980–2008) *percentage. . . . .)*	Share of wheat imports in domestic utilization (1980–1990)	(1991–2008)	Average country cereal imports (1980–2008) *(000 tonnes)*	Share of wheat in country's cereal imports (1980–2008) *(. . . percentage . . .)*
Bangladesh	1622	3.9	1.6	59.5	57.7	2285	71.0
China, Mainland	6772	16.3	6.6	12.5	3.7	8813	76.8
Egypt	6839	16.4	6.7	73.2	53.2	9756	70.1
India	1122	2.7	1.1	2.5	1.7	1359	82.6
Indonesia	3137	7.5	3.1	101.2	103.7	4844	64.8
Mozambique	210	0.5	0.2	95.1	102.5	589	35.6
Nicaragua	98	0.2	0.1	105.2	92.8	220	44.3
Pakistan	1345	3.2	1.3	6.3	8.5	1368	98.3
Philippines	1956	4.7	1.9	103.4	100.2	2963	66.0
Sudan	772	1.9	0.8	70.3	68.4	960	80.4
Tanzania	177	0.4	0.2	44.8	85.4	370	47.9
Total of above	**24049**	**57.8**	**23.4**			**33527**	
Total LIFDC	**41638**	**100.0**	**40.5**			**62846**	
World	**102786**					**220716**	

Maize importers	Average country maize imports (1980–2008) *(000 tonnes)*	Share in LIFDC maize imports (1980–2008) *(. . . . .*	Share in world maize imports (1980–2008) *percentage. . . . .)*	Share of maize imports in domestic utilization (1980–1990)	(1991–2008)	Average country cereal imports (1980–2008) *(000 tonnes)*	Share of maize in country's cereal imports (1980–2008) *(. . . percentage . . .)*
Egypt	2885	32.9	4.1	28.7	38.0	9756	29.6
Indonesia	506	5.8	0.7	1.2	7.5	4844	10.5
Kenya	414	4.7	0.6	4.8	19.4	911	45.5
Malawi	127	1.4	0.2	2.1	9.5	174	72.9
Mozambique	219	2.5	0.3	40.1	18.1	589	37.1
Tanzania	94	1.1	0.1	5.5	2.9	370	25.4
Total of above	**4245**	**48.5**	**6.0**			**16644**	
Total LIFDC	**8760**	**100.0**	**12.5**			**62846**	
World	**70314**					**220716**	

Source: Authors' calculations.

large countries such as China, India, Indonesia, Mozambique, Philippines, and Pakistan, as well as smaller ones such as Nicaragua and Tanzania. Of these, three large countries, namely China, India, and Pakistan, have become significant exporters of wheat in the last decade, while continuing to import the product. In the case of maize, most countries are regular importers, except Kenya, Mozambique, and Malawi, which have become occasional exporters in the last 10 years. A landlocked country such as Malawi is also included.

Different profiles of countries imply different problems associated with cereal imports. For example, large countries could experience deficits and surpluses in different areas, and this may prompt imports as well as exports at different times in the year, if the domestic market cannot arbitrage appropriately, or if it is cheaper to buy or sell abroad; this behavior is observed in some of the countries included in our sample. Occasionally, importing countries may face conditions that would make regular hedging strategies difficult to implement. Landlocked countries, for instance, may face significantly larger basis risk, given their isolation and the importance of transport costs. The variance of international prices for landlocked countries may therefore constitute a smaller risk compared to the variance of the basis between the international purchasing center and their import point. These *caveats* should be kept in mind when interpreting the results.

Most of the actual wheat and maize imports by the countries included in our sample are obtained and priced on the basis of export prices in major exporting countries, such as the United States, Australia, and Argentina. Sarris et al. (2006) showed, however, that export prices in these markets are strongly correlated, and also that the import unit values of the selected importing countries are significantly correlated to the reference export prices. Furthermore, it was shown that the various reference prices are closely related among each other. This implies that it is possible to use one of the international reference prices for wheat and maize as a proxy for the import price (minus transport cost) of the importing country. We choose U.S. Gulf prices to represent international reference prices for imports of wheat and maize. Similarly, we consider the CBOT as the major hedging market for orders made with reference to the Gulf prices. We explore the relationship between the Gulf export prices and the Chicago futures below.

Consider first the problem of hedging the price risk for an amount of wheat and/or maize equal to the hedge ratio times the known amount that will be imported some months ahead. As shown, *ex post* uncertainty about the level of imports does not affect hedging rules when the objective is to minimize the conditional variance of import bills. Hence, we shall restrict the empirical analysis to the case when the imports are known or have been estimated precisely *ex ante*. Adding uncertainty to imports does not change the overall results of the simulations.

The hedging rules analyzed here imply transactions through futures or options. In terms of data, we employed first the actual imports of wheat and maize for all LIFDCs on an annual basis (both calendar year as well as July–June) from the 1960s. Second, we used International Wheat Council and FAO data on monthly wheat and maize imports for LIFDCs by origin of imports, since 1995. Given this monthly information, for the years in which monthly import data are not available, we assumed that the monthly import pattern is the same as the average pattern of the years for which monthly observations are available. Third, futures and options daily data were obtained from the CBOT from 1986 to 2008. We assumed that all import transactions are done at Gulf prices. This is certainly an approximation, as not all transactions are undertaken on this basis; but it is a reasonable assumption, given that all major export market prices are related to these prices. The simulations involve buying futures or call options at a given point in time, ahead of the physical wheat or maize contracting, and selling them later, namely when the actual physical transaction for wheat or maize imports is concluded.

The actions of the agent will aim at insuring the price risk of the physical purchases. It is assumed that the cash orders for wheat and maize imported in a given month are placed one month in advance. This appears reasonable in light of the norms of the trade, and implies that the price at which wheat and maize imports will be valued and eventually paid are those of one month ahead of the actual physical arrivals at the border.

The hedging rules are defined by the following parameters:

- the day of the year at which the contract (futures or option) is bought;
- the contract to be purchased (namely the month for which a futures or option contract is purchased);
- the amount to be purchased under the contract;
- for options, the strike price at which the call option is purchased.

We will simulate the following two sets of rules (strategies).

Rule 1. Hedging only with futures contracts

Under this set of rules, which are similar to those simulated by Faruqee et al. (1997), we assume that the agent buys futures k months in advance of the date when s(he) needs to contract the actual delivery. The contract date is assumed to be one month before the needed physical delivery of import, as per the seasonal import needs, which, as indicated above, is assumed to be known. In other words, suppose that according to the requirements, the importing agent needs to physically import 100,000 tons of wheat in December. The actual contract for physical delivery in December will have to be placed in November, and this implies that the price at which the transaction and the payment will be made is the November price. Therefore, the need is for hedging the November transaction and payment. If we assume that $k = 4$, then the agent will buy futures contracts for amounts totaling $\beta \times 100{,}000$ tons in July (namely in the $11 - 4 = 7$th month of the year). The futures contract at which the futures transaction will be made will be the closest available after the date in which the purchase is needed. In the above example, the actual forecasted transaction is in November, and the nearest traded futures is the December contract, hence the agent will buy December wheat futures in July, and sell them in November.

In the simulations, it is assumed that the agent can buy futures contracts for the exact amount of the product that s(he) needs to hedge. This is an approximation, as the actual futures contracts are available only for fixed lump amounts (for instance the standard CBOT wheat futures contract is for 5,000 bushels[7] or about 130 metric tons), but it is possible to obtain futures for whatever amount the agent may wish through brokers and traders, for a small extra fee.

Once the month of purchase is determined, for the simulations, we still need an assumption on the exact days at which the agent will purchase and, later, sell the contracts; this is assumed to be the closest day to the middle of the month.[8] The same strategy is applied month after month. Concerning costs, it is assumed that buying or selling futures implies a US$0.15 per ton commission, as in Faruqee et al. (1997) and that each futures transaction requires a deposit margin equivalent of 5% of its value. We also assumed that there is an opportunity cost on this margin, valued at a rate equal to U.S. base interest rate, which changes every month (published by the U.S. Federal Reserve). This cost is calculated over the period of the hedge.

Rule 2. Hedging with options

The conditions stated above for futures, concerning the dates at which the contracts are bought and the dates of expiration, also hold for the simulations with call options. The only difference is that in this case also the strike price has to be determined. The strike price is parameterized as $(1 + \alpha)\, p^f_{t,t+k}$, where $p^f_{t,t+k}$ denotes the futures price observed in month t for the contract expiring at, or in the nearest month after, the period $t + k$, when the actual transaction will be made. The parameter α is the proportion above $p^f_{t,t+k}$ for which insurance is sought. Hence if $\alpha = 0.1$, the (out of the money) call option bought implies that if the future price observed at the time of ordering is above the strike price—which as per the option specification is 1.1

[7] In the CBOT, one could purchase also miniwheat and minicorn contract, which trade in 1,000 bushel units.

[8] The sensitivity of results to this assumption was checked by repeating the simulations under the assumption that transactions would take place at the beginning and at the end of the month. The results were virtually unchanged; hence we decided to report only those for the midmonth transactions.

times the future price observed at the time of purchase of the option—then the difference between the actual higher futures market price and this strike price will be paid to the buyer of the option, namely the agent. Based on industry information, we assume a transactions cost for buying the call option equal to 4.5% of the option price.

An example is in order. Suppose that in a given trading day in the seventh month of the year, namely July 15, the agent purchases a call option with $\alpha = 0.1$ and $k = 4$. This means that the call option expires in November (month 7 + 4), when the contract will have to be made for the physical wheat or maize shipment to be delivered in December. Suppose that on July 15, the December future is quoted at US$90.9 per ton.[9] With $\alpha = 0.1$ the desired strike price at which the call option will be bought is $P_s = 100 = (1.1$ times $90.9)$ US$. As options are not available for all strike prices, the strike price at which the call option is bought is the nearest to the desired price of US$100 among those quoted. Assume that this is US$98.0 and that the cost of buying this call is $PR = 12.0$ US$. The calculation of the gain from the option purchase examines the December future price in mid November; as mentioned we consider the settlement price on November 15 or the nearest trading day. Suppose that this price has moved upward beyond expectations, to $P_{NF} = 120$ US$. In this case, the option will be exercised, and the net gain, taking into account the transactions cost, will be $N = (120 - 98) - 12 - 0.045 \times 12 = 9.46$ US$. Suppose now that price growth expectations have not fully materialized, so that the December future on November 15 has only reached $P_{NF} = 95$. In this case, the option will *not* be exercised, and the net loss accounted for will be $N = -12 - 0.045 \times 12 = -12.54$ US$.

Given that the objective of the hedging exercise is to reduce the conditional variance of the import bills, an *ex post* measure of success of the hedging strategy, as per the theory exposed earlier, is the variance of the unpredictable changes in the values of imports with and without hedging. For each period, we first compute for each t the unexpected change in import cost

$$M_{t+k} - E(M_{t+k,t}) = \left\{p_{t+k}m_{t+k} - E(p_{t+k,t})m^e_{t+k}\right\}, \tag{12}$$

and then compute the variance (or standard deviation) of the changes in Eq. (12) over a given historical period. When the same imports are hedged with futures, the unpredictable change in the import cost is equal to

$$\begin{aligned} M_{t+k} - E(M_{t+k,t}) &= \left[p_{t+k}m_{t+k} - E(p_{t+k,t})m^e_{t+k}\right] \\ &\quad - \beta\left(f_{t+k} - f_t - \tau_f f_t - g i_{t,t+k} f_t\right)m^e_{t+k}, \end{aligned} \tag{13}$$

where τ_f denotes the unit transactions cost of buying a futures contract, g is the margin requirement (assumed to be 5%), and $i_{t,t+k}$ denotes the interest charge on the margin over the period t to $t + k$. Note that we neglect possible margin calls during the period of holding the futures contracts. When prices fall in the course of holding a long futures contract, the agent will have to post additional margin, and this may create liquidity and financing problems with the agent. In the simulations, we ignore this aspect of futures hedging, albeit for cash-constrained LIFDCs it may be important.

Finally, when the same imports are hedged only with call options, the unpredictable change in the import cost is equal to

$$\begin{aligned} M_{t+k} - E(M_{t+k,t}) &= \left[p_{t+k}m_{t+k} - E(p_{t+k,t})m^e_{t+k}\right] \\ &\quad - \beta(\pi_{t+k} - r_t - \tau_o r_t)m^e_{t+k}, \end{aligned} \tag{14}$$

where π_{t+k} is the actual realized profit on the option contract (namely equal to $f_{t+k} - s$, if this quantity is positive at time $t + k$, and zero otherwise); and τ_o denotes the unit transactions cost of buying a call option contract. As discussed earlier, the *ex ante* uncertainty about the value of the eventual physical imports does not affect the hedging rules. Hence for the simulations the expected values above will be set equal to the actual observed values of imports.

In order to implement Eqs. (12)–(14), we need to estimate the conditional expectation of the future cash price. Under the assumption (5), the conditional expectation at time t of the cash price at time $t + k$ is a linear function of the conditional expectation of the nearest futures price at time $t + k$. Under the assumption that future markets are unbiased, this latter expectation is equal to the price of the futures contract that expires at or near time $t + k$, observed at time t. Hence, we can use the following expression for estimating the conditional expectation in equations Eqs. (12)–(14):

$$E(p_{t+k,k}) = \alpha + \beta f_t^{t+k}, \tag{15}$$

where f_t^{t+k} is the price at time t of the futures contract expiring at or nearest after period $t + k$, and α, β are parameters to be estimated empirically.

The simulation exercise compares the standard deviations of the normalized expressions in Eqs. (12)–(14). The normalization is obtained by dividing the expression in Eqs. (12)–(14) by the average unhedged import bill for the period under investigation, namely the average of the magnitudes $p_t m_t$. This normalization is the same in the case of unhedged and hedged imports, so that whatever difference is estimated in the variability measures of the above expressions are due to the application of the futures and options hedges, and not the denominator. It should be underlined that the monthly import values are approximate and indicative of import bills for wheat and maize. As discussed above, they are computed on the assumption that the price paid by a country when importing from the United States or any of the other main exporters is the Gulf price. This is an approximation, as there may be significant transport- and other country-specific transactions-related cost differentials between the Gulf prices and the border prices in the country. But since data on actual transactions and monthly cif prices are unavailable, it is meant to provide at least some indicative figure. If the

[9] In fact, prices are quoted in cents per bushel, but we refer to dollars per tons for simplicity.

transport costs and any other country-specific costs are independent of the world market price, which we assume is represented by the Gulf price, then all the previous discussion remains intact, but the amount of the actual import bill that is hedged in our analysis would be a fraction, different for each country, of the total actual import bill. Our results and the analysis do not take into consideration these latter costs, whose variability is in fact assumed to be orthogonal to world prices. However, this may not be the case in periods of price spikes, depending on the source of the spike. In point of fact, during the recent price boom of 2007–2008, the Baltic freight rate index, which is a representative index of bulk freight rates, has been highly correlated with commodity prices, but it is not clear whether this is a recent and only temporary phenomenon.

Before undertaking the simulations, we discuss whether the CBOT futures prices can be employed as expectations of the reference cash prices, as per Eq. (15); and to verify that the CBOT futures prices—and hence those of the related options—are indeed effective reference prices for hedging wheat and maize imports of the selected LIFDCs.

The bulk of wheat imports into the countries included in our sample is obtained from the United States, Australia, and Argentina. Hence we considered the U.S. Gulf price for hard winter ordinary no. 2 wheat, and the monthly export unit values for Australia and Argentina as world import reference prices for wheat.[10] As far as maize is concerned, the major source of imports of the studied countries is the United States; therefore we consider the monthly U.S. Gulf yellow maize price as a reference. Time series analysis involving cointegration tests between the three world wheat reference prices revealed that they move closely together (Sarris et al., 2006). Hence we could safely choose one of the three world wheat reference price as the single representative price for wheat imports, and we chose the U.S. Gulf price.

Moreover, we studied the relationship between the Gulf prices and CBOT spot prices in order to compute hedge ratios and to determine the functional form for price expectations. Since futures are defined only for certain months, the CBOT price that was considered as the corresponding reference futures price for the Gulf market was assumed to be the one for the nearest futures contract.

In order to study the basis risk of the Gulf prices, time series price relations were analyzed econometrically, following Rapsomanikis et al. (2003). First, the dynamic properties of the series involved were investigated, through standard tests for the presence of unit roots, to establish the order of integration.[11] The following Auto Regressive Distributed Lags logarithmic model was then estimated between cash prices p and nearest futures prices f in levels:

$$p_t = a + \tau T + \sum_{j=1}^{J} \beta_j p_{t-j} + \sum_{k=0}^{K} \gamma_k f_{t-k} + e_t, \tag{16}$$

in which lag orders J and K were chosen through the minimization of the Akaike information criterion, and T represents a time trend. The test for a long-run relationship between p and f—akin to the theoretical Eq. (5) namely $p_t = \lambda_0 + \lambda_1 f_t + u_t$—was derived from Eq. (16) under the restriction that $p_t = p_{t-k} \forall k$ and $f_t = f_{t-j} \forall j$. Results indicated presence of a significant long-run relationship between p and f, which allowed estimating the following Error Correction representation:

$$\Delta p_t = a + \delta T + \rho[p_{t-1} - \lambda_1 f_{t-1}] + \sum_{j=1}^{J} \beta_j^* \Delta p_{t-j} + \sum_{k=0}^{K} \gamma_j^* \Delta f_{t-k} + h_t. \tag{17}$$

This takes into account adjustments around the long-run equilibrium, and includes separate parameters for short-run adjustment $\rho = (1 - \sum \beta_j)$, and the long-run λ_1. Estimates for these two parameters, as well as parameter λ_0 are reported in Table 2 for wheat and maize.[12]

Table 2
Transmission between international reference prices (at the U.S. Gulf) and the nearest Chicago Board of Trade (CBOT) futures price for wheat and maize (monthly data–sample: April 1985–Jan 2009)

Regressor	Dependent variables		*PWUS*	*PMUS*
Nearest future price at CBOT	λ_0	Coefficient	9.86	6.68
		t-ratio	5.17	5.29
	λ_1	Coefficient	0.99	1.01
		t-ratio	71.99	81.15
	ρ	Coefficient	−0.64	−0.69
		t-ratio	−23.75	−26.37

PWUS = U.S. Gulf no. 2 wheat price; *PMUS* = U.S. Gulf maize price.
λ_1 and ρ are the long-run and short-run coefficients, respectively.
Source: Authors' calculations.

For both wheat and maize, Gulf prices appear highly correlated to the CBOT future prices, given that the λ_l coefficient is highly significant and close to 1. The error correction model (ECM) parameters, also appear to be large, suggesting that departures from the long-run relationship are corrected rapidly in subsequent periods.

These results indicate that there is a near-perfect transmission of long-run price signals between the Chicago futures market and the average Gulf import prices relevant for the selected countries; this allows hypothesizing that the Chicago futures market is viable to hedge import price risks. However, in the short run, the relationship between reference export prices and

[10] Data for these three prices is reported in the IMF International Financial Statistics.

[11] The Augmented Dickey-Fuller and the Phillip-Perron tests were applied, both including time trend and constant. Lag orders were selected by minimizing the Akaike information criterion. Both tests suggest that the series of monthly Gulf prices as well as CBOT nearest futures are integrated of order one, or $I(1)$.

[12] The estimated values of the trend parameter τ was very small and not significantly different from zero; hence it did not make any difference in the estimates of λ_0.

Table 3
Variability of unanticipated cash price changes and hedged price changes for wheat and maize 1985–2008

		Wheat			Maize		
		1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12
Stdev of $(P_t - E_{t-k}(P_t))/P_t$ (percent)	$k = 2$	8.3	16.1	9.6	9.3	15.4	10.4
	$k = 4$	10.9	22.6	13.0	12.9	24.1	14.9
	$k = 6$	13.3	26.0	15.6	14.9	27.8	17.3
Stdev of $[(P_t - E_{t-k}(P_t)) - \beta(F_t - F_{t-k,t} - \tau_f - gi_{t-k,t})]/P_t$ (percent)	$k = 2$	5.2	7.3	5.5	4.1	4.8	4.2
	$k = 4$	5.3	7.3	5.6	4.1	4.8	4.2
	$k = 6$	5.3	7.3	5.6	4.1	4.8	4.2
Stdev of $[(P_t - E_{t-k}(P_t)) - \beta(F_t - (S_{t-k,t,a=0} + (1+\tau_o)r_{t-k}))]/P_t$ (percent)	$k = 2$	6.5	10.9	7.3	6.5	21.9	10.6
	$k = 4$	8.3	13.5	9.1	8.6	29.2	13.9
	$k = 6$	10.1	14.7	10.8	9.7	35.7	16.3

Source: Authors' calculations.

Table 4
Average ratio of the price of at-the-money wheat and maize options in Chicago Board of Trade to the futures price on which the option is written at various advance periods (k's) (percent)

	Wheat				Maize			
	1985–7 to 2005–12	2006–1 to 2006–12	2007–1 to 2007–12	2008–1 to 2008–12	1985–7 to 2005–12	2006–1 to 2006–12	2007–1 to 2007–12	2008–1 to 2008–12
$k = 2$	0.37	0.61	0.94	8.67	3.29	5.82	8.87	28.58
$k = 4$	0.48	0.64	0.74	9.08	4.63	7.13	7.59	44.01
$k = 6$	0.52	0.68	0.69	6.65	5.70	7.91	8.46	46.49

Source: Authors' calculations.

CBOT prices may not be perfect, and there are lags in the adjustment. As shown by the estimates of Eq. (17), the relation between cash and futures prices is more complex than assumed in Eq. (5); hence the optimal hedging strategy is more complex than assumed above, as well as in Faruqee et al. (1997). For instance, hedging a given import amount may require the allocation of variable shares to different futures contracts.

The definition of an optimal hedging dynamic strategy based on the dynamic relation between the country-level import price and the CBOT prices is beyond the scope of this article. Since, however, the steady-state relationship in Eq. (5) is econometrically robust, deviations in the optimal strategy from one based on the long-run relationship are expected to be small. Moreover, if the unanticipated price variance is reduced by hedging with the static rules simulated in this article—as the empirical results show—then it is to be expected that more complex rules, based on the dynamic relation in Eq. (17), will reduce it even further. Thus, in the simulations described below, the assumption is made that the value of the hedging parameter β in Eq. (15) is equal to the value of λ_1 reported in Table 2; and that the value of α corresponds to that of λ_0 in Eq. (20), and is also indicated in Table 2.

5. Results of hedging strategies with futures and options

Statistics of the measures in Eqs. (12)–(14) are presented first with reference to one unit of imports, in order to show separately the contributions of prices to the overall unpredictability of the import bills. Table 3 exhibits the relevant statistics in the form of standard deviations of the relevant percent changes.

Hedging with futures reduces considerably the unexpected variability of import prices for both wheat and maize, and for all periods simulated. The reductions are substantial, and as large as 72% in the recent price boom period. Standard deviations of futures hedging (the middle set of rows) are homogeneous across the different values of k, since the hedge ratio β is close to 1, as seen in Table 2. Hence, as per formula (15), the expression (13) reduces largely to the difference between the cash and futures price at time t, whose size is not significantly affected by changes in the *ex ante* futures price that varies with k.

In the strategy that includes options only, reductions in the variability of the unexpected price changes for wheat are still substantial for all simulation periods, and all values of k (last three rows of Table 3). Such reductions are smaller than those observed for the strategy based on futures only. This is consistent with the earlier theory, since options are not the optimal strategy. Maize shows mixed results, with reductions of unpredictability smaller than those based on futures only in the period before 2006. However, in the three year of the recent price spike, option-only-based strategies would have implied an increased unpredictability. This is due to the behavior of maize options prices in that period. Table 4 exhibits average ratios of the price of call option in CBOT to the price of the underlying future at which the option is written. For wheat, this ratio was smaller than 1% up to year 2006; but it showed a steady increase from 2006 and a large jump in 2008. This is the outcome of the

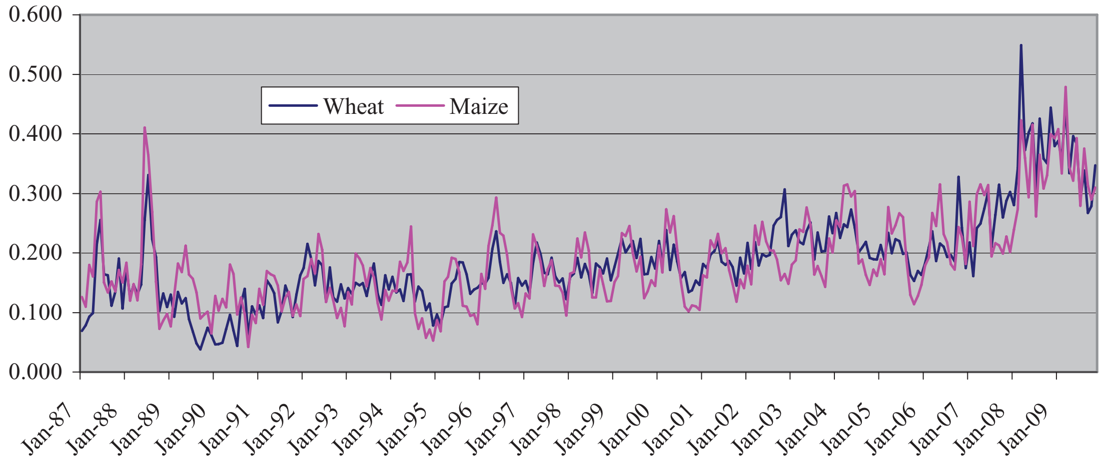

Fig. 1. Implied volatility of at-the-money options in the Chicago Board of Trade.

extreme unpredictability and underlying uncertainty about future price movements. For maize, the ratios appear to have been considerably larger for the whole pre-crisis period and then just as in wheat they increased steadily in the years 2006, 2007, and then jumped to very high values in 2008. It seems that there is generally more uncertainty and unpredictability in the maize market compared to the wheat market, and that something very particular affected the Chicago maize market in the peak of the crisis period, namely in 2008.

Such condition of extreme unpredictability is confirmed by Fig. 1, which shows the implied volatility of wheat and maize call options in the CBOT over the last two decades. The index shows a significant peak in 2008; the annual average values in 2008 compared to the averages for the period 1987–2005 were 137% higher for wheat and 105% higher for maize.

Concerning import bills, Table 5 indicates the unanticipated normalized standard deviations of monthly wheat import bill changes with and without hedging with futures only, for the same periods indicated in the previous table. Table 6 reports the same variables for hedging strategies exclusively based on at-the-money call options.

In all countries analyzed there seems to be substantial reductions in the unpredictability for all periods and for all values of k, when imports are hedged with futures (Table 5). The only exception is India, where unpredictability for $k = 4$ increased slightly with the future-based strategy and in the recent period 2006–2008. In general, reductions in unpredictability of import bills seem to be larger during the recent price boom period of 2006–2008 compared to the earlier period, with the notable exceptions of China and India.

Table 6 shows that if hedging was based on at-the-money options only, the unpredictability of wheat import bills would have also decreased considerably in most countries and periods, again with the exception of India for the recent period and $k = 4$. As expected from the discussion in Section 4, reductions are smaller with options. And they are larger for the crisis period in all countries, but China and India.

Tables 7 and 8 exhibit the same results for maize imports of a sample of LIFDCs. The futures-based strategies reduce unambiguously the unpredictability of maize import bills in all countries, periods, and values of k; and such reduction is mostly larger during the recent price spike period. Indonesia is the exception in this case, for $k = 4$. The results for option-based strategies (Table 8), instead, suggest that throughout the period prior to the recent price turbulence, hedging would have brought about a reduction in unpredictability, albeit smaller than the one obtained by hedging with futures only. However, this would not have been the case during the recent price peak period: unpredictability would have been higher for most maize-importing countries, had they hedged their imports in the CBOT using exclusively at-the-money options.

These unexpected results observed for maize and wheat imports (in India only), are the outcome of two combined occurrences: the high unpredictability of prices during the 2006–2008 spike, on the one hand, and the erratic monthly import patterns on the other. As mentioned, the high price level reached by maize and wheat options during 2007 and 2008—exhibited also in Table 4—was correctly reflecting the condition of extreme unpredictability of the market in that period, shown by the implied volatility of options in the CBOT (Fig. 1), which also peaked in 2008, and particularly in the summer months, and for maize. Options, therefore, were particularly expensive in that period.

Moreover, in some countries the import pattern employed in the simulation required that significant amounts of maize and wheat were to be purchased in the more critical months of 2007 and 2008. For maize, this is the case of Mozambique and Tanzania, which show the higher increases in unpredictability with hedging in 2006–2008 (Table 8). In the former country, for instance, the monthly import profile for maize required an inflow of 43,000 tons in August 2008 and of 45,000 tons in the subsequent month. These amounts are among the highest recorded in Mozambique over the sample period. Trying to hedge such a large amount of maize with options only in that

Table 5
Unanticipated normalized standard deviations of monthly wheat import bill changes with and without hedging with futures

	Unanticipated normalized standard deviation of monthly import bill changes without hedging			Unanticipated normalized standard deviation of monthly import bill changes, when hedged with futures only			Percent difference from unhedged		
	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12
	$k = 2$			$k = 2$			$k = 2$		
Bangladesh	10.0	21.1	16.4	6.0	5.9	6.2	−40.5	−72.1	−61.8
China	11.1	20.3	11.9	5.2	11.2	5.5	−53.3	−44.9	−53.3
Egypt	9.4	21.5	15.5	5.3	6.0	5.8	−43.1	−72.0	−62.6
India	24.3	27.7	41.3	14.0	25.7	35.4	−42.3	−7.2	−14.4
Indonesia	10.9	18.7	17.0	6.8	6.8	7.1	−37.8	−63.8	−58.5
Mozambique	9.4	15.0	14.9	6.9	7.9	8.4	−26.1	−47.2	−43.4
Nicaragua	13.8	23.6	18.8	7.0	8.1	7.7	−49.2	−65.6	−58.9
Pakistan	14.9	48.2	30.6	5.9	4.8	5.8	−60.1	−90.0	−81.2
Philippines	10.0	18.4	14.7	6.1	6.6	6.6	−39.2	−64.0	−55.1
Sudan	10.3	19.1	16.0	6.8	6.7	7.2	−34.5	−64.8	−54.9
Tanzania	11.8	26.8	33.8	9.4	6.9	10.3	−19.9	−74.3	−69.6
	$k = 4$			$k = 4$			$k = 4$		
Bangladesh	14.4	30.3	23.5	5.9	5.9	6.2	−58.7	−80.6	−73.4
China	16.0	27.0	17.1	5.2	11.2	5.5	−67.5	−58.5	−67.5
Egypt	12.3	23.1	17.8	5.3	6.0	5.8	−56.6	−73.9	−67.4
India	30.8	25.1	40.4	14.0	25.7	35.4	−54.4	2.4	−12.3
Indonesia	14.1	21.9	20.7	6.0	6.8	7.1	−57.3	−69.0	−65.9
Mozambique	12.6	22.2	21.5	6.9	7.9	8.4	−44.9	−64.3	−60.7
Nicaragua	21.5	32.8	27.4	7.0	8.1	7.7	−67.3	−75.3	−71.8
Pakistan	20.9	52.7	35.0	5.9	4.8	5.8	−71.7	−90.9	−83.6
Philippines	12.8	23.6	19.0	6.1	6.6	6.6	−52.6	−71.9	−65.2
Sudan	12.8	18.8	17.4	6.8	6.7	7.2	−46.9	−64.2	−58.5
Tanzania	14.3	24.8	31.8	9.4	6.9	10.3	−34.0	−72.3	−67.6
	$k = 6$			$k = 6$			$k = 6$		
Bangladesh	17.0	40.9	30.9	5.9	5.9	6.2	−65.1	−85.6	−79.8
China	19.7	35.1	21.0	5.2	11.2	5.6	−73.5	−68.0	−73.5
Egypt	14.6	27.6	21.7	5.3	6.0	5.8	−63.4	−78.2	−73.2
India	34.6	33.6	51.7	14.0	25.7	35.4	−59.4	−23.5	−31.4
Indonesia	15.8	26.3	25.0	6.0	6.8	7.1	−62.0	−74.3	−71.7
Mozambique	14.3	24.2	24.3	6.9	7.9	8.4	−51.7	−67.3	−65.3
Nicaragua	24.4	55.0	40.1	7.0	8.1	7.7	−71.2	−85.3	−80.7
Pakistan	27.0	63.2	42.7	5.9	4.8	5.7	−78.1	−92.4	−86.6
Philippines	14.9	24.1	21.0	6.1	6.6	6.6	−59.5	−72.6	−68.5
Sudan	14.8	21.5	20.7	6.8	6.8	7.2	−54.1	−68.4	−65.0
Tanzania	17.5	30.0	38.8	9.4	6.9	10.3	−46.0	−77.0	−73.5

Source: Authors' calculations.

particular period, given the lower requirements of the other months, would have resulted in a more variable expenditure compared to the one generated by transactions in the cash and futures markets. In the case of Tanzania, the monthly import patterns appear to be erratic, with peaks in few months such as May and July. In years 2007 and 2008 the high cost of hedging with options, arising from the particular condition of unpredictability, explains the counterintuitive results. For wheat imports in India, during 2008 requirements declined substantially compared to the previous two years, and the country shows a marked seasonal pattern of wheat imports, with low imports early in the calendar year, peaking in the middle of the year, and then declining. Also in this case, in the simulations this implied hedging large amounts especially when options were more expensive.

Apart from these exceptions, which pertain to options hedging during the price peak period, the other results show that it is possible to reduce unpredictability of import bills through hedging.

However, given that hedging is a costly activity, it is worth exploring the extent to which the simulated strategies can affect the level of the import bill, to understand whether more predictability requires higher import bills. This is certainly a relevant question for LIFDCs, albeit not the focus of this

Table 6
Unanticipated normalized standard deviations of monthly wheat import bill changes with and without hedging with at-the-money options

	Unanticipated normalized standard deviation of monthly import bill changes without hedging			Unanticipated normalized standard deviation of monthly import bill changes, when hedged with at-the-money options only			Percent difference from unhedged		
	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2005–12	1985–7 to 2008–12	2006–1 to 2008–12	1985–7 to 2008–12
	$k = 2$			$k = 2$			$k = 2$		
Bangladesh	10.0	21.1	16.4	7.6	12.7	10.7	−24.5	−40.0	−34.5
China	11.1	20.3	11.9	6.9	13.5	7.4	−37.9	−33.5	−37.9
Egypt	9.4	21.5	15.5	6.4	13.1	10.0	−31.6	−39.3	−35.9
India	24.3	27.7	41.3	20.7	25.5	37.4	−14.9	−7.8	−9.3
Indonesia	10.9	18.7	17.0	7.7	11.6	11.2	−29.3	−37.9	−34.5
Mozambique	9.4	15.0	14.9	8.1	8.1	10.5	−13.3	−45.9	−29.6
Nicaragua	13.8	23.6	18.8	9.5	9.1	9.8	−31.6	−61.3	−47.8
Pakistan	14.9	48.2	30.6	9.0	29.9	19.4	−39.6	−38.0	−36.6
Philippines	10.0	18.4	14.7	7.6	11.6	10.1	−23.2	−36.8	−31.3
Sudan	10.3	19.1	16.0	8.1	12.1	11.0	−21.6	−36.9	−31.4
Tanzania	11.8	26.8	33.8	11.6	17.0	22.7	−2.1	−36.7	−32.9
	$k = 4$			$k = 4$			$k = 4$		
Bangladesh	14.4	30.3	23.5	10.3	15.1	13.4	−28.1	−50.1	−43.1
China	16.0	27.0	17.1	9.1	16.1	9.7	−43.3	−40.2	−43.2
Egypt	12.3	23.1	17.8	8.3	10.9	9.8	−32.2	−52.7	−45.0
India	30.8	25.1	40.4	29.2	26.1	39.6	−5.1	3.9	−2.0
Indonesia	14.1	21.9	20.7	9.7	10.7	11.4	−30.8	−51.3	−45.1
Mozambique	12.6	22.2	21.5	10.4	11.2	12.3	−17.5	−49.4	−42.6
Nicaragua	21.5	32.8	27.4	15.4	10.8	14.5	−28.7	−67.0	−47.3
Pakistan	20.9	52.7	35.0	14.5	30.2	21.7	−30.6	−42.7	−38.1
Philippines	12.8	23.6	19.0	9.1	11.7	10.9	−28.7	−50.4	−42.8
Sudan	12.8	18.8	17.4	9.7	9.1	10.2	−23.6	−51.7	−41.4
Tanzania	14.3	24.8	31.8	12.8	14.8	20.3	−10.4	−40.6	−36.3
	$k = 6$			$k = 6$			$k = 6$		
Bangladesh	17.0	40.9	30.9	12.4	21.1	17.6	−27.5	−48.3	−43.0
China	19.7	35.1	21.0	10.8	21.9	11.5	−45.2	−37.6	−45.0
Egypt	14.6	27.6	21.7	10.0	12.7	11.6	−31.9	−54.0	−46.6
India	34.6	33.6	51.7	29.3	28.2	42.4	−15.2	−16.1	−18.0
Indonesia	15.8	26.3	25.0	10.5	12.3	12.8	−33.2	−53.1	−48.7
Mozambique	14.3	24.2	24.3	11.4	12.1	13.4	−20.5	−49.8	−44.7
Nicaragua	24.4	55.0	40.1	18.6	26.7	22.9	−24.0	−51.6	−42.8
Pakistan	27.0	63.2	42.7	19.8	36.5	27.2	−26.7	−42.2	−36.3
Philippines	14.9	24.1	21.0	10.5	11.4	11.5	−29.9	−52.9	−45.1
Sudan	14.8	21.5	20.7	11.0	8.7	10.9	−25.6	−59.2	−47.3
Tanzania	17.5	30.0	38.8	16.1	16.2	22.5	−7.7	−46.0	−42.0

Source: Authors'calculations.

article. Tables 9 and 10 exhibit, for wheat and maize, respectively, the simulated changes in actual average *ex post* import bills that would have occurred had the countries of our sample hedged with futures and at-the-money options. For most LIFDCs, during 1985–2005, routine hedging with futures only would have affected slightly the average size of the countries' wheat import bill. The simulated changes range from a minimum of −1.8% for China (for $k = 6$) to a maximum of 5.1% for Tanzania (also for $k = 6$). For most countries, changes are between −1% and 3%. In 2006–2008, during the commodity price spike, simulations show that hedging would have reduced the average wheat import bills in most countries of our sample, with some exceptions. Changes range from a minimum of −9.4% (Sudan for $k = 6$) to a maximum of 7.6% (Pakistan for $k = 2$). Increases in the wheat import bills pertain to only one to three countries, depending on the value of k. This suggests that the substantial increase in the predictability of wheat import bills shown earlier does not appear to be earned at the expense of much higher import bills.

Turning to hedging with at-the-money options, the simulated changes in the average cost of wheat import bills during the normal period seem to be more pronounced than those

Table 7
Unanticipated normalized standard deviations of monthly maize import bill changes with and without hedging with futures

	Unanticipated normalized standard deviation of monthly import bill changes without hedging			Unanticipated normalized standard deviation of monthly import bill changes, when hedged with futures only			Percent difference from unhedged		
	1985–1 to 2005–12	2006–1 to 2008–12	1985–1 to 2008–12	1985–1 to 2005–12	2006–1 to 2008–12	1985–1 to 2008–12	1985–1 to 2005–12	2006–1 to 2008–12	1985–1 to 2008–12
	$k = 2$			$k = 2$			$k = 2$		
Egypt	11.4	14.4	13.8	5.5	5.0	5.7	−51.8	−64.9	−58.8
Indonesia	16.8	34.1	25.7	7.6	8.6	8.6	−54.4	−74.7	−66.5
Kenya	16.9	26.7	22.9	6.8	6.1	6.9	−59.8	−77.0	−69.9
Malawi	17.3	29.1	19.5	9.3	14.7	10.2	−46.3	−49.6	−47.8
Mozambique	11.2	32.8	15.7	4.6	7.2	5.1	−58.4	−78.2	−67.7
Tanzania	20.3	12.6	19.0	9.5	4.3	8.6	−53.1	−66.1	−54.9
	$k = 4$			$k = 4$			$k = 4$		
Egypt	16.1	20.1	19.8	5.5	5.0	5.7	−66.0	−74.9	−71.3
Indonesia	23.4	26.2	26.0	7.6	8.6	8.6	−67.4	−67.1	−66.9
Kenya	25.7	49.4	40.0	6.8	6.1	6.9	−73.6	−87.6	−82.7
Malawi	29.1	60.0	35.1	9.3	14.6	10.2	−68.1	−75.6	−70.9
Mozambique	16.6	34.8	20.1	4.7	7.2	5.0	−71.9	−79.4	−74.8
Tanzania	23.2	24.9	24.3	9.5	4.3	8.6	−59.2	−82.9	−64.7
	$k = 6$			$k = 6$			$k = 6$		
Egypt	18.1	22.6	23.1	5.5	5.1	5.7	−69.8	−77.7	−75.4
Indonesia	26.8	24.8	27.9	7.6	8.7	8.6	−71.6	−65.1	−69.2
Kenya	35.9	51.6	46.9	6.8	6.1	6.9	−81.1	−88.1	−85.3
Malawi	33.0	65.8	39.5	9.3	14.6	10.2	−71.8	−77.8	−74.2
Mozambique	21.0	35.2	23.9	4.7	7.2	5.1	−77.7	−79.6	−78.8
Tanzania	27.3	40.2	32.6	9.4	4.2	8.6	−65.4	−89.5	−73.7

Source: Authors' calculations.

exhibited under futures hedging. Changes in the level of the import bill during this period range from a minimum of −3.9% (China for $k = 6$) to a maximum of 9.5% (India for $k = 6$). During the latest period, however, most countries would have achieved considerable reductions in their wheat import bills—with the exception of Pakistan—ranging from 0.1% (Tanzania for $k = 2$) to as much as 14.6% (Pakistan for $k = 6$). This suggests that while hedging with options leads to a smaller reduction in unpredictability compared to hedging with futures, as seen above, it may lead to considerable reductions in actual import bills during a spike period.

As for maize, for the period prior to the 2006–2008 price spike, hedging with futures only in most cases appears to bring about an increase in the import bill. However, this was not the case during the price spike period, when there would have been substantial reductions in almost all countries in the sample, and potentially as high as 18.9% (Malawi for $k = 6$). The only exception is Mozambique for $k = 2$, where hedging with futures in 2006–2008 would have resulted in a slight increase in maize import bills, of 1.3%.

Hedging with options only yields mixed results; but for most countries they suggest that the average import bill would have been higher both during the normal period as well as over the crisis period. Malawi and Tanzania are exceptions, as hedging with Chicago options would have reduced the average maize import bill during the price spike by significant amounts for some values of k.

6. Concluding remarks and implications for import strategies

The results of the simulations suggest that hedging wheat and maize imports by agents in several LIFDCs using futures and options in the CBOT exchange can be a viable strategy to reduce the unpredictability of basic food import bills. The scope for the reduction in unpredictability in normal periods seems larger when hedges are made with futures compared to hedging with options only. The reason for this result appears to be that prices in the CBOT futures market for wheat and maize are highly correlated with the major export markets; and given that they incorporate most of the available world trade information, they are likely to be unbiased. The simulated reductions in unpredictability are substantial for both wheat and maize for most countries. Despite the cost of hedging with futures and options, it appears that overall the actual cost of food imports does not increase because of the addition of hedging as part of the food import strategies.

An important result is that simulated reductions in unpredictability were significant also during the recent commodity

Table 8
Unanticipated normalized standard deviations of monthly maize import bill changes with and without hedging with at-the-money options

	Unanticipated normalized standard deviation of monthly import bill changes without hedging			Unanticipated normalized standard deviation of monthly import bill changes, when hedged with at-the-money options only			Percent difference from unhedged		
	1985–1 to 2005–12	2006–1 to 2008–12	1985–1 to 2008–12	1985–1 to 2005–12	2006–1 to 2008–12	1985–1 to 2008–12	1985–1 to 2005–12	2006–1 to 2008–12	1985–1 to 2008–12
	$k = 2$			$k = 2$			$k = 2$		
Egypt	11.4	14.4	13.8	7.9	26.0	20.9	−30.8	81.2	51.0
Indonesia	16.8	34.1	25.7	12.2	13.0	14.0	−27.4	−61.8	−45.4
Kenya	16.9	26.7	22.9	8.9	74.1	53.3	−47.5	177.2	132.8
Malawi	17.3	29.1	19.5	12.7	28.5	15.9	−26.8	−2.1	−18.4
Mozambique	11.2	32.8	15.7	7.9	35.9	15.1	−29.6	9.3	−4.0
Tanzania	20.3	12.6	19.0	14.3	101.2	53.4	−29.6	701.9	181.4
	$k = 4$			$k = 4$			$k = 4$		
Egypt	16.1	20.1	19.8	10.1	45.5	35.4	−36.9	125.7	78.6
Indonesia	23.4	26.2	26.0	15.6	17.1	18.3	−33.4	−34.7	−29.6
Kenya	25.7	49.4	40.0	11.7	73.6	53.4	−54.4	49.0	33.5
Malawi	29.1	60.0	35.1	16.9	115.1	46.6	−42.1	92.0	32.8
Mozambique	16.6	34.8	20.1	10.2	52.6	22.0	−38.4	51.1	9.5
Tanzania	23.2	24.9	24.3	18.7	96.9	53.9	−19.2	289.8	121.7
	$k = 6$			$k = 6$			$k = 6$		
Egypt	18.1	22.6	23.1	10.8	44.1	34.2	−40.3	94.9	48.1
Indonesia	26.8	24.8	27.9	17.0	19.3	20.0	−36.6	−22.1	−28.3
Kenya	35.9	51.6	46.9	17.3	67.6	49.9	−51.7	31.1	6.3
Malawi	33.0	65.8	39.5	19.1	98.8	41.3	−42.1	50.3	4.6
Mozambique	21.0	35.2	23.9	13.4	145.2	55.1	−36.4	312.9	130.7
Tanzania	27.3	40.2	32.6	19.1	61.7	36.0	−30.0	53.2	10.6

Source: Authors'calculations.

price boom period; in some instances, reductions were even larger than in normal times. This suggests that during turbulent periods, considerable advantage in import bill management can be obtained by the use of organized futures and options markets.

As organized futures and options markets in the CBOT are likely to be efficient, no agent can be expected to make profits in the long run from applying the simple hedging rules simulated here. Hence the motivating force for hedging can be predictability and improved planning, and not profitability, which may rather motivate private investors. Nevertheless, it was shown that there can also be benefits in terms of reductions in the average cost of imports, albeit it is not clear whether this result is due to the particular history of prices observed, or can be generalized.

Of notable interest is the result that hedging with options could have reduced considerably not only the unpredictability, but also the average cost of wheat import bills during the recent commodity price spike, albeit not so for maize. The reason for this asymmetry may have to do with the particular workings of these markets, with the Chicago wheat market being perhaps more representative of the global wheat market than maize, and the fact that market uncertainty about subsequent prices reached unprecedented levels for maize at the height of the crisis. As such, spikes are one-off events with their own particularities, which are unlikely to replicate in the same form; this may not be unexpected.

Apart from the reduction in unpredictability, there may be benefits deriving from the insurance through hedging such as, for instance, that the overall quantity of imports may increase, thus resulting in higher domestic food supplies, and possibly improved domestic food security

The existence of significant transmission of price signals for the commodities chosen among the major export markets with CBOT confirmed that this market offers viable hedging opportunities for wheat, albeit less so for maize.

A number of *caveats* are in order when considering the results of the simulations. First, given the importance of the countries involved in global wheat and maize imports, one may question whether their involvement in the CBOT would influence the price determination process in the exchange. Second, as mentioned, the simulations are based on a comparison with purely commercial transactions in the spot market, whereas it is known that for many of the selected countries, concessional transactions make up a considerable share of cereal imports. Third, it may be that a dynamic hedging strategy along with the seasonal import pattern, and possibilities for substitution among food products, may make a difference to outcomes.

Table 9
Differences between unhedged and hedged wheat import bills

	Average monthly import bills without hedging (‘000 US$)		Average monthly import bills with futures hedging (percent difference from average unhedged import bills)		Average monthly import bills with at-the-money options hedging (percent difference from average unhedged import bills)	
	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12
	$k = 2$					
Bangladesh	19001	41690	−0.3	−0.6	−1.4	−1.6
China	80701	3370	−0.7	−0.8	−2.3	−1.3
Egypt	80816	161110	0.0	−0.3	−1.2	−1.9
India	8696	54177	2.7	−5.3	4.5	−5.4
Indonesia	39354	107564	0.3	−1.4	2.1	−2.4
Mozambique	2406	7051	0.5	−3.9	1.5	−3.9
Nicaragua	1254	2512	0.0	−3.2	1.4	−3.5
Pakistan	19523	34622	−1.0	7.6	1.7	1.8
Philippines	25505	54984	0.3	−1.4	2.5	−2.4
Sudan	9230	22000	0.5	−1.1	−0.1	−2.4
Tanzania	1852	10168	1.3	2.4	3.2	−0.1
	$k = 4$					
Bangladesh	19001	41690	0.7	−1.2	−1.9	−4.9
China	80701	3370	−1.0	0.9	−3.2	−4.9
Egypt	80816	161110	0.8	−3.5	−1.6	−7.1
India	8696	54177	3.7	−6.4	5.6	−9.5
Indonesia	39354	107564	1.2	−4.0	2.0	−7.5
Mozambique	2406	7051	1.7	−5.3	1.2	−11.2
Nicaragua	1254	2512	1.6	−4.6	1.9	−7.0
Pakistan	19523	34622	0.5	5.8	2.2	−0.8
Philippines	25505	54984	1.1	−3.3	2.4	−7.8
Sudan	9230	22000	1.6	−5.3	−0.8	−8.9
Tanzania	1852	10168	3.2	0.5	3.2	−4.9
	$k = 6$					
Bangladesh	19001	41690	1.1	−3.5	−2.9	−6.2
China	80701	3370	−1.8	−0.2	−3.9	−3.1
Egypt	80816	161110	1.1	−7.5	−2.2	−10.6
India	8696	54177	2.7	−8.8	9.5	−0.3
Indonesia	39354	107564	1.5	−7.9	1.6	−11.7
Mozambique	2406	7051	2.2	−8.7	−0.4	−7.4
Nicaragua	1254	2512	2.0	−3.3	0.7	−7.8
Pakistan	19523	34622	1.0	2.5	5.6	1.5
Philippines	25505	54984	1.5	−8.1	1.5	−12.0
Sudan	9230	22000	2.2	−9.4	−2.9	−14.6
Tanzania	1852	10168	5.1	−2.7	2.4	−7.0

Source: Authors’ calculations.

Finally, it was pointed out that these rules will reduce neither the risks involved in variable transactions costs, or transport costs, nor the risks involved in foreign exchange. Some of these risks may be substantial in developing countries, and since they cannot be diversified through the rules simulated here, they may diminish the effectiveness of hedging. Foreign exchange risk can be dealt with in foreign exchange futures and options markets, and it may be possible to hedge also some of the transport costs in organized markets. Also, it might be possible to hedge part of the basis risk, which may be large for some countries, through organized regional exchanges. This may be possible in some of the countries included in our sample, such as India, China, and South Africa. However, it is not clear that such exchanges offer good hedging media for imports to be purchased internationally. These issues call for more extensive research that might involve additional products and markets.

The implications in terms of development policy are that many LIFDCs may benefit from encouraging their main import agents to institute more predictable food import expenditure schemes based on the hedging rules of the type suggested in this article. Even if the average monetary benefits are small in the long run, the indirect benefits from increased predictability can be large in terms of securing food supplies, and hence the assurance for many developing countries that they will not have

Table 10
Differences between unhedged and hedged maize import bills

	Average monthly import bills without hedging (‘000 US$)		Average monthly import bills with futures hedging (percent difference from average unhedged import bills)		Average monthly import bills with at-the-money options hedging (percent difference from average unhedged import bills)	
	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2005–12	2006–1 to 2008–12
	$k = 2$					
Egypt	25918	59112	0.9	−2.6	5.0	11.6
Indonesia	5677	10316	1.3	−6.2	8.7	−1.1
Kenya	5046	8941	−2.4	−5.2	8.6	20.6
Malawi	4776	4345	−4.7	−14.3	−3.5	−7.3
Mozambique	1986	2013	1.2	1.3	3.1	9.9
Tanzania	556	835	2.0	−3.0	0.1	23.0
	$k = 4$					
Egypt	25918	59112	2.3	−6.2	6.3	12.2
Indonesia	5677	10316	2.3	−5.4	9.7	2.4
Kenya	5046	8941	−1.6	−10.7	8.4	12.5
Malawi	4776	4345	−3.0	−10.1	−2.2	9.6
Mozambique	1986	2013	2.9	−5.4	4.1	10.0
Tanzania	556	835	3.4	−7.7	1.8	25.6
	$k = 6$					
Egypt	25918	59112	3.2	−10.6	7.4	5.6
Indonesia	5677	10316	3.3	−6.9	11.1	0.2
Kenya	5046	8941	0.2	−17.6	9.1	3.8
Malawi	4776	4345	−3.4	−18.9	−1.3	1.7
Mozambique	1986	2013	4.7	−11.2	5.6	32.0
Tanzania	556	835	4.9	−16.3	2.6	−6.9

Source: Authors’ calculations.

to reallocate development funds to deal with short-term food crises. This, in turn, could lead to a more orderly pattern of public investments and hence potentially faster growth.

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