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

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ABSTRACT

The paper considers the possibility of insuring the price risks of wheat and maize imports of low-income food-deficit countries (LIFDCs), as a way to insure one part of their external commodity risks. Under the assumption that the objective of food import planners is to minimize the conditional variance of import bills, the optimal hedge strategies when the importing agent can hedge with futures or options, are derived. Subsequently a set of LIFDCs that account for a large share of the LIFDC wheat and maize imports is considered. It is shown that the prices in the US Gulf, which is the main world reference market for the wheat and maize imports of the LIFDCs, are significantly related to the futures prices of the Chicago Board of Trade (CBOT), thus opening the possibility of CBOT being a hedging market for LIFDC wheat and maize imports. Simulations of the optimal hedging rules are conducted for the period 1986-2002 with actual CBOT futures and options data to explore the possibility of reducing unpredictability of import bills. It is shown that hedging with futures offers superior opportunities for reducing unpredictability over a short period before the actual import orders, while hedging with options appears to offer better possibilities for ensuring import bill predictability over longer lead times.

RÉSUMÉ

Ce document étudie la possibilité d'assurer les risques liés au prix des importations de blé et de maïs des pays à faible revenu et à déficit vivrier (PFRDV) afin de mitiger en partie les risques externes qui affectent les produits dont ils ont besoin. L'hypothèse étant que ceux qui planifient les importations de produits alimentaires essaieront de minimiser les variations de la facture des importations, il est possible de formuler des stratégies optimales de couverture des risques fondées sur le recours par l'importateur à des marchés à terme ou à des options. Le document étudie ensuite une série de PFRDV qui représentent une large proportion des importations de blé et de maïs de ces pays, et montre que les prix départ du Golfe du Mexique, aux États-Unis, qui sont les principaux prix mondiaux de référence pour les importations de blé et de maïs des PFRDV, sont directement liés aux prix des marchés à terme cotés à la Bourse des produits de Chicago (CBOT), ce qui offre la possibilité d'utiliser celle-ci comme moyen de couverture des importations de blé et de maïs de ces pays. Le document présente des simulations des méthodes de couverture optimales pour la période 1986-2002, sur la base des cours effectifs des marchés à terme et des options à la Bourse des produits de Chicago, pour étudier la possibilité de réduire l'imprévisibilité des factures d'importation. Le document montre qu'une couverture fondée sur des marchés à terme offre de meilleures possibilités de réduire l'imprévisibilité au cours de la période précédant immédiatement les commandes effectives d'importation, tandis qu'une couverture au moyen d'options paraît offrir de meilleures possibilités de garantir la prévisibilité des factures d'importation à plus longue échéance.

RESUMEN

El documento examina la posibilidad de asegurar los riesgos en los precios de importación de trigo y maíz en países de bajos ingresos y con déficit de alimentos (PBIDA), como una manera de asegurar una parte de los riesgos externos de sus productos básicos. Suponiendo que el objetivo de los encargados de planificar las importaciones de alimentos sea reducir al mínimo la variación condicional de la facturación, las estrategias de salvaguardia óptimas surgen cuando el agente importador puede proteger mediante futuros u opciones. En consecuencia, se analiza un grupo de los PBIDA que supone una gran fracción de las importaciones de trigo y maíz. Se señala que los precios en la zona del golfo de los Estados Unidos de América, que es la principal referencia del mercado mundial para las importaciones de trigo y maíz de los PBIDA, están relacionados de manera indicadora con los precios futuros del Chicago Board of Trade (CBOT), lo que permite la posibilidad de que el CBOT se convierta en un mercado de protección para las importaciones de trigo y maíz de los PBIDA. Se computan simulaciones de las reglas de protección óptimas para el período 1986-2002 con datos de futuros y opciones del CBOT para estudiar la posibilidad de reducir la imprevisibilidad de las facturaciones de la importación. Se indica que la protección con futuros brinda mejores oportunidades para reducir la imprevisibilidad en un corto período de tiempo previo al concreto pedido de importación, mientras que la protección con opciones pareciera brindar mejores posibilidades para asegurar la previsibilidad de los costos por importación en períodos de preaviso más largos.

CONTENTS

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1 INTRODUCTION

One of the important trends in world agricultural trade that has been observed in the last decade is the shift of developing countries from being net agricultural exporters before the 1990s to being net agricultural importers (Bruinsma, 2003). Projections to 2030 indicate a deepening of this trend (*ibid*.). The trend comes about because of the projected decline of exports of traditional agricultural products from developing countries (such as tropical beverages and bananas) combined with projected large and growing deficits in basic foods, such as cereals, meat, dairy products and oil crops. Within developing countries those classified as Least Developed Countries (LDCs[1]) have seen an agricultural trade balance that has worsened at a very fast pace in the last fifteen years. Since 1990, the food import bills of LDCs have not only increased, but also constituted more than 50 percent of their total merchandise exports in all years, while the food import bills of other developing countries (ODCs) as a share of merchandise exports have stayed the same or declined (FAO 2004).

A recent FAO study (Gürkan et al 2003) has indicated that between the mid-1980s and 1990s, the LDCs were under economic stress when importing the food they needed to maintain their national food security. The food they imported gradually reached, on average, about 12 percent of their apparent food consumption by the end of the millennium. While this is not necessarily a negative outcome, as it may be due to domestic production restructuring along comparative advantage lines, the study showed that throughout this period, the growth in these countries' commercial food import bills consistently outstripped the growth of their GDP as well as total merchandise exports. Relief was at hand only during the past few years, when international prices of many food commodities reached historical lows because of a confluence of diverse factors. The study also revealed that these countries faced large and unanticipated price 'spikes' that exacerbated their already precarious food security situation. Indeed, it was discovered that variations in import unit costs of many important food commodities contributed to around two-thirds of the variation in their commercial food import bills. Coupled with substantial declines in food aid flows over the same period, these developments have meant a significant increase in the vulnerability of these countries.

In the light of the above developments, it seems that the problem of managing the risks of food imports is increasing in importance, and is already a major issue for several low-income food-deficit countries (LIFDCs[2]). The major problem of LIFDCs is not price or quantity variations per se, but rather major unforeseen and undesirable departures from expectations. The purpose of this paper is to explore how LIFDCs can manage some of the risks facing their economies, due to fluctuating and unpredictable world prices for basic foods.

The issue of food import risk for LIFDCs has been discussed extensively for some time, especially since the commodity crisis of the early 1970s, and several proposals for international food insurance schemes have appeared (for an early review see Konandreas et al 1978). The issue of financing of food imports by LIFDCs figured prominently in the discussions leading to the Uruguay Round Agreement (which, among other things, led to the creation of the World Trade Organization, WTO), and gave rise to the "*Decision on measures concerning the possible negative effects of the reform programme on least-developed and net food-importing developing countries"***,** also known as the Marrakesh Decision. In the Marrakesh Decision, 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."

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[1] There are 49 developing countries, currently classified by the World Trade Organization (WTO) as well as by the United Nations as "Least Developed".

[2] According to the FAO definition, which is also used by the rest of the United Nations, there are currently 86 developing countries that are classified as low-income food-deficit countries (LIFDCs). This list is updated annually.

Subsequent FAO and UNCTAD analysis (FAO, 2003) showed that these risks and short term difficulties arise largely from unexpected price developments in international commodity markets or adverse domestic production developments. It also showed that the major constraint facing low-income food-importing developing countries is the credit ceiling imposed by developed country on import financing for such countries. Such credit limits relate to the foreign exchange constraints facing such countries. Since imports of food are closely related to food security objectives of many low income countries, the proper management of foreign exchange needs and risks related to food imports is crucial. In particular it is important that unpredictable needs for foreign exchange required to import food does not create restrictions in imports in other important sectors of an economy.

Food import risks have not been a key issue in the recent policy debate, both internationally as well as nationally, for several reasons. First, there have been ample supplies of basic foods commercially available for export from developed and other cereal exporting countries, at prices that have been secularly declining. Second, despite the fact that there have been some price spikes in recent years, the crisis situation of the early-mid 1970s has not occurred since then. Third, food aid, while declining, has continued to flow, alleviating many of the immediate concerns.

Nevertheless, new problems are arising, which suggest that the issue of food imports may loom large in the near and medium term future. In particular, given the secular decline in prices of many primary commodities on which several LIFDCs are dependent for export revenues, these countries are becoming increasingly unable to meet commercial food import demands, despite secular declines in the prices of basic foods. In addition, and given simultaneous dependence on commodity exports, price instability is becoming a problem not only on the export but also on the import side. As different commodity prices do not move together, the likelihood of high import prices, in the face of low export prices, is real, and presents new challenges for policy. International price volatility has not declined, and, if anything, has remained at high levels.

The liberalization of domestic markets, and the continuing instability of international markets, creates considerable risks for LIFDCs, which, unless dealt with, can lead to food insecurity and increased vulnerability of the poor. The development of a variety of risk management instruments in international markets, such as futures and especially options for basic food commodities, presents opportunities for managing the risks that LIFDCs face in a more organised and cost effective manner.

It thus becomes important to examine whether there are nationally based strategies to deal with the food import risk management problem. This paper deals with this issue, by examining how a number of LIFDCs would have fared in the past, had they adopted market based risk management strategies.

The only other paper in the literature to deal with a similar issue with actual futures prices is the one by Faruqee et al (1997). In their analysis of Pakistan’s wheat imports, however, they utilized data for only one year, and this opens their analysis to the criticism that their positive results (which favoured the use of futures) could have depended on the specificity of the particular year, or the particular import pattern of that country. Furthermore, they only used a particular hedging rule, and did not explore alternatives. Earlier research by Sarris (2000) proposed and analyzed an import insurance scheme similar to what is analyzed in this paper, but without utilising actual options and futures data.

In this paper we consider the wheat and maize imports of several of the major LIFDCs, and examine in a counterfactual manner the possible benefits or losses that they could have incurred, in terms of reduced variance of unpredictable foreign exchange costs, over a past period of time, had they combined their cash imports with easy to apply and transparent hedging strategies, using futures. We use actual import as well as futures data to implement the simulations, and explore a variety of rules.

Section 2 below discusses some issues concerning food imports of developing countries. In section 3 the methodology of the analysis, as well as our data are presented. In section 4 we explore econometrically the world wheat and maize markets and in particular the relationship between the import prices of the selected countries, and the reference international prices, as well as the prices in Chicago, the largest futures and options market for wheat and maize in the world. In section 5 we present the results of our simulations for individual countries, while in section 6 we explore results when all countries are pooled together. In section 7 we consider sensitivity analysis of the results, and in the final section we summarize our results and the policy conclusions.

2 ISSUES RELEVANT TO FOOD IMPORTS OF LIFDCS

In the context of the WTO discussions concerning follow-up to the Marrakesh Decision, the WTO fourth Ministerial Conference in Doha, established an Inter-agency Panel[3] with the objective, among others, *"...to explore ways and means for improving access by least developed and net food importing developing countries[4] to multilateral programs and facilities to assist with short term difficulties in financing normal levels of commercial imports of basic foods...*". This panel produced a report in June 2002 (WTO, 2002). In the same context FAO has sponsored a study carried out by UNCTAD to explore the mechanisms for financing imports of basic foodstuffs (FAO, 2003).

The FAO-UNCTAD study contains an extensive discussion of the current state of food import trade by developing countries. It notes that while state entities still play a very important role in the exports of some basic foods in some LIFDCs, food imports have been mostly privatized in recent years, although there are exceptions, and in some countries state agencies operate alongside private importers.

The biggest problem highlighted by the report is that private traders in LIFDCs do not always have access to import finance, unless they are part of an international group. Furthermore, financing conditions for food imports differ considerably across countries and products. Since credit relations involve the issues of who provides the finance, and who takes the risk, credit relations - and hence food imports - can be constrained by finance capacity as well as risk-taking capacity. It is pointed out that in both areas there are severe constraints in developing countries. These may imply higher interest rates for food import financing, and a disproportionate shift of the burden of risk to developing countries, if there is limited risk bearing capacity between developed country financiers and developing country counterparties as well as between developing country banks and their local trading clients. Both constraints imply smaller food imports with direct consequent implications for domestic food availability, and domestic prices, as well as food security. The report suggests that the major constraint is risk bearing capacity, rather than absolute lack of finance. There appears to be no empirical study to date on how credit and risk bearing capacity constraints affect the level of food imports in LIFDCs.

The major problem with risk is that developing country clients, whether they are importers or banks, are generally considered as risky counterparts by developed country traders and banks. It is in this context that the notions implicit in this paper and earlier ones must be examined. While in the case of Pakistan, examined by Faruqee et al (1997), government agencies did the importing, and hence it was straightforward to examine hedging strategies by them, in the case of LIFDCs whose food import trade is all in private hands, one must think about which could be the agent implementing the risk management strategies that are analyzed here.

There are three types of agents one can think of that could utilize the type of strategies explored in this paper. First are the large import traders themselves (private or publicly owned), who have enough resources and international connections to do the hedging themselves. In their case, assuming that they can obtain the financing for their imports domestically or internationally, the problem is to repay the loan after selling the imported product in the domestic market. Hence the risk they face relates to the possibility of the domestic price (namely the international price after import and marketing costs) moving against (namely lower than) the international price at which imports have been obtained. Another risk that these agents face concerns the timing of the import orders. Given their knowledge of the domestic market, they may have advance information concerning the amounts of imports needed at given periods during the year. However, while they may know this several months in advance, they may need to plan for these imports in advance to avoid unpredictable price movements in the international market.

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[3] The agencies represented include the World Bank, the IMF, the International Grains Council, FAO, and UNCTAD.

[4] The WTO group of net food importing developing countries (NFIDCs) comprises 22 developing countries that are WTO members. While most of these countries are also in the FAO group of 86 LIFDCs, the large difference is due to the fact that many LIFDCs are not WTO members.

The second type of agent that may need risk management strategy is the local banks that finance import trade. Their problem is the risk of non-repayment by the food importers that have obtained loans to import basic food.

The third type of agent is the central bank of a country, which may need to plan on allocations of scarce foreign exchange, including external loans, well in advance of the requirements of the various domestic banks or other agents. Given that food imports are a crucial part of a LIFDC's imports, related to domestic food security, unexpected price variations may influence adversely the allocation of foreign exchange to other sectors, and create problems in other productive sectors. Hence this unpredictability may need to be managed actively.

For the sequel we will not be concerned with the particular institutional character of the agent that does the physical importing or financing of imports. We will refer to an "agent" as the institution that does both the actual importing as well as the hedging, knowing full well that in an actual country situation, the relevant import related and financing functions may be split among various institutions. This assumption is made, in order to concentrate on the hedging strategies, rather than on the specific institutional arrangements in any food importing country. Nevertheless, it is assumed that the agent will need to plan for imports (in physical or financial terms) ahead of the actual time that imports are needed to be ordered.

3 METHODOLOGY

Consider an agent who needs to plan imports of some basic food into a LIFDC. The analysis will concentrate on wheat and maize imports. Wheat and maize are two of the most widely traded cereals, have well established cash, futures and options markets, and are imported by many LIFDCs. Of course, many LIFDCs import more than just wheat and maize. Depending on the country, food imports may include rice, other cereals, as well as other staples. It is not clear whether there is any short term substitution between the various types of food imported by a given country. In any case we will examine the wheat and maize parts of food imports only, assuming implicitly that the presence of the hedging would not affect the short term quantities imported of either wheat or maize. This, of course, may not be correct, as the capacity to manage risks better may increase the possibilities as well as the amounts of food imports. This, however, is beyond the objectives of this paper.

The problem posed is the following. In the course of a year, the agent will need to import a certain amount of wheat and/or maize for delivery to the country's border in given months. We shall assume that the agent knows the amounts to be imported in every month several months ahead. This assumption is necessary in order to justify the need for hedging. If this knowledge is available only with a short lag, say one month, then there is no point in hedging, as it normally takes a period of about one month or so (depending on the distance and other trade related specificities etc. between the exporter and the importer) from the actual ordering of some wheat or maize, until the shipments arrive at the port or entry point of the importing country. Hence, in such a case the optimal strategy would be to order only on a cash basis. However, in most countries, the total requirements or demand for cereal and other food imports, as well as the likely pattern of imports, will be known some time in advance by traders, as well as other market participants, especially since domestic production conditions become clear normally several months before the onset of the marketing year. Of course, the assumption is not perfectly valid, as the monthly requirements may not be exactly known many months in advance. This will invariably influence the hedge rules of the agent, but for this paper we shall assume that this uncertainly is non-existent.

In order to expose simply the theory behind the hedging rules, assume that the agent knows that at time 1, which is some months ahead of the present time, he will need to import m_1 units of the basic cereal (wheat or maize). The price he will pay when ordering the above amount will be denoted as p_1. Define the following variables: f is the futures price, observed at the current period, of the commodity (in some appropriate organized commodity market) for the futures contract expiring closest after the period 1, at which the actual order for imports will be placed. Define by f_1 the price of the same futures contract at time 1. Denote by x the amount of futures contracts (in units of the quantity of the product) purchased at the current period, and by z, the amount of call options contracts purchased also at the current period. The call option contract is written on the same futures contract expiring soonest after period 1, and stipulates that if the futures price f_1 at time 1 is above 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 is denoted by r, whereas the profit from the option in period 1 is denoted by π. This profit will be equal to f_1 –s if the option is exercised and zero otherwise.

Given the above definitions, the foreign exchange cost to the agent can be written as follows.

$$M = p_1 m_1 - (f_1 - f)x - (\pi - r)z \quad (1)$$

It shall be postulated that the agent wishes to minimize the unanticipated variance of M. In other words the agent is concerned about unpredictability, and wishes to minimize it. The variance involved is the conditional one, namely based on information available at the current time.

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) and others, the cash price is written as a linear function of the futures price

$$p_1 = \alpha + \beta f_1 + \theta \quad (2)$$

where θ (the basis risk) 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 is the (conditional) expected value of f_1 , and that the options are fairly priced in the sense that the price r is the expected value of π.

Given the above assumptions the conditional expected value of M is equal to $M^* = (\alpha + \beta f)m_1$. We can write the variance of M as a quadratic expression in x and z. To minimize we consider the first derivatives in x and z, which are linear functions of x and z (the second order conditions for minimization hold globally). The solution of these two equations, after some manipulation can be written as follows.

$$\frac{x}{m_1} = \frac{1}{\Delta}\{Var(\pi - r)E[p_1(f_1 - f)] - E[(f_1 - f)(\pi - r)]E[p_1(\pi - r)]\} \quad (3)$$

$$\frac{z}{m_1} = \frac{1}{\Delta}\{-E[(f_1 - f)(\pi - r)]E[p_1(f_1 - f)] + Var(f_1)E[p_1(\pi - r)]\} \quad (4)$$

where the denominator Δ is equal to

$$\Delta = Var(f_1)Var(\pi - r) - E^2[(f_1 - f)(\pi - r)] \quad (5)$$

Given the unbiasedness assumption in (2), it is easy to show that the right hand side in (4) is equal to zero. In other words when m_1 is known with certainty and when the futures markets are unbiased (or at least perceived as such by the agent), then it is optimal not to buy options. This is a result identical to the one derived by Lapan et al (1991), who examined the case of a farmer who hedges a known production. Their model, while pertaining to production rather than imports, is mathematically quite similar to the one analyzed here, and hence our result comes as no surprise.

From (3) and utilizing (2) and the unbiasedness assumptions it is easy to show that the optimal futures hedge ratio is equal to β, namely the correlation coefficient between the futures and the cash price. This is a well known result in the futures hedging literature (for example see Benninga et al 1984, Rolfo, 1980).

Sakong et al (1993) extended the results of Lapan et al (1991) and showed that quantity uncertainty in production is enough to imply that the optimal hedge includes options as well. Translated to our problem the equivalent condition would be that the import purchases are not known with certainly ex-ante, or whether the actual imports ordered at time 1, are a function of the then prevailing prices. Their result, which can be transposed to this case as well, as their model is mathematically quite similar to ours, suggests that in such a case the optimal futures hedge ratio is lower than β, and supplemented by purchases of calls. It is not, however easy to compute the simultaneous optimal hedge ratios for futures and options, as the involved expressions are quite complicated.

Nevertheless, one can postulate even in our case, of certain imports, that the importer only has call options available as a hedging instrument, instead of futures, and explore the optimal hedge rule for this case. It can then be derived from the above equations in such a case, that the optimal hedge ratio with call options is also equal to β, irrespective of the strike price.

4 EMPIRICAL IMPLEMENTATION AND DATA

For our analysis we choose from the LIFDCs, eleven major wheat importers among LIFDCs over the past 20 years, and 6 similarly defined major maize importers, with a view to geographical representation. Table 1 shows these countries and some relevant numbers. Between them the wheat importers chosen accounted for 55 percent of the wheat imports of all LIFDCs in the period 1980-2003 and 24 percent of world wheat imports. The maize importers accounted for 27 percent of all LIFDC maize imports and 6 percent of world maize imports. Notable is the high share of wheat and maize in the countries' total cereal imports, the percentages in the last column indicating that wheat is the major cereal import with maize second, and between them accounting for almost all cereal imports.

Consider now the problem of hedging the price risk for an amount of wheat and/or maize equal to the hedge ratio times the amount that is known will be imported some months ahead. The method that will be studied is transactions through futures or options. The data available to us is the following. First we know the actual imports of wheat and maize for all LIFDCs on an annual basis (both calendar as well as crop (July-June) crop year) for a period going back to the 1960s. Secondly we have monthly wheat and maize import data for all LIFDCs by origin of imports since 1995 from the International Wheat Council (IWC) and FAO. Given this monthly import data, we assume that for the years where we do not have monthly import data, the pattern of imports, namely the shares of total annual imports imported in each month, is the same as the average pattern of monthly imports from the years where we have monthly observations. Our actual futures and options data is obtained from the Chicago Board of Trade (CBOT) and is daily from 1986. Our analysis will simulate the hedging actions of the agent. This will involve buying futures or call[5] options at a given point in time, ahead of the physical wheat or maize contracting, and selling them at some later point, namely when the actual physical transaction for wheat or maize imports is concluded.

The actions of the agent will try to insure the price risk of the physical purchases. It will be 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. This implies that the prices at which wheat and maize imports will be valued and eventually paid, are prices of one month ahead of the actual physical arrival at the border.

In order to implement the simulations, given that we have all the daily data available for futures and options, the agent must decide on the rules to follow. The following parameters must be specified.

- The day of the year at which the contract (future or option) is bought
- What contract to buy (namely for which month to buy a future or option contract)
- How much (quantity) to buy of the contract

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[5] A call option on wheat gives the buyer the right, but not the obligation, to buy a certain amount of wheat (specified in the standard option contract) at a given prespecified "strike" price. The buyer pays a price for this right, the option price. If the actual price of wheat at the time of the "exercise" of the option, is above the strike price the option holder gains the difference, while if the actual price is below the strike price the option holder gains nothing, and will not exercise the option, and loses the amount paid for the option in the beginning. In actual markets the right is not for a physical amount of wheat, but for a futures contract usually traded in the same market. This then makes the option contract a "derivative" contract, as its value "derives" from the value of the underlying futures contract. However, as futures markets, especially for cereals, are hedging markets for the physical traders, the futures markets are closely related to the real markets.

- In addition in the case of options, the decision must be made at what strike price to buy a call option.

We will simulate the following types of rules (strategies):

Rule 1 Hedging only with futures contracts

Under this set of rules, basically similar to what Faruqee et al (1997) did, we assume that the agent buys futures k months in advance of the date when he/she needs to contract the actual delivery. This actual contract date is assumed to be one month before the needed monthly physical import delivery as per the seasonal import needs, which as indicated above we assume are known. In other words suppose that according to the needs, the importing agent needs to physically import 100 000 tonnes of wheat in December. This implies that the physical quantities must be ordered one month before. Hence 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 will take place, and the payment made (or the loan obtained) is the November price. Hence 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 totalling β*100 000 tonnes in July. The futures contract at which the futures transaction will be made will be the one traded as close to (after) the date of needed purchase as possible. In the example here, the actual forecasted transaction is in November, and the nearest traded futures contract is the December contract, hence the agent will buy December wheat futures in July (namely in the 11-4=7th month of the year), and sell it in November.

It will be assumed that the agent can buy futures contracts for the exact amount of the product that he will need 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[6] or about 130 tonnes) but it is possible through brokers and traders to obtain futures for whatever amount the agent may wish, for a small extra fee.

Once the month of purchase is agreed, the agent must decide the exact day in the month which he will make the transaction (both purchase and later sale). For the simulations reported below it has been assumed that this is the day closest to the middle of the month. For sensitivity analysis we also assumed alternatively that the transactions take place in the beginning of the month, and at the end of the month. However, the results were almost identical so we report only the results for mid-month transactions. The same strategy is applied month after month. It is finally assumed that the cost of buying or selling futures is 0.15 $ per tonne, just as was assumed in Faruqee et al (1997).

Rule 2 Hedging with options

The simulation under this scenario will involve examining how the agent in the specific LIFDC would have fared if he had hedged past imports with call options.

Everything that was said above for futures concerning the dates at which the contracts are bought and the dates of expiration, also holds for the simulations with call options. The only difference is that in this case the strike price also has to be determined. The rule here is that 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 in the nearest month after the period $t+k$, when the actual transaction will be made. The parameter α is the proportion above this future price for which insurance is sought. Hence if α =0.1, the call option bought implies that if the future price observed at the time of ordering the grain import is above 1.1 times the current future price (namely the strike price), 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 percent of the option price.

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[6] In CBOT one bushel of wheat is 36.7437 kg.

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

Given that the objective of the hedging exercise is to reduce the conditional variance of the import bills, we compute the change in the value of imports with and without hedging. Assuming that the cash market is efficient and that that the basis risk is small, the conditional expected value of imports at time t+k can be approximated as the product of the currently observed cash price and the anticipated imports, namely $M^*_{t+k} = p_t m_{t+k}$. The unanticipated or unpredictable at time t change in the cost or value of imports between period t and period t+k for imports that are planned in period t but will actually be ordered in period t+k is:

$$(p_{t+k} - p_t)m_{t+k} \tag{6}$$

When the same imports are hedged with futures, the actual change in the import cost is equal to:

$$\{(p_{t+k} - p_t) - \beta(f_{t+k} - f_t - \tau_f f_t)\}m_{t+k} \tag{7}$$

where τ_f denotes the unit transactions cost of buying a futures contract.

When finally the same imports are hedged only with call options, the actual change in the import cost is equal to:

$$\{(p_{t+k} - p_t) - \beta(\pi_{t+k} - r_t - \tau_o r_t)\}m_{t+k} \tag{8}$$

where π is the actual realized profit on the option contract (namely equal to f_{t+k} –k, if this quantity is positive at time t+k, and zero otherwise) τ_o denotes the unit transactions cost of buying a call option contract

The simulation exercise compares the normalized variances of the expressions in (6)-(8). The normalization is obtained by dividing each one of the standard deviations of the expressions in (6)-(8) by the average unhedged import bill over the whole period of the simulation (namely the average of the magnitudes $p_t m_t$). This normalization number is the same in the case of unhedged and hedged imports, so that whatever differences are estimated in the variabilities of the above expressions are due to the application of the futures and options hedges and not the denominator. It should be underlined that this average monthly import value is an approximate and indicative wheat and maize import bill that was built up on the assumption that the proper price paid by an importing country when importing from the United States or any of the other main exporters is the Gulf price. This is, of course, an approximation but, as actual transaction price data is unavailable, it can serve as an indicative number. Also the cost of transport is not included in the calculations of the reference cost of imports.

5 PRICE RELATIONS BETWEEN BORDER PRICES AND WORLD REFERENCE AS WELL AS CHICAGO PRICES

The previous section discussed the methodology of simulations of wheat and maize import hedging strategies, but did not delve into the question of whether the Chicago wheat and maize market is an effective hedging medium for the wheat and maize importing developing countries. The objective of this section is to examine whether the Chicago Board of Trade futures prices and hence those of the related options are indeed effective reference prices for hedging wheat and maize imports of the selected developing countries.

The first observation concerns the source of imports for wheat and maize of the studied countries. Analysis of wheat import data by source for the studied countries reveals that the bulk of wheat imports is obtained from three sources, namely the United States, Australia, and Argentina. As far as maize is concerned, the major source of imports of the studied countries is the United States. Given this observation, as world import reference prices for wheat we consider the monthly US Gulf price for hard winter ordinary no 2 wheat, and the monthly export unit values for Australia and Argentina as reported in the IMF International Financial Statistics. For maize we consider as reference price the monthly US Gulf yellow maize price. All series are transformed into common units, namely US$ per tonne.

While the prices of imports of wheat and maize of the studied countries are based on the prices of the three main export markets, as discussed above, the actual cif prices in the countries will be different because of transport and other transaction costs. However, these transaction costs (which are subsumed in the random error term θ in equation (2)) can be reasonably assumed to be independent of the prices in the main cash and futures markets, in which case they do not affect the hedging strategies of the countries. In other words these transaction costs are an independent source of variability in import bills, which cannot be hedged. In the sequel we shall not be concerned with this source of variability, and shall instead concentrate only on the variability of import bills that arises from variations in the primary product markets, namely the sources of the imports. One may argue that if the transaction costs constitute the bulk of the variability in import bills, then the hedging strategies will contribute little to the reduction of the overall unanticipated variability of food import bills. Unfortunately we do not have data for monthly unit import values for the products and countries concerned, and hence we cannot evaluate the importance of this consideration. Nevertheless, analysis using annual unit import values, while admittedly crude, suggests that there is considerable transmission between the reference prices and the observed unit import values (Sarris et al 2005).

Time series analysis involving co-integration tests, between the three world wheat reference prices reveals that they are highly correlated as well as co-integrated. Hence we can choose one of the three world wheat reference prices as the representative price for wheat imports, and we choose the US Gulf price. The next issue concerns the relationship between the Gulf prices and CBOT, as it is this that will dictate the hedge ratio. As futures do not exist for all 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 available futures contract.

To analyze the basis risk of the Gulf prices, time series price relations were analyzed with the econometric approach proposed in Rapsomanikis et al (2003). First, the dynamic properties of the series involved are investigated, through standard tests for the presence of unit roots, aimed at understanding their order of integration. Two different tests were applied: the Augmented Dickey-Fuller (ADF) test, and the Phillip-Perron (PP) test,[7] both including a time trend and a constant term[8].

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[7] As is well known, the first test is a parametric one, based on the estimation of an AR(*n*) model, in which what is tested is the null hypothesis that the coefficients of the lagged dependent variables are unitary, against a one sided alternative that they are strictly smaller than one; the former identifies a random walk, while a coefficient higher than one would imply an explosive behaviour. The Phillips-Perron test is conceptually similar to the ADF,

Both tests suggest that the series for monthly Gulf prices as well as CBOT near futures are integrated of order one, or $I(1)$.

Given that the results of the order of integration suggest that the monthly time series are all integrated with the same order, for each price, the following Auto Regressive Distributed Lags (ARDL) model was estimated between cash prices p and nearest futures prices f (all prices are in log forms):

$$p_t = a + \tau T + \sum_{j=1}^{J} \beta_j p_{t-j} + \sum_{k=0}^{K} \gamma_k f_{t-k} + e_t \qquad (9)$$

in which J and K were chosen through the minimization of the Akaike information criterion. The presence of a long run relationship between p and f was tested by computing the parameters of the long run relation between Gulf and CBOT near futures prices $p_t = \lambda_0 + \lambda_1 f_t + u_t$,which is derived from (9) under the assumptions that $p_t = p_{t-k} \forall k$ and $f_t = f_{t-j} \forall j$. These assumptions imply that

$$\lambda_0 = \frac{a}{1-\sum_j \beta} + \frac{\tau T}{1-\sum_j \beta} \; ; \qquad \lambda_1 = \frac{\sum_k \gamma_k}{1-\sum_j \beta_j} \text{, and} \qquad u_t = \frac{e_t}{1-\sum_j \beta_j} \qquad (10)$$

In order to take into account the adjustment taking place around the long run equilibrium, the ARDL model (9) has also been estimated in the corresponding Error Correction (ECM) specification, which is as follows:

$$\Delta p_t = a + \delta T + \rho[p_{t-1} - \lambda_1 f_{t-1}] + \sum_{j=1}^{J} \beta_j^* \Delta p_{t-j} + \sum_{k=0}^{K} \gamma_j^* \Delta f_{t-k} + h_t \qquad (11)$$

The above relation, in which the long run parameter λ_1.is the same as the one calculated from the ARDL model in (10), allows one to distinguish between the short run adjustment parameter $\rho = (1 - \sum \beta_j)$ known as the ECM coefficient, and the long run parameter λ_1. Estimates for these two parameters are reported in Table 2 for wheat and maize.

The wheat Gulf price appears closely related to the Chicago futures, given that the λ_1 coefficient is significant and close to 1. The ECM short run parameter, instead, appears to be small suggesting fast adjustment to the long run relationship. For maize, the Gulf price does not appear to be very closely related to the CBOT nearest future price. However, the ECM parameter appears much higher than that for wheat prices.

Altogether, these results indicate that there is a considerable, albeit not perfect, transmission of price signals between the Chicago future market and the average prices actually paid for ordering wheat, but less for maize, for imports into the selected countries. In turn, this allows us to hypothesize that the Chicago futures market could be a viable trading marketplace in which risk in import prices may be hedged by the selected countries. Of course, since our econometric time series models are dynamic, the relationship between the reference export prices and the CBOT prices is not too strong contemporaneously, as it extends over several periods. In other words a shock in CBOT will not be transmitted fully to the various export prices in the same month, but only over time. This implies a more complicated optimal hedging strategy than one based on simple contemporaneous correlations (in level or difference form) as is usually done, and as was done by Faruqee et al (1997). For instance it may imply that the hedging for price risk for given desired import shipment may need to be done by allocating different portions of the desired hedged quantity to several futures contracts. It is, however, beyond the purpose of this article to examine the optimal (and most likely complicated) hedging

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but it is based on an AR(I) model, in which the same test on the coefficient of the lagged variable is performed by correcting the usual t-statistic with a (non parametric) estimate of the spectrum of the error term.

[8] Detailed results for these tests are not reported for brevity, but they are available upon request.

strategy in the presence of a dynamic relation between the price of interest to the importing country and the CBOT price. In the simulations reported below the assumption is made that the value of the hedging parameters β are equal to the value of the parameter λ_1 as indicated in table 2.

6 RESULTS OF HEDGING STRATEGIES WITH FUTURES AND OPTIONS

The results of the simulations with and without hedging are presented in Tables 3-6. We have made simulations for two cases, namely k=4 and k=10. In other words we examine the situations of hedging in a period close to the actual purchase date, and a period much earlier. As indicated in the methodological section, imports are hedged for both futures and options with the empirically estimated hedge ratios (the values of the parameters λ_1 in table 2). When options are utilized, the value of the parameter α is set equal to 0.05. In other words, strike prices for the call options are set at 5 percent above the futures price for the futures contract expiring nearest after the month of order. Experiments with other strike prices were also done, but the overall results were not much different. The figures in the table compare the normalized standard deviations of import value changes over a period of k months, with and without hedging. Given the data we have available, the period for the simulations with futures is from 1986-6 to 2002-12, while for the simulations with options the period is from 1987-3 to 2003-5, and this is what accounts for the differences in the unhedged standard deviations for the cases of hedging with futures and options.

For wheat, Table 3 indicates that hedging with futures offers considerable reduction in unpredictability of monthly import bills. The reduction in the normalized standard deviations of import bill changes is more than 50 percent in all case. Hedging with options also reduces the unpredictability of import bill changes but not by as much. This is expected, as options smooth out only upward price changes, and hence only one part of the price variance. In light of the fact that the cost of hedging is included in the above calculations, and that the applied hedging rules are only first approximations, as dynamic hedging rules could offer even more possibilities for reductions in unpredictability, it appears that hedging wheat imports in CBOT is something that can considerably reduce the unpredictability of wheat imports.

Table 4 Repeats the calculations when hedging is assumed done 10 months in advance of the actual ordering of wheat imports. In this case the results are much less conclusive. There appears to be reduction in the variability of import bill changes when hedging with futures, for some countries, but this is not a universal conclusion. For 8 out of our 11 simulated countries, namely Egypt, Indonesia, Mozambique, Nicaragua, Pakistan, Philippines, Sudan and Tanzania, hedging with futures such a long period in advance appears to worsen the unpredictability of food import bills. For all countries, however, except Tanzania, hedging with options reduces the variability. This maybe explained by considering that 10 months is a long period before the market realization, and the information available is quite inaccurate. Hence hedging with futures may not offer much predictability, in contrast to hedging only few months before the actual order, when much more information is available and predictions incorporated in the futures prices maybe more reliable. Hence in such a case, it may be that the best that potential importers can do to obtain better predictability of import bills, is to hedge with options, which at least offer some insurance against upward price movements.

Tables 5 and 6 present the same results for maize. The results are largely similar, namely that the 4 month hedge with futures offers somewhat better predictability than the hedge with options, while for the 10 month hedge, hedging with futures tends to worsen predictability, while hedging with options seems to improve it.

7 CONCLUDING REMARKS AND IMPLICATIONS FOR IMPORT STRATEGIES

The results of this paper suggest that hedging wheat and maize imports by agents in several LIFCDs using futures and options in the CBOT exchange appears a viable strategy to reduce the unpredictability of basic food import bills. It appears that the scope for the reduction in unpredictability is larger when hedges are made not long before the actual date of contracting the imports, and in such cases hedging with futures appears to be more efficient than hedging with options. However, when one is interested in longer term planning of foreign exchange needs for food imports, and avoiding unpredictable excesses in those bills, hedging with options maybe more advantageous.

The net gains considered were purely in terms of predictability. As organized futures and options markets, and especially those in the CBOT, are quite efficient, one is not expected to make profits from applying hedging rules of the types simulated here over a long period. Hence the motivating force for hedging is not profitability (this would be the motive of speculators but should not be the motive of financial planners) but rather predictability and better planning. 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 perhaps better domestic food security.

The existence of significant transmission of price signals for the commodities chosen among the major export markets and CBOT, confirmed that the CBOT offers a viable hedging market for wheat albeit less so for maize imports for many of the countries considered.

However, there are some *caveats* to be taken into account when considering the results of the simulations. Firstly, given the importance of the countries involved in global wheat and maize imports, one may question whether their involvement in the CBOT may influence the price determination process in the exchange. Secondly, 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 are a considerable share of cereal imports. Thirdly, it may be that a dynamic hedging strategy along with the seasonal import pattern, and possibilities for substitution among food products, would make a difference to outcomes. This calls for more extensive research that might involve additional products and markets.

The implications for development are that many of the LIFDCs could benefit considerably from helping their main import agents institute more predictable food import expenditure schemes of the type suggested in this paper. Even if the monetary benefits are zero or small, the indirect benefits can be large. They involve securing enough food for those in need, and hence the assurance for many developing countries that they will not have to reallocate development funds to deal with short term food crises. This, in turn could lead for a more orderly pattern of public investments and hence potentially faster growth.

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TABLES

Table 1. Countries selected for the analysis

Wheat importers

	Average country wheat imports 1980-2003 (000 tonnes)	Share in LIFDC wheat imports (%)	Share in world wheat imports (%)	Average country cereal imports 1980-2003 (000 tonnes)	Share of wheat in country's cereal imports (%)
Bangladesh	1 543	3.6	1.5	2 115	72.9
China, Mainland	7 802	18.0	7.7	9 806	79.6
Egypt	6 589	15.2	6.5	9 156	72.0
India	974	2.2	1.0	1 233	79.0
Indonesia	2 712	6.3	2.7	4 491	60.4
Mozambique	173	0.4	0.2	521	33.2
Nicaragua	94	0.2	0.1	185	50.7
Pakistan	1 334	3.1	1.3	1 363	97.9
Philippines	1 796	4.1	1.8	2 532	70.9
Sudan	644	1.5	0.6	793	81.2
Tanzania	115	0.3	0.1	297	38.9
Total of above	**23 776**	**54.8**	**23.5**	**32 491**	**73.2**
Total LIFDC	**43 384**	**100.0**	**42.8**	**65 632**	**66.1**
World	**101 324**			**212 647**	**47.6**

Source: FAO.

Maize importers

	Average maize imports 1980-2003 (000 tonnes)	Share in LIFDC maize imports (%)	Share in world maize imports (%)	Average cereal imports 1980-2003 (000 tonnes)	Share of maize in cereal imports (%)
Egypt	2 539	18.1	3.8	9 156	27.7
Indonesia	476	3.4	0.7	4 491	10.6
Kenya	366	2.6	0.5	760	48.1
Malawi	121	0.9	0.2	159	76.3
Mozambique	233	1.7	0.3	521	44.7
Tanzania	96	0.7	0	297	32.5
Total of above	**3831**	**27.4**	**5.5**	**15384**	**24.9**
LIFDC	**14 023**	**100**	**20.8**	**65 632**	**21.4**
World	**67 332**			**212 647**	**31.7**

Source: FAO.

Table 2. Transmission between international reference prices (at the US Gulf) and the nearest CBOT future price for wheat and maize (monthly data - sample: Jan 1973 - Dec 2002)

	Dependent variables		PWUS	PCUS
regressor				
nearest future price at CBOT	λ_1	coefficient	0,92	0,27
		t-ratio	17,07	6,89
	ρ	coefficient	-0,14	-0,40
		t-ratio	-5,03	-14,97

PWUS=US Gulf n.2 wheat price (IMF, IFS Statistics); PCUS= US Gulf maize price; sample Jan 1985 to Dec 2003; λ_1 and ρ are the long run and short run coefficients, respectively.

Source: Authors' calculations.

Table 3. Normalized standard deviations of wheat import bill changes over 4 months with and without hedging with futures and options

	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation variance of monthly import bill changes with futures hedging	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation of monthly import bill changes with options hedging
	k=4		k=4	
Bangladesh	0.028	0.010	0.030	0.022
China, Mainland	0.031	0.014	0.032	0.028
Egypt	0.020	0.009	0.027	0.018
India	0.067	0.029	0.069	0.051
Indonesia	0.038	0.016	0.039	0.027
Mozambique	0.038	0.017	0.040	0.027
Nicaragua	0.195	0.064	0.192	0.132
Pakistan	0.042	0.017	0.043	0.032
Philippines	0.022	0.010	0.025	0.018
Sudan	0.030	0.013	0.031	0.024
Tanzania	0.107	0.055	0.111	0.098

Source: Authors' calculations.

Table 4. Normalized standard deviations of wheat import bill changes over 10 months with and without hedging with futures and options

	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation of monthly import bill changes with futures hedging	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation of monthly import bill changes with options hedging
	k=10		k=10	
Bangladesh	0.068	0.066	0.069	0.045
China, Mainland	0.084	0.077	0.089	0.056
Egypt	0.041	0.048	0.041	0.026
India	0.300	0.237	0.299	0.199
Indonesia	0.065	0.071	0.065	0.043
Mozambique	0.084	0.088	0.087	0.064
Nicaragua	0.072	0.101	0.074	0.043
Pakistan	0.095	0.099	0.094	0.054
Philippines	0.045	0.046	0.046	0.033
Sudan	0.046	0.060	0.051	0.039
Tanzania	0.110	0.141	0.113	0.122

Source: Authors' calculations.

Table 5. Normalized standard deviations of maize import bill changes over 4 months with and without hedging with futures and options

	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation variance of monthly import bill changes with futures hedging	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation of monthly import bill changes with options hedging
	k=4		**k=4**	
Egypt	0.023	0.019	0.021	0.019
Indonesia	0.067	0.058	0.065	0.060
Kenya	0.078	0.063	0.079	0.075
Malawi	0.092	0.064	0.073	0.065
Mozambique	0.024	0.018	0.021	0.018
Tanzania	0.034	0.021	0.031	0.028

Source: Authors' calculations.

Table 6. Normalized standard deviations of maize import bill changes over 10 months with and without hedging with futures and options

	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation variance of monthly import bill changes with futures hedging	Unanticipated normalized standard deviation of monthly import bill changes without hedging	Unanticipated normalized standard deviation of monthly import bill changes with options hedging
	k=10		**k=10**	
Egypt	0.054	0.056	0.054	0.046
Indonesia	0.101	0.106	0.097	0.084
Kenya	0.342	0.382	0.348	0.308
Malawi	0.179	0.177	0.156	0.146
Mozambique	0.043	0.043	0.038	0.033
Tanzania	0.114	0.110	0.113	0.119

Source: Authors' calculations.

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