ISSN 1020-492X

COMMODITY MARKET REVIEW

2009–2010

COMMODITY MARKET REVIEW

2009–2010

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2010

ISBN 978-92-5-106552-5

Table of Contents

Foreword

The purpose of the Commodity Market Review (CMR), a biennial publication of the FAO Trade and Markets Division, is to examine in depth issues related to agricultural commodity market developments that are deemed by FAO as current and crucial for FAO's Member countries. The significant food price increases of 2007–08 and their negative effect on food security and poverty in developing countries prompted a shift in policy thinking towards making global markets less fragile and more resilient.

Countries responded to the food price surge through a spectrum of policies. A number of countries chose to intervene directly in the market by managing food reserves in order to stabilize domestic prices. Several food importing countries reduced import tariffs, while many producing countries limited, or even banned, exports in order to avoid food shortages and further price increases. There have also been proposals for establishing international mechanisms to either counteract speculation in futures markets, or establish regional physical food reserves.

This biennial CMR is devoted to exploring a variety of issues relevant to the recent price surge. It focuses on a number of key topics that feature highly in discussions among analysts and policy-makers and discusses a number of policy options, both international and domestic. It also draws a number of lessons from the price episode and the policy reactions. The main drivers of the surge, including the effect speculation had in futures markets, are examined. Different aspects of public buffer stock policies, including their effectiveness to stabilize prices, are discussed, while a number of proposals are put forth that aim to assure import supplies to net food importing developing countries during crises.

The articles included in this CMR are all written by collaborators and staff of the FAO Trade and Markets Division and have undergone both internal and external review. They are published as a contribution of FAO to the ongoing policy debate on food price surges, as well as to increase general awareness of the relevant issues and provide policy guidelines.

Alexander Sarris
Director
FAO Trade and Markets Division
Rome, May, 2010

Introduction

George Rapsomanikis and Alexander Sarris[1]

Editors, Commodity Market Review 2009–2010

[1] FAO Trade and Markets Division

1. INTRODUCING THIS ISSUE

In 2008, the world experienced a dramatic surge in the prices of commodities. The prices of traditional staples such as maize, rice and wheat increased significantly, reaching their highest levels in nearly thirty years. In October 2008, the price upswing decelerated and prices decreased sharply in the midst of the financial crisis and the wake of economic recession. Although many food prices fell in excess of 50 percent from their peaks in June 2008, they continue to remain at a significantly higher level than that of 2005. Price volatility has been considerable, making planning very difficult for all market participants. In general, commodity prices are characterized by volatility with booms and slumps punctuating their long run trend. Both abrupt changes and long run trend movements in agricultural commodity prices present serious challenges to market participants and especially to commodity dependent and net food importing developing countries.

The long-run behaviour of prices is not well understood and the issue of which are the main drivers of booms and slumps remains controversial. For example, the long-run decline in real agricultural prices is often attributed to weak demand combined with production and productivity increases. Volatility is frequently thought of as the result of droughts and other supply shocks. However, shocks in the demand for commodities can also trigger price surges. Macroeconomic policies also play a vital role in determining price behaviour. Speculation is also thought to contribute to price surges. Nevertheless, on the whole, economists suggest that none of these factors by itself appears to explain price behaviour satisfactorily.

Little is known on the frequency, magnitude and persistence of price spikes such as those of 1973–74 and the one in 2007–08. Both price episodes took place during periods of rapidly accelerating economic activity, driven by growth and macroeconomic policies, such as increases in money supply. Both ended with economic recession. However, fast economic growth on its own does not always lead to price surges. Many other conditions should also prevail in order for a price spike to take shape.

In 2008, in a manner similar to the 1974 price boom and slump, low interest rates played a central role in influencing commodity price movements by encouraging economic activity and fast growth. Low interest rates also shape the behaviour of market participants to hold or not commodity inventories. Indeed, a number of empirical studies have acknowledged the contribution of expansionary money supply policies in the recent price surge.

Market fundamentals play an important role. For example, crop failures in the years before 1974 intensified the food price surge. In 2008, stagnant productivity and tight food markets, low global inventories and strong demand for crops from the biofuel sector in an environment of rapidly increasing oil prices all affected the movements of prices. In the debate that followed, the role of futures markets and the impact of speculation on prices received particular attention. Trading in agricultural futures markets was not a central feature during the 1974 price surge. However, since the 1980s and especially now, futures markets are an integral part of the food market system. Over the 2005–2008 period agricultural futures prices increased dramatically and the question whether the food price rise was a phenomenon similar to a 'speculative bubble' lingers in the minds of many observers.

Although researchers have reached a common understanding on what triggered the behaviour in food prices in 2008, the relative importance of these drivers is not yet clear. There is also little to advise on the future frequency, magnitude and persistence of price surges, as the above observations suggest that many conditions have to concur for such an event to occur. It is certain that price surges will take place periodically and given that the main driving forces are macroeconomic in nature, little can be done to prevent them.

Nevertheless, the scope for policy advice and for mechanisms to effectively manage price booms and volatility is compelling.

Many governments, policy think tanks, and analysts have called for improved international mechanisms to manage sudden food price rises. The recent food market episode occurred in the midst of another important longer-term development, namely the shift of developing countries from the position of net agricultural exporters to that of net agricultural, especially basic food, importers. The contribution of food price increases to growing levels of poverty and food insecurity around the developing world appears to have galvanized attention on food price volatility and to have strengthened the efforts to formulate institutional mechanisms in order to instill more confidence, predictability and assurance in global markets of basic food commodities.

This issue of the Commodity Market Review focuses on a number of key topics that are related to the recent price episode. It contains selected papers from a two-day workshop entitled 'Institutions and Policies to Manage Global Market Risks and Price Spikes in Basic Food Commodities'. These papers review different aspects of the price surge. Which are the main drivers of volatility? Has speculation in the futures markets contributed to the food price spike? Have export restrictions amplified the surge? Were national buffer stocks successful in stabilizing prices? How can the international community assure that low income food importing countries have access to imports when prices surge? The answers to these questions have important policy implications, especially for shaping a more stable market environment, instilling more confidence and assurance in the markets.

2. SOURCES OF VOLATILITY

In the first paper, Balcombe explores the nature and causes of price volatility in agricultural commodity prices over time. The contribution of factors such as the level of stocks, yields, export concentration and the volatility of oil prices, interest rates and exchange rates is analysed. Most of these factors have been thought of as crucial in giving rise to the recent price surge. In addition to these factors, the article assesses the existence of the periodic form of volatility. Past volatility can be a significant predictor of current volatility giving rise to periods with either high or low price volatility. Such volatility patterns are commonly found in markets where prices are partly driven by speculative forces.

An important aspect of this study lies in the measurement of volatility. Agricultural commodity prices, as well as interest and exchange rates are decomposed in trends, cyclical and seasonal components. Within this approach, volatility is not just defined in terms of ex post changes in the series, but in terms of the variance of the shocks governing the volatility of series' components. Using this method, the influence of other variables on these variances can be estimated. Given the different frequency of the data, the analysis is based on two econometric methods. In the first method monthly data on commodity prices, interest rates and exchange rates is used. In the second method, the author employs a panel estimator utilising variables such as stocks, yields and export concentration, for which data are available annually.

Using monthly data, the results indicate that nearly all commodities have significant trend and cyclical components. Volatility seems to spill across agricultural markets with markets experiencing common shocks, rather than being isolated from each other. Past volatility is also found to be a significant predictor of current volatility. This suggests that volatility in commodity prices is persistent with periods of relatively high volatility followed by periods of relatively low volatility. As in many financial markets, this pattern hints upon speculative behaviour contributing towards volatile prices.

Quite importantly, oil price volatility is found to be a significant predictor of volatility in prices for a majority of food commodities. Given the period analyzed, which for some commodities spans more than 40 years, this result suggests that volatility in energy prices has been a determinant of volatility in agricultural prices even before agriculture became a provider of energy through the production of energy crops, such as sugar and maize. As the integration of the energy and agricultural markets strengthens, through biofuels, there is the possibility that the role of oil prices in determining agricultural price volatility may even be more significant in the future. Besides oil prices, exchange rate volatility also impacts the volatility of prices for slightly more than half of the commodities analyzed.

The panel data approach complements the above results. Stock levels have a significant and downward effect on price volatility for each of the three markets for which data on stocks exist, (wheat, maize and oilseeds). This finding is consistent with expectations that as stocks become lower, the markets become more volatile. Low stocks weaken the buffer capacity of the market and limit the possibility of adjustment to supply and demand shocks without wide price changes. Finally, the empirical evidence also suggests that overall, agricultural price trends are significant. These trends are independent of the variables used to explain volatility. This is an important result. It means that price volatility will increase only if there are changes in its determinants, such as stock levels, exchange rates, or oil prices.

The paper sets an agenda for further research, as well as one for policy formulation. If speculative behaviour in either futures or spot markets results in increasing price volatility at periods, there is need for further analysis in exploring the nature of speculation in agricultural markets and the extent to which it affects prices. Buffer stocks are also seen as a policy solution to price volatility by many developing countries. However, the experience with public buffer stocks suggests that, although there are positive examples, in some cases such interventions have been disruptive, rather than stabilizing. These issues are the subject matter of the papers that follow.

3. THE ROLE OF FUTURES MARKETS

The papers by Gilbert, and Hernandez and Torero, both examine the functioning of the agricultural futures markets during the price surge and focus on the behaviour of market actors and their impact on prices. Gilbert centres his attention on non-commercial participants, studying their behaviour and assessing their contribution to price rises. The paper attempts to answer a question which lingers in the minds of many an analyst: Is the food price surge similar to a financial 'speculative bubble'? Torero draws attention to the linkages between futures prices and spot market prices during the surge. His analysis extends the argument on the impact of speculative behaviour from futures to cash markets.

Futures markets perform two essential functions. First, they facilitate the transfer of price risk and increase liquidity between agents with different risk preferences. The second major economic function of future markets is price discovery. Commercial traders, including producers and processors of agricultural commodities, utilize futures contracts to insure their future inventories against the risk of fluctuating prices. Non-commercial traders, such as speculators, operate in futures markets for possible gains from futures prices increases.

This decade has witnessed a significant increase in commodity futures trading by a new class of non-commercial actors composed of institutional investors. Gilbert discusses both commercial and non-commercial participants and focuses his analysis on a particular class of institutional actors, the commodity index investors. These are comprised of pension funds, university endowments, banks and sovereign wealth funds and regard commodity futures as an asset class comparable to traditional asset classes such as equities and bonds. Their behaviour in futures markets differs from that of traditional speculators in several ways. These actors engage in trading by taking long-term positions on a number of commodities, rather than in specific futures markets. They follow commodity portfolios or indices that comprise of energy, metal or food commodities such as the Goldman Sachs Commodity Index (S&P GSCI) and the Dow Jones AIG commodity index (DJ-AIG). They also 'roll over' their futures contracts. Futures contracts have an expiration date and commodity index investors maintain their commodity futures position by periodically selling expiring futures contract and buying contracts which expire later.

Researchers suggest that the returns to commodity futures are negatively correlated with returns to equities and bonds. This makes commodity futures an attractive vehicle for portfolio diversification. In addition to this property, historically commodity futures are shown to be attractive, with returns equal or even higher than those of equities and bonds. Gilbert looks into the components of the returns of such investments. He concludes that investments in a passive commodity index could have bought diversification of an equities portfolio at a lower cost than through bonds. However, he finds that profitable investment in commodity futures will likely depend on adoption of an active investment strategy, rather than simply tracking a standard index.

Such considerations give rise to questions on the contribution of commodity index funds to the food price spike through trend-following behaviour. Gilbert reviews the literature on the impact of extrapolative speculating behaviour on future prices. He suggests that, in spite of the argument that actors with information on supply and demand will always bring prices to their fundamental values, in tight markets with low stocks it will be very difficult to assess the market-clearing price on the basis of longer-term fundamental factors. This difficulty may allow the weight of the speculative money to determine the level of futures prices.

Gilbert assesses the conjecture that increases in index-based investment have contributed to increases in futures prices of maize, wheat soybeans and soybean oil by means of Granger causality tests. The tests indicate that changes in index positions had a persistent positive impact on soybean prices over the sample considered. However, there is no evidence for similar effects in the maize, soybean oil and wheat markets. Overall, therefore, there is weak evidence that index investment may have been responsible for raising commodity futures prices during the recent boom. Nevertheless, Gilbert stresses that it may be too simple to rule out the possibility that index-based investment may have affected prices in some markets and especially in the shorter term. More research in the operation of these markets is necessary in order to enable economists to provide policy prescriptions and advice.

Hernandez and Torero make an additional contribution to the debate on the role of futures markets during the recent price surge, focusing on the dynamic relationship between futures and spot market prices. Their evidence suggests that the markets are closely related with changes in futures prices leading those in spot markets. In theory, both futures and spot prices reflect the fundamental value of the same commodity. If instantaneous arbitrage were possible, prices in both futures and spot markets would be identical with changes taking place at the same time in line with the supply and demand fundamentals. Nevertheless, purchases and sales for physical delivery in the spot markets are subject to transaction costs. Contract and transport costs, cash constraints, as well as the need for storage for the physical commodity render spot prices slow in their response to new information. In contrast, futures market transactions can be implemented immediately by hedgers and speculators who react to new information with minor cash requirements.

The path and speed in which new information is filtered in the market and embedded in prices lies behind the notion of price discovery, which is the process by which supply, demand, storage and expectations determine the price for a commodity. Hernandez and Torero use this notion to investigate the relationship between prices in the spot and futures market in a number of food commodities between 1992 and 2009, thus including the period of the recent price surge. Most empirical studies of the price discovery mechanism support the hypothesis that changes in futures prices lead those in spot prices. However, this is not always the case and in a number of cases, changes in spot prices have triggered responses by futures market participants.

Hernandez and Torero utilize a battery of tests for Granger causality. They conduct linear as well as nonlinear Granger causality tests to uncover the causal links between spot and futures prices of maize, wheat and soybeans. They also extend their analysis to assessing causality between futures and spot prices volatility. Their results indicate that prices are discovered in the futures markets with futures prices causing spot prices, in the Granger sense. Although in some cases, the tests reveal bi-directional causality between futures and spot prices, in general, in most of the markets and periods analyzed, futures prices lead changes in spot prices more often than the reverse. Similar results are obtained in terms of price volatility. Again, price volatility is discovered in the futures markets in most cases.

The authors discuss these results in terms of policy implications and suggest that the evidence they provide underpins intervention in the futures markets. Excessive speculation in futures markets could, in principle, result in futures price increases and, through arbitrage opportunities, affect spot prices to levels that are not justified by supply and demand market fundamentals. Robles, Torero and von Braun (2009) test the hypothesis that speculation in futures markets does result in increasing futures prices by means of Granger causality tests. The article by Hernandez and Torero in this Review provides empirical evidence that futures prices lead spot prices. These findings support the case for intervention in the futures markets in times of significant volatility. This is the policy option proposed by von Braun and Torero (2008, 2009) to intervene in the futures markets in times of excessive price spikes in grains prices through a virtual reserve. The role of the virtual reserve would be to increase the supply of futures contracts sales progressively and reduce futures prices until speculators move out of the market as the incentives for further investments in on futures contracts disappear.

From the policy perspective, the article by Gilbert and that by Hernandez and Torero both call for increased attention on the futures markets. As the evidence is still scarce, both hint upon more research on the issue. First, although useful in exploring causal relationships, Granger causality tests are not sufficient in identifying the main drivers of price increases. There are 'identification' problems and more detailed models are necessary for accurately assessing causal effects, as the omission of relevant variables may result in wrong assessments. Second, more analysis may also necessary in order to explore the feasibility and effectiveness of direct interventions to alter the fundamentals of the futures markets. There are a number of questions to be answered related to the size of funds necessary for such intervention and an assessment of the likely reaction of market participants. This is important, as any attempt to publicly influence the prices in futures markets may quickly become expensive, but would also most likely lead to withdrawal of the agents who use the futures markets for hedging purposes.

4. THE ROLE OF FOOD RESERVES

Many countries attempted to alleviate domestic price increases through a combination of buffer stocks and trade policy. In Asia, large rice producing countries used both food reserves and trade policy to stabilize grain prices and ensure food security. China, India and Indonesia managed to protect well over 2 billion consumers through food reserves and export restrictions. In Africa, maize producing and consuming countries, such as Kenya, Malawi and Zambia, also attempted to intervene through a similar mix of policies, but without success. The paper by Timmer and that by Jayne and Tschirley focus on food reserve management in these regions.

Most economists are unconvinced that food price stabilization measures can be successful and inexpensive. In the context of rice in Asia, Timmer argues for the contrary. His article builds a case for the benefits of stabilizing staple food prices. In Asia, rice accounts for half the income of farm households and between 25–40 percent of consumption expenditures. In the absence of stabilization, price surges can cause famine for the poor who cannot afford higher food costs. Price stabilization also benefits producers as a second-best solution to missing credit markets. Instead of subsidizing credit, governments, by stabilizing rice prices, reduce the risk to which farmers are exposed and thus promote investment.

However, Timmer suggests that there are additional, and perhaps more important benefits. As rice accounts for a large share of expenditures, price fluctuations affect the demand of other goods and services in the economy. These effects are all the more significant as the demand for rice is inelastic relative to that of other goods. Therefore, rice price stabilization brings about macroeconomic stability for investment and growth. For example, in Indonesia rice price stabilization shapes the country's approach towards food security. However, these price policies also consider dynamic and economy-wide issues, such as the distributional consequences for farmers and consumers.

Price stabilization places significant demands for logistical and operational capacity, access to financial resources and strong analytical skills. Timmer puts emphasis on these by providing an account of BULOG, Indonesia's price stabilization agency. Stabilizing domestic prices requires buffer stock operations in conjunction with trade policy. BULOG, and other price stabilization agencies in Asia, implement such policies to keep rice prices within a certain band sometimes with complex financial operations, going through periods characterized by food crises or self-sufficiency. The stabilization mechanism relies heavily on trade policy to maintain the desired balance between production, consumption and stock changes. However, such fine tuning through trade is against the World Trade Organization rules.

Timmer's discussion of the recent price surge reveals that domestic stabilization policies can have a significant international impact. India, China, Indonesia and Viet Nam stabilized their domestic rice prices during the 2007–08 food crisis by using export bans, or very restrictive controls and buffer stocks. Although successful, these policies had also a significant impact on the world market. In 2008, the decision of India and Viet Nam, the world's second and third largest rice exporters, to ban exports of rice resulted in a 43 percent increase in the price of rice between October and February of the same year. Timmer discounts this impact. The international market of rice is quite thin, with most important producing and consuming countries stabilizing their domestic markets. He stresses that in terms of aggregate global welfare, the use of buffer stocks and export bans in these large countries may be both an effective and an efficient way to cope with food crises, even after considering the effects on increased world price volatility.

The relevant World Trade Organization (WTO) provisions essentially permit export prohibitions or restrictions on basic foodstuffs to relieve domestic critical shortages of foodstuffs. Export taxation was never disallowed, unlike import tariffs. This asymmetry in the WTO disciplines applying to imports and exports has been pointed out during the current negotiations on agriculture and several countries proposed stronger rules in this area. However, there is resistance on these issues form other WTO members and it is unlikely that stronger disciplines on export restrictions would materialise under the Doha Development Round. In the case of rice, although export restrictions stabilized domestic prices in many large countries, they created substantial uncertainty in the market especially because governments announced the export bans without clarifying their duration. More predictable and less discretionary policies would convey clearer information and render panic and hoarding less likely, resulting in less uncertainty.

Jayne and Tschirley focus on the experience of East and Southern African countries, where marketing board operations are still a central characteristic of the food economies, in spite of the perception that markets in the region have been liberalized. Like rice in Asia, white maize is the main food staple in East and Southern Africa and as the authors stress, the cornerstone of a 'social contract' binding governments to promote the welfare of smallholders and ensure cheap food for the urban population. Marketing board operations, such as domestic procurement, food releases and import programmes, in conjunction with trade policy are the instruments the government uses to satisfy the terms of this social contract.

The presence of the government in the market, trading along the private sector, has given rise to a dual marketing system in which the environment is shaped by both frequent and unpredictable changes in policies. In the East and Southern Africa region marketing boards are often the single most important player in the market and their power over maize prices affects market participants. Largely unexpected changes in marketing boards' operations and trade policy result in increased risk and losses for other market participants, thus hindering the development of efficient private markets.

Jayne and Tschirley examine the interactions between the government and private traders using tools of economic analysis and also drawing from political science and sociology. The government's objective is seen as remaining in power by maximizing votes, while traders aim at maximizing profits. Actions by one party will affect the other. For example, a decision by the government to import food and proceed in subsidized sales can erode the value of private traders' stocks. In a similar manner, traders' non-competitive behaviour can impede the government from ensuring cheap food.

In addition, the relationship between governments and traders is shaped by uncertainty on what the other will do, giving rise to a credible commitment problem. For example, the government may announce the importation of food, but traders are not certain that this will be carried out. They are also not certain that, in the event imports arrive, the government will allow them to purchase. As a result they prefer to remain inactive. This can have significant negative consequences in times of crises and the authors discuss the two cases of Kenya and Malawi in order to illustrate the impact of governments and traders' interaction during the recent price surge.

The authors provide a classification of competing visions for staple market development. On one end of the spectrum they place the current practice of discretionary market intervention, while at the opposite end the government provides only public goods and does not intervene in the market. An intermediate solution consists of a rules-based state intervention. This involves the provision of credible information on public import programs and changes in import tariffs in a timely manner in order to avoid private sector disruptions and ensure the availability of food. In addition, it requires the establishment of clear and transparent rules for the intervention of governments in the market. Once more, predictable and non-discretionary intervention can reduce the fragility of some markets in East and Southern Africa and reduce volatility.

5. INSTRUMENTS TO ASSURE IMPORT SUPPLIES

During the last two decades, the agricultural trade position of developing countries, on aggregate, has changed from net exporting to net importing. This attribute increases their vulnerability during food price surges. High food prices can have significant impacts on importing countries and a direct adverse effect on food security. A major problem many net food importing developing countries face is that of major trade finance constraints which can prevent both public institutions and private traders from importing the required amount of food. In his paper, Sarris examines a number of issues related to food import management and discusses three specific mechanisms which can facilitate imports.

The first mechanism aims at reducing the unpredictability of food import bills by hedging in the futures markets. High food bills may result in major repercussions on the whole economy, worsening the current account balance, aggravating foreign exchange constraints and reducing the country's import choices. Should importing countries use the futures markets and hedge, the unpredictability of their food bills and the risk these countries are exposed to, will be reduced. Sarris uses simulations to assess the potential reduction in unpredictability through hedging with futures contracts and options. His findings suggest that the reduction in unpredictability is significant. The analysis also indicates that the reductions in the unpredictability of food import bills during the recent price surge, if importing countries had hedged by using futures or options, would have been substantial. This has important implications for food import management, as well as for the development of commodity exchanges in the developing world.

A facility to assist net food importing developing countries to meet the cost of excess food import bills is Sarris' second proposal. The Food Import Financing Facility (FIFF), put forward in this paper, is in accordance with the Marakkesh Decision to maintain usual levels of imports in the face of price shocks. The design of the FIFF is based on existing practices of international trade and finance, involving the international community as provider of conditional guarantees, rather than finance. Sarris provides an analysis of the Facility's basic functions and structure. FIFF is designed to operate as a guarantee fund enabling commercial banks to extend new credit to food importers in times of need. It would benefit itself from guarantees by a number of donor countries in order to make up its operational fund. Another central aspect of the design is that the FIFF would not finance the whole import bill of a country, but only the excess part. The mechanisms by which credit would be extended are also discussed. For example, trigger conditions based on specific food import bill indicators would prompt importing countries to seek finance.

Since the Marakkech Decision, very little has been pursued in the WTO on such facilities or similar alternatives, perhaps due to the low food price period that ensued. However, in retrospect, a functional international food import financing programme would have provided some relief to the affected countries during the recent period of soaring food prices, had it been in place.

The third mechanism Sarris proposes is that of an International Grain Clearing Arrangement to assure the supply of food imports. This attempts to reduce the risk of reneging on a delivery contract between private agents in different countries. This risk is not related to the unpredictability of food import bills, as in the first mechanism, but to that underlying import supplies. Sarris notes that although contracts in commodity exchanges are enforced, there is no international contract enforcement institution to ensure that physical delivery takes place. The way to enforce contracts in the international market would be to establish linkages between commodity exchanges around the world so that guarantees could be provided that physical supplies are available to execute the international contracts.

A number of aspects of such an institution are discussed by the author. These include the ownership, the risks of defaults, the link with physical reserves and financing. Indicative estimates of the size of the institution suggest that it would not weigh heavily on the market and hence would not influence the fundamentals of supply and demand in global import trade. Its objective would be to facilitate trade and hence assure that there is enough physical grain to execute normal commercial contracts.

6. CONCLUDING REMARKS

Volatile prices have significant negative effects on developing countries. Price surges induce substantial income risks and can be particularly detrimental to developing countries' welfare and growth prospects.

This issue of the Commodity Market Review enquires into the determinants of food price movements and examines a number of policy options. The papers contribute towards analysing the empirical behaviour of food prices during the recent price surge and provide a systematic examination on a number of issues. The main drivers of agricultural price volatility are discussed. The role of speculators in the food futures markets and the effect of national food reserve and trade policy responses are examined, illustrating the implications for developing countries. Most of these issues are controversial, but at the same time raise a variety of important policy questions. Should food price volatility increase, concerted effort at the international level will be necessary in order to shield low income food importing developing countries from the negative effects of sudden and unpredictable increases.

The nature and determinants of volatility in agricultural prices: An empirical study from 1962–2008

KELVIN BALCOMBE[1]

[1] University of Reading.

1. INTRODUCTION

There is now considerable empirical evidence that the volatility in agricultural prices has changed over the recent decade (FAO, 2008). Increasing volatility is a concern for agricultural producers and for other agents along the food chain. Price volatility can have a long run impact on the incomes of many producers and the trading positions of countries, and can make planning production more difficult. Arguably, higher volatility results in an overall welfare loss (Aizeman and Pinto, 2005),[2] though there may be some who benefit from higher volatility. Moreover, adequate mechanisms to reduce or manage risk to producers do not exist in many markets and/or countries. Therefore, an understanding of the nature of volatility is required in order to mitigate its effects, particularly in developing countries, and further empirical work is needed to enhance our current knowledge. In view of this need, the work described in this chapter, seeks to study the volatility of a wide range of agricultural prices.

Importantly, when studying volatility, the primary aim is not to describe the trajectory of the series itself, nor to describe the determinants of directional movements of the series, but rather to describe the determinants of the absolute or squared changes in the agricultural prices.[3] We approach this problem from two directions: First, by directly taking a measure of the volatility of the series and regressing it against a set of variables such as stocks, or past volatility. Second, by modelling the behaviour of the series,[4] while examining whether the variances of the shocks that drive the evolution of prices can be explained by past volatility and other key variables.

More specifically, we employ two econometric methods to explore the nature and causes of volatility in agricultural price commodities over time. The first decomposes each of the price series into components. Volatility for each of these components is then examined. Using this approach we ask whether volatility in each price series is predictable, and whether the volatility of a given price is dependent on stocks, yields, export concentration and the volatility of other prices including oil prices, exchange rates and interest rates. This first approach will be used to analyse monthly prices.[5] The second approach uses a panel regression approach where volatility is explained by a number of key variables. This second approach will be used for annual data, since the available annual series are relatively short.

On a methodological level, the work here differs from previous work in this area due to its treatment of the variation in the volatility of both trends and cyclical components (should a series contain both) of the series. Previous work has tended to focus on either one or the other. Alternatively, work that has used a decomposed approach has not employed the same decomposition as the one employed here. Importantly, in contrast to many other approaches, the framework used to analyse the monthly data requires no prior decision about whether the series contain trends.

The report proceeds as follows. Section 2 gives a quick review of some background issues regarding volatility. This report does not discuss the consequences of volatility. Its aim is limited to conducting an empirical study into the nature and causes of volatility, and to explore whether these have evolved over the past few decades. To this purpose,

[2] For a coverage of the literature relating the relationship between welfare, growth and volatility, readers are again referred the Aizeman and Pinto, 2005, page 14 for a number of classic references on this topic.

[3] In order to model volatility, it may be necessary to model the trajectory of the series. However, this is a necessary step rather than an aim in itself.

[4] This is done using a 'state space form' which is outlined in a technical appendix.

[5] Data of varying frequencies is not used for theoretical reasons, but due to the data availability. These were provided by FAO.

Section 3 outlines the theoretical models that are used for the analysis. Section 4 outlines the estimation methodology, and Section 5 presents the empirical results, with tables being attached in Appendix A. Section 6 concludes. Mathematical and statistical details are left to a technical appendix (Appendix B).

2. BACKGROUND

2.1 Defining volatility

While the volatility of a time series may seem a rather obvious concept, there may be several different potential measures of the volatility of a series. For example, if a price series has a mean,[6] then the volatility of the series may be interpreted as its tendency to have values very far from this mean. Alternatively, the volatility of the series may be interpreted as its tendency to have large changes in its values from period to period. A high volatility according to the first measure need not imply a high volatility according to the second. Another commonly used notion is that volatility is defined in terms of the degree of forecast error. A series may have large period to period changes, or large variations away from its mean, but if the conditional mean of the series is able to explain most of the variance then a series may not be considered volatile.[7] Thus, a universal measure of what seems to be a simple concept is elusive. Where series contain trends, an appropriate measure of volatility can be even harder to define. This is because the mean and variance (and other moments) of the data generating process do not technically exist. Methods that rely on sample measures can therefore be misleading.

Shifts in volatility can come in at least two forms: First, an overall permanent change (whether this is a gradual shift or a break) in the volatility of the series; and, second in a 'periodic' or 'conditional' form whereby the series appears to have periods of relative calm and others where it is highly volatile. The existence of the periodic form of volatility is now well established empirically for many economic series. Speculative behaviour is sometimes seen as a primary source of changeable volatility in financial series. The vast majority of the evidence for periodic changes in volatility is in markets where there is a high degree of speculation. This behaviour is particularly evident in stocks, bonds, options and futures prices. For example, booms and crashes in stock markets are almost certainly exacerbated by temporary increases in volatility.

While there is less empirical evidence that changes in volatility are exhibited in markets for agricultural commodities, the evidence is strong that this is the case. Moreover, there are good a priori reasons to think that changes in volatility might exist. For example, Deaton and Laroque (1992) present models based on the theories of competitive storage that suggest, inter alia, that variations in the volatility of prices should exist. Moreover, market traders are to some extent acting in a similar way to the agents that determine financial series. They are required to buy and sell according to conditions that are changeable, and there is money to be made by buying and selling at the right time. However, agricultural commodity prices are different from most financial series since the levels of production of these commodities along with the levels of stocks are likely to be an important factor in the determination of their prices (and the volatility of these prices) at a given time. The connectedness of agricultural markets with other markets (such as energy) that may also be experiencing variations in volatility may influence the volatility of agricultural commodities.

[6] That is, the underlying data generating process has a mean, not just the data in the sample.

[7] This definition is embodied in the notion of 'implied volatility', whereby futures or options prices relative to spot prices are used to measure volatility.

For a series that has a stable mean value over time (mean reverting[8]), the variance of that series would seem to be the obvious statistic that describes its *ex ante* (forward looking) volatility.[9] More generally, if a series can be decomposed into components such as trend and cycle, the variance of each of these components can describe the volatility of the series. The use of the words *ex ante* requires emphasis, because clearly a price series can have relatively large and small deviations from its mean without implying that there is a shift in its overall variability. It is important to distinguish between ex post (historical or backward looking) volatility and *ex ante* (forward looking) volatility. One might believe that comparatively high levels of historical volatility are likely to lead to higher future volatility, but this need not be the case.[10] However, the variance of the series (or component of the series) may be systematic and predictable given its past behaviour. Thus, there will be a link between changes in *ex ante* and ex post volatility. Where such a link exists, the series are more likely to behave in a way where there are periods of substantial instability. It is for this reason that we are primarily interested in *ex ante* volatility, and whether we can predict changes in *ex ante* volatility using historical data.

A wide range of models that deal with systematic volatility have been developed since the seminal proposed by Engle (1982).[11] Since then, the vast majority of volatility work has focused on series of which the trajectory cannot be predicted from their past. Financial and stock prices behave in this way. Simply focusing on the variability of the differenced series is sufficient in this case. However, for many other series (such as agricultural prices) this may not really be appropriate, as there is evidence that these series are cyclical, sometimes with, or without, trends that require modelling within a flexible and unified framework. Deaton and Laroque (1992), citing earlier papers, note that many commodity prices also behave in a manner that is similar to stock prices (the so called random walk model). However, they also present evidence that is inconsistent with this hypothesis. They note that within the random walk model, all shocks are permanent, and that this is implausible with regard to agricultural commodities (i.e. weather shocks would generally be considered transitory). In view of the mixed evidence about the behaviour of agricultural prices, we would emphasise the importance of adopting a framework that can allow the series to have either trends or cycles or a combination of both. Importantly, there may be alterations in the variances that drive both these components. Therefore, the approach adopted within this paper allows for changes in the volatilities of both components should they exist, but does not require that both components exist.

From the point of view of this study, it is not just volatility in the forecast error that is important. Even if food producers were able to accurately forecast prices a week, month or even year before, they may be unable to adapt accordingly. Aligned with this point, it may be unrealistic to believe that agricultural producers would have access to such forecasts, even if accurate forecasts could be made. Thus, we take the view that volatility can be a problem, even if large changes could have been anticipated given past information. This viewpoint underpins the definitions of volatility employed within this study.

The definitions of volatility employed within this study are also influenced by the frequencies of the available data (the data is discussed in Section 5). Since we have price data at the monthly frequency for the majority of series, but a number of explanatory variables at

[8] A mean reverting series obviously implies that an unconditional mean for the series exists, and that the series has a tendency to return to this mean. This is less strong than assuming a condition called stationarity, which would assume that the other moments of the series are also constant.

[9] If the series has a distribution with 'fat tails', even the variance may give an inaccurate picture of the overall volatility of a series.

[10] For this reason, some writers make the distinction between the realized and the implied volatility of a series.

[11] For a number of papers on this topic, see Engle R. (1995) and the article in Oxley *et al.*, (2005).

the annual frequency, we need to create a measure of annual volatility using the monthly price data. 'Annual volatility' should not just be defined by the difference between the price at the beginning of the year and the end. Any measure should take account of the variability within the year. Therefore, to create the annual volatility measures we take yearly volatility to be the log of the square root of the sum of the squared percentage changes in the monthly series. Admittedly, this measure is one possible measure among many. However, it is a convenient summary statistic that is approximately normally distributed, and therefore usable within a panel regression framework. This statistic is an ex-post measure of volatility. Changes in this statistic, year to year, do not imply that there is a change in the underlying variance of the shocks that are driving this series. However, any shift in the variability of the shocks that drive prices are likely to be reflected in this measure.

When focusing on the higher frequency data, this study then defines volatility as a function of the variance of the random shocks that drive the series, along with the serial correlation in the series. This volatility is then decomposed into components: 'cyclical'; and 'level'. Within this approach, volatility is not just defined in terms of ex-post changes in the series, but in terms of the underlying variance of the shocks governing the volatility of series. The influence of other variables on these variances can be estimated using this method. Our approach is outlined at a general level in Section 3 (the decomposition approach), and at a more mathematical level in a technical appendix.

Before proceeding, it is also worth noting that there are some further aspects of price behaviour that are not directly explored within this report. Other 'stylised facts' relating to commodity prices are that commodity price distributions may have the properties of 'skew' and 'kurtosis'. The former (skew) suggests that prices can reach occasional high levels, that are not symmetrically matched by corresponding lows, with prices spending longer in the 'doldrums' than at higher levels (Deaton and Laroque, 1992). The latter (kurtosis) suggests that extreme values can occur occasionally. Measurements of skew and kurtosis of price distributions can be extremely difficult to establish when the prices contain cycles and/or trends, and have time varying volatility. Some of the previous empirical work that supports the existence of the skew and kurtosis has been extremely restrictive in the way that it has modelled the series (e.g. such as assuming that the series are mean reverting). Moreover, kurtosis in unconditional price distributions can be the by product of conditional volatility and by conditioning the volatility of prices on the levels of stocks we may be able to account for the apparent skew in the distributions of prices. Thus, some of the other 'stylised facts' may in reality be a by product of systematic variations in volatility.

2.2 Potential factors influencing volatility

It has been argued that agricultural commodity prices are volatile because the short run supply (and perhaps demand) elasticities are low (Den *et al.*, 2005). If indeed this a major reason for volatility then we should see a change in the degree of volatility as the production and consumption conditions evolve.

Regardless of the definition of volatility, there is ample empirical evidence that the volatility of many time series does not stay constant over time. For financial series, the literature is vast. For agricultural prices the literature is smaller. However, changes in volatility are evident in simple plots of the absolute changes in prices from period to period. These demonstrate a shift in the average volatility of many agricultural prices, and this is further supported by evidence on implied volatility (FAO 2008). This is against the backdrop of a general shift towards market liberalisation and global markets, along with dramatic changes in the energy sector with an increasing production of biofuels. We consider the factors listed below, each with a short justification. Due to data constraints, we are unable to include all factors in the same model over the whole period. Therefore, a subset of these factors enters each of the models, depending on the frequency of the data used in estimation.

Past Volatility: The principles underlying autoregressive conditional heteroscedasticity (ARCH) and its generalised forms (e.g. GARCH) posit that there are periods of relatively high and low volatility, though the underlying unconditional volatility remains unchanged. Evidence of ARCH and GARCH is widespread in series that are partly driven by speculative forces. Accordingly, these may also be present the behaviour of agricultural prices.

Trends: There may be long run increases or decreases in the volatility of the series. These will be accounted for by including a time trend in the variables that explain volatility. An alternative is that volatility has a stochastic trend (i.e. a trend that cannot be described by a deterministic function of time). This possibility is not investigated here.

Stock levels: As the stocks of commodities fall, it is expected that the volatility in the prices would increase. If stocks are low, then the dependence on current production in order to meet short term consumption demands would be likely to rise. Any further shocks to yields could therefore have a more dramatic effect on prices. As noted earlier, the storage models of Deaton and Laroque (1992) have played an important role in theories of commodity price distributions. Their theory explicitly suggests that time varying volatility will result from variations in stocks.

Yields: The yield for a given crop may obviously drive the price for a given commodity up or down. A particularly large yield (relative to expectations) may drive prices down, and a particularly low yield may drive prices up. However, in this study we are concerned not with the direction of change, but with the impact on the absolute magnitude of these changes. If prices respond symmetrically to changes in yields then we might expect no impact on the volatility of the series. However, if a large yield has a bigger impact on prices than a low yield, then we might expect that volatilities are positively related to yields, and conversely if a low yield has a bigger impact on prices than a high yield then volatilities are negatively related to yields. A priori, it is difficult to say in which direction yields are likely to push volatility, if they influence the level of volatility at all. For example, a high yield may have a dramatic downward pressure on price, thus increasing volatility). However, this higher yield may lead to larger stocks in the next year, decreasing volatility in a subsequent period.

Transmission across prices: A positive transmission of volatility of prices is expected across commodities. International markets experience global shocks that are likely to influence global demand for agricultural prices, and these markets may also adjust to movements in policy (trade agreements etc.) that may impact on a number of commodities simultaneously. Additionally, volatility in one market may directly impact on the volatility of another where stocks are being held speculatively.

Exchange Rate Volatility: The prices that producers receive once they are deflated into the currency of domestic producers may have a big impact on the prices at which they are prepared to sell. This also extends to holders of stocks. Volatile exchange rates increase the riskiness of returns, and thus it is expected that there may be a positive transmission of exchange rate volatility to the volatility of agricultural prices.

Oil Price Volatility: Perhaps one of the biggest shifts in agricultural production in the past few years, and one that is likely to continue, is the move towards the production of biofuels. Recent empirical work has suggested a transmission of prices between oil and sugar prices (Balcombe and Rapsomanikis, 2005). There is also likely to be a strong link between input costs and output prices. Fertilizer prices, mechanized agriculture and freight costs are all dependent on oil prices, and will feed through into the prices of agricultural commodities. In view of the fact that the oil price has shown unprecedented realised volatility over the past few years, there is clearly the potential for this volatility to spill over into the volatility of commodity prices.

Export Concentration: Fewer countries exporting could expose international markets to variability in their exportable supplies, weather shocks and domestic events such as policy changes. Lower Herfindahl (the index used here) concentration would lead to higher potential volatility and vice versa.

Interest Rate Volatility: Interest rates are an important macroeconomic factor that can have a direct effect on the price of commodities, since they represent a cost to holding of stocks. However, they are also an important indicator of economic conditions. Volatility of interest rates may therefore indicate uncertain economic conditions and subsequent demand for commodities.

3. MODELS

This section outlines the main elements of the models used for analysis. The mathematical details behind the models are contained in Appendix B. As outlined in the preceding sections, there are two main methods of analysis used within this report. Each is dealt with below.

3.1 The decomposition approach

At the heart of this approach is the decomposition for the logged price y_t at time t as in equation (3) below.

$$y_t = Level_t + Seasonal_t + Cycle_t \qquad \text{(A3)}$$

The level component may either represent the mean of the series (if it is mean reverting) or may trend upwards or downwards. The cyclical component, by definition, has a mean of zero and no trend. However, the level components are driven by a set of shocks (v_t), and the cyclical components are driven by shocks (e_t). Each of these is assumed to be a random shock, governed by a time varying variances h_{vt} and h_{et} respectively. Either one of these variances may be zero for a given price, but both cannot be zero since this would imply that the series had no random variation. For the level component, a variance of zero would imply a constant mean for the series, and therefore all shocks are transitory. If the cyclical variance was zero, this would imply that all shocks to prices were permanent.

The seasonal component is deterministic (that is, it does not depend on random shocks). Two different methods of modelling the seasonality were explored. First 'seasonal dummies' were employed, whereby the series is allowed a seasonal component in each month. Alternatively, the seasonal frequency approach from Harvey (1989) was employed. Here, there are potentially 11 seasonal frequencies that can enter the model, the first of which is the 'fundamental frequency'. The results were largely invariant to the methods employed. However, the results that are presented in the empirical section use the first seasonal frequency only.

The Level and Cyclical components have variances, which we label as follows:

$Var(\Delta Level_t)$: *volatility in mean*

$Var(Cycle_t)$: *volatility in cycle*

Each of these are governed by an underlying volatility of a shock specific to each component, and can (within the models outlined in the appendix) be shown to be:

$$Var(\Delta Level_t) = Constant_L \times h_{v,t}$$

$$Var(Cycle_t) = Constant_C \times h_{e,t}$$

Having made this decomposition, then we can make h_{vt} and h_{et} depend on explanatory variables. In this paper we consider the following explanatory variables for the volatilities of the factors, which we have discussed earlier in Section 2:

i) a measure of the past realised volatility of the series;
ii) realised oil price volatility;
iii) a measure of the average realised volatility in the other agricultural prices within the data;
iv) stocks levels;
v) realised exchange rate volatility;
vi) realised interest rate volatility; and,
vii) a time trend.

In each case where we use the term 'realised' volatility, the measure will is the square of the monthly change in the relevant series, as distinct from the *ex ante* measures h_{vt} and h_{et} respectively.

Using the approach above, we then produce:

i) measures in volatility (mean and cycle) for each of the agricultural price series through time;
ii) tests for the persistence in the changes in volatility for these series;
iii) tests for the transmission of volatility across price series; and,
iv) tests for the transmission of volatility from oil prices, stocks etc to agricultural prices.

3.2 The panel approach

In order to complement the approach above, use of annual data is also made. A panel approach is used due to the relatively short series available (overlapping across all the variables) at the annual frequency. The following approach is employed:[12]

$$\ln V_{it} = \beta_{0i} + \beta_{1i} t + \lambda_v \ln V_{i(t-1)} + \lambda' z_{it} + e_{it} \quad (4)$$

Where V_{it} is a (realized) measure of volatility of the i^{th} commodity at time t,z_{it} is a vector of factors that could explain volatility, and e_{it} is assumed be normal with a variance that is potentially different across the commodities, serially independent, but with a covariance across *i* (commodities). We additionally estimate the model imposing $\beta_{1i} = \beta_1$ (a common time trend) across the models. Thus this model is one with fixed effects (intercept and trend) across the commodities.[13]

Within z_{it} we consider the following:

[12] The distribution of the volatilities was examined prior to estimation, and the logged volatilities had a distribution that was reasonably consistent with being normal. Therefore, estimation was conducted in logged form.

[13] The issues of trends, stochastic trends and panel cointegration are not considered in this report. The volatilities are unlikely to be I(1) processes, and certainly reject the hypothesis that they contain unit roots. Stochastic trends could exist in the stocks, yield and export concentration data, and we recognise therefore these could have an influence on the results.

i) Realised oil price volatility
ii) Stocks.
iii) Yields
iv) Realised exchange rate volatility; and,
v) Realised export concentration (the Herfindhal index).

Where the price data is monthly, the realised annual volatility is defined herein as:

$$V_{it} = \sqrt{\frac{\sum_{j=1}^{12}\left(\Delta \ln\left(p_{i,j,t}\right)\right)^2}{12}} \qquad (5)$$

Where $p_{i,j,t}$ is the price of the i^{th} commodity in the j^{th} month of the t^{th} year. As noted earlier, there are a number of other potential measures of annual volatility. However, the statistic above usefully summarises intra year volatility into an annual measure. Alternative transformations (such as the mean absolute deviation of price changes) are very similar when plotted against each other, and are therefore likely to give similar results within a regression framework. The logged measure of volatility, as defined here, is approximately normally distributed for the annual series used in this report, which is attractive from an estimation point of view.

4. ESTIMATION AND INTERPRETATION

4.1 Estimation

The work in this study employs a Bayesian approach to estimation. The reason for using a Bayesian framework is that it is a more robust method of estimation in the current context. The estimation of the random parameter models can be performed using the Kalman Filter (Harvey, 1989). The Kalman Filter enables the likelihood of the models to be computed, and may be embedded within Monte Carlo Markov Chain (MCMC) sampler that estimates the distributions of the parameters of interest.

A full description of the estimation procedures are beyond the scope of this report as while many of the methods are now standard within Bayesian econometrics. Good starting references include Chib and Greenberg (1995) and Koop (2003). A brief coverage of the estimation procedures is given in the Technical Appendix B2.

4.2 Interpretation of the parameter estimates and standard deviations

In interpreting the estimates produced, readers may essentially adopt a classical approach (the statistical approach with which most readers are more likely to be familiar). Strictly speaking, the Bayesian approach requires some subtle differences in thinking. However, there are theoretical results (see Train, 2003) establishing that using the mean of the posterior (the Bayesian estimate of a parameter) is equivalent to the 'maximum likelihood' estimate (one of the most commonly used classical estimates), sharing the property of asymptotic efficiency. As the sample size increases and the posterior distribution normalises, the Bayesian estimate is asymptotically equivalent to the maximum likelihood estimator and the variance of the posterior identical to the sampling variance of the maximum likelihood estimator (Train, 2003). Therefore, we will continue to talk in terms of 'significance' of parameters, even though strictly speaking p-values are not delivered within the Bayesian methodology (and for this reason are not produced within the results section). Broadly speaking, if the estimate is twice as large as its standard deviation then this is roughly consistent with that estimate being statistically significant at the 5 percent level.

5. EMPIRICAL RESULTS

5.1 Data

The data for this study were provided by FAO. A summary of the length and frequency of the data is provided in Table A1. The models discussed in the previous section will be estimated using this data. The first set of models outlined in section 3 will be run on the monthly series, and the panel approach will be used for the annual data. The annual price volatilities were calculated from the monthly data. There are 19 commodities listed in the tables.

Because some of the variables are recorded over a shorter period that others, the models were run using a subset of the data for longer periods and all of the variables for longer periods. Where stocks are used in the models, at a monthly frequency, they were interpolated from the quarterly data, but the models were estimated at the shorter frequency.[14]

5.2 Results

5.2.1 Monthly results

We begin with the results for the monthly data run over the longest possible period for each commodity. In the first instance exchange rates were not included, since these were available only from 1973 onwards (see Table A1). The models using monthly data were then re-estimated including exchange rates (over the shorter period). When running the models, we imposed positivity restrictions on the coefficients of some of the explanatory variables. Without these restrictions, a minority of commodities had perverse signs on some of the coefficients, though in nearly all cases these were insignificant. The monthly results are presented in Tables A2 to A21. In each case the results for the model with and without exchange rates are presented for each commodity. Importantly, the time period over which the two sets of results are obtained differs for the case where exchange rates are included, since exchange rates were only available from 1973 onwards. The difference in the parameter values will therefore differ due to this as well as the inclusion of exchange rates. Table A21 presents the monthly results for the three series for which stocks data are available.

In Tables A2 through A24, the error variance refers to the square root estimate of the intercept for h_e as defined in Section 3. The Random intercept variance is the square root of intercept estimate of h_v. The rest of the parameter estimates are the lambda parameters in equations *b*10 and *b*11 (in Appendix B) where these are the coefficients of the variables listed in the first column of each table. The last four coefficients in each table are: the intercept; estimates of the autoregressive coefficients; and, the seasonal coefficient (the first fundamental frequency).

The estimates within the table are the means and standard deviations of the posterior distributions of the parameters. In each case the significance of a variable is signified by the estimate being in bold italics indicating that the standard deviation is less than 1.64

[14] Weekly prices also exist for a few commodities only. We did analyse this data, but the results were rather inconclusive. Our analyses of this data are not included in this report but are available.

Table 1. Summary of monthly data

	Summary of monthly data	Error variance	Random intercept variance	Past own volatility	Lag aggregate volatility	Oil volatility	Trend	Exrate Vol	Stocks
2	Wheat	√ √	√ √	√ √	√ √		√(+) √(+)		√
3	Maize	√ √	√	√	√ √	√ √	√(+) √(+)	√	√
4	Rice	√ √	√ √	√ √	√ √	√ √			
5	Soyabean	√ √	√ √	√ √	√ √		√(-)	√	√
6	Soybean oill	√	√ √	√ √	√ √	√ √	√(-)	√	
7	Rape	√ √	√	√ √	√ √	√	√(-) √(-)		
8	Palm		√ √	√ √	√ √	√ √	√(-) √(-)	√	
9	Poultry	√ √	√ √	√	√	√	√(-)	√	
10	Pigmeat	√ √		√ √		√ √	√(-)	√	
11	Beef	√ √	√ √	√ √	√		√(+) √(-)		
12	Butter	√ √	√ √	√ √	√	√ √	√(-)	√	
13	SMP	√ √	√ √	√ √	√ √	√ √	√(-) √(-)	√	
14	WMP	√	√ √	√ √	√ √	√ √			
15	Cheese	√ √	√ √	√ √	√	√ √	√(-)	√	
16	Cocoa	√ √	√ √	√ √	√ √				
17	Coffee	√ √	√ √	√ √	√	√ √			
18	Tea	√ √	√ √	√ √	√ √		√(-)		
19	Sugar	√ √	√ √	√ √	√	√	√(-) √(-)		
20	Cotton	√ √	√	√ √	√	√ √	√(+)	√	

of the absolute mean of the posterior distribution. As noted in Section 4.2, this roughly corresponds to a variable being significant at the 5 percent level (one tailed).

While the focus of our analysis is mainly on the determinants of the volatility of the series, it is worth nothing that the autoregressive representation of order two is sufficient to capture the serial correlation in the series. The first lag is significant for most of the commodities. In only a few cases is the second order coefficient significant. However having said this, the majority of the series have negative second order coefficients suggesting that the majority of the series contain cyclical behaviour. The seasonal components of the series are insignificant for nearly all commodities.[15] While the second order coefficient and seasonal components could be removed, an exploratory analysis suggested that inclusion of these components had not substantive impact on the results. Therefore, for consistency, these explanatory variables are included for all the series.

Table 1 summarises the results for the monthly data (see also Tables A2 through A21). Each series has two sets of results in Tables A2 through A20. The first is where the model is run on the longest possible period, excluding exchange rate volatility. The second is on the shorter series where exchange rate volatility is included. Therefore, the two sets of results will differ because an additional variable is included and they are run over different periods. The stocks data was available for only 3 of the series (Wheat, Maize and Soyabean). Therefore, there is another table (A21) which utilises the stocks data. Again, this is run over a shorter period than for all the previous results, since the stocks data is only available from the periods listed in Table 1. The rest of the column in Table 1 is blacked out for the other

[15] This finding was supported when the series were estimated with higher seasonal frequencies and seasonal dummies.

commodities for which stocks data is unavailable. A tick (√) in a given cell indicates that the variable listed in the column heading is significant in influencing the volatility of the series for one of models in Tables A2 through A20. Two ticks in a cell indicate that the variable was significant for both the models (i.e. with and without exchange rates).

Broadly, the results in Table 1 (and Tables A2 through A21) can be summarised as follows:

i) Nearly all the commodities have significant stochastic trends (as the variance in the random intercept is significant). Pigmeat is the exception.
ii) Most of the commodities have cyclical components with the exception of palm oil.
iii) Past volatility is a significant predictor of current volatility for nearly all variables run over both periods (with and without exchange rate volatility).We therefore conclude that there is persistent volatility in commodity prices. That is, we would expect to see periods of relatively high volatility in agricultural commodities and periods of relatively low volatility.
iv) There is evidence that there is transmission of volatility across agricultural commodities for nearly all commodities (except pigmeat). The aggregate past volatility is a predictor of volatility in most commodities. This is indicative of a situation where markets are experience common shocks that impact on many markets rather than being isolated to one commodity or market.
v) Oil price volatility a significant predictor of volatility in agricultural commodities in the majority series. With the growth of the biofuel sector, commodity prices and oil prices may become more connected, so there is reason to believe that the role of oil prices in determining volatility may even be stronger in the future.
vi) As with oil prices, exchange Rate volatility impacts on the volatility of commodity prices for 10 out of the 19 series.
vii) Stock levels have a significant (downward) impact on the volatility for each of the three series for which we have data on stocks. This is consistent with our expectations that as stocks become lower, the markets become more volatile.
viii) A number of commodity prices have significant trends. However, these trends are positive for some series and negative for others. Recent high levels of volatility should not lead us to believe that agricultural markets are necessarily becoming more volatile in the long run.

5.2.2 Annual results

The annual results were produced using the panel approach outlined in Section 3.2 and are presented in Table A22. Four sets of results are presented within that table. First, results are produced with and without the inclusion of stocks. This is because the stocks data was for a shorter period than for the commodity price data. Next, we allowed for the trends in the panel regression to be restricted to be the same across each of the commodities, and in another model they were allowed to vary, giving four sets of results overall.

Where stocks are included, stocks are significant for the model in which the trend is restricted, but becomes insignificant when the trends in volatility are allowed to vary for each of the commodities. Notably, the estimated trends are generally negative, and the restriction of common trends across the commodities seems reasonable. Thus, the results do suggest (as with the higher frequency data) that as stocks rise the level of volatility in the prices decreases.

As with the higher frequency data, there is strong evidence that there is persistence in volatility. This finding is robust to the specification of the model since lagged volatility is significant in all four specifications. Yields also appear to be a significant determinant of volatility. In each of the four specifications higher yields lead to larger volatility in the series.

As argued in Section 2.3, there is no clear case for expecting yields to have a positive or negative influence on volatility in the first instance. Obviously, we would expect high yields to drive prices down, and low yields to drive prices up. However, this does not imply the volatility of the series should go up or down. Our results suggest that high yields have a tendency to drive prices downwards to a greater extent than low yields tend to drive prices up. While we do not investigate this further here, it is also possible that the response to yields is dependent on the level of stocks.

Finally, unlike the higher frequency data, there is only weak evidence that oil price volatility and exchange rate volatility have an impact on the volatility of commodity prices.

6. CONCLUSIONS

Several important findings emerge from our empirical study. First, there is strong evidence that there is persistent volatility in agricultural series. In nearly all of the series examined, there was evidence that the variance of the series was a function of the past volatility of the series, and this finding was robust to the choice of model and frequency of the data. Next, there was convincing evidence that there was some degree of transmission of volatility across commodities in the monthly data. Where stocks and yield data were available, these also appeared to be significant determinants of the volatility of agricultural commodity prices.

There is also convincing evidence that many of the candidate variables have an impact on volatility. In monthly series, oil price volatility had a positive impact on commodity price volatility. Thus, from the evidence available, the recent coincidental high volatility in oil and commodity prices is symptomatic of a connection between commodity price volatility and oil price volatility. As discussed earlier. The link between oil prices and agricultural commodity prices is likely to arise through the impact of energy prices on the costs of production, along with the alternative use of some crops for biofuel production. Therefore, we would expect the link between oil price volatility and agricultural prices to continue or strengthen as the biofuels sector grows. Likewise, exchange rate volatility was found to influence the volatility of agricultural prices. Thus, perhaps unsurprisingly, if the global economy is experiencing high levels of volatility these will also be reflected in agricultural prices. Although, in this study we could not identify any significant link between export concentration (as measured by the Herfindahl index) and oil price volatility.

Finally, the evidence produced in this chapter also suggests that the volatility of agricultural prices contained trends that were independent of the variables used to explain volatility. However, the evidence is mixed with regard to the direction of these changes. In the monthly data, these trends were positive for some commodities and negative for others. For the annual data, the evidence was that the trends were, having accounted for oil price volatility and other factors, negative. Thus, overall the results here do not suggest that there will be increasing volatility in agricultural markets unless there is increasing volatility in the variables that are determining that volatility. On the other hand, if factors such as oil prices continue to be volatile, then agricultural prices may continue to be volatile or become increasingly volatile.

REFERENCES

Aizeman J. & Pinto, B. 2005. Managing Economic Volatility and Crisis, A Practitioner's Guide. New York, World Bank, Cambridge University Press.

Balcombe, K. & Rapsomanikis, G. 2008. Bayesian estimation and selection of non-linear vector error correction models: The case of the sugar-ethanol-oil nexus in Brazil. *American Journal of Agricultural Economics*, 90(2): 658–668.

Chib, C. & Greenberg, E. 1995. Understanding the Metropolis-Hastings Algorithm. *The American Statistician*, November, 49(4): 327–335.

Deaton, A. & Laroque, G. 1992. On the behaviour of commodity prices. *Review of Economic Studies*, 59: 1–23.

Engle, R.F. 1982. Autoregressive conditional heteroscedasticity of the variance of United Kingdom Inflation. *Econometrica*, 50(4): 987–1006.

Engle, R.F. 1995. ARCH, Selected Readings. *Advanced Texts in Econometrics*. Oxford, University Press.

FAO. 2008. Food Outloook, Global Market Analysis, June (available at: http://www.fao.org/docrep/010/ai466e/ai466e00.htm).

Harvey, A.C. 1989. *Forecasting Structural Time Series Models and the Kalman Filter.* Cambridge, Cambridge University Press.

Koop, G. 2003. *Bayesian Econometrics*. Sussex, England, Wiley.

Oxley, L., Donald, A.R., Colin, J. & Sayer, S. 1994. *Surveys in Econometrics*. Wiley Blackwell.

Train, K. 2003. *Discrete Choice Methods with Simulation*. Cambridge, Cambridge University Press.

APPENDIX A: TABLES

Table A1. Data Series summary

	Frequency Series	Annual Stocks	Annual Yield	Annual Herfindel	Monthly Price	Quarterly Stocks
Commodity						
Wheat	1	1962-2007	1962-2007	1961-2006	Jan 57 - Mar 09	June: 1977: Dec 2008
Maize	2	1962-2007	1962-2007	1961-2006	Jan 57 - Mar 09	June 1975: June 2008
Rice, Milled	3	1962-2007	1962-2007	1961-2006	Jan 57 - Mar 09	
Oilseed, Soyybean	4	1962-2007	1962-2007	1961-2006	Jan 57 - Jan 09	Dec 1990: Dec: 2008
Oil, Soybean	5	1962-2007		1961-2006	Jan 57 - Jan 09	
Oil, Rapeseed	6	1962-2007	1962-2007	1961-2006	Jan 70 - Jan 09	
Oil, Palm	7	1962-2007	1962-2007	1961-2006	Jan 60 - Jan 09	
Poultry, Meat, Broiler	8	1962-2007		1961-2006	Feb 80 - Nov 08	
Meat, Swine	9	1962-2007		1961-2006	Feb 80 - Nov 08	
Meat, Beef and Veal	10	1962-2007		1961-2006	Jan 57 - Oct 08	
Dairy, Butter	11	1962-2007		1961-2006	Jan 57 - Jan 09	
Dairy, Milk, Nonfat Dry	12	1962-2007		1961-2006	Jan 90 - Jan 09	
Dairy, Dry Whole Milk Powder	13	1962-2007		1961-2006	Jan 90 - Jan 09	
Dairy, Cheese	14	1962-2007		1961-2006	Jan 90 - Jan 09	
Cocoa	15		1962-2007	1961-2006	Jan 57 - Nov 08	
Coffee, Green	16	1962-2007	1962-2007	1961-2006	Jan 57 - Nov 08	
Tea	17		1962-2007	1961-2006	Jan 57 - Nov 08	
Sugar	18	1962-2007	1962-2007	1961-2006	Jan 57 - Nov 08	
Cotton	19	1962-2007	1962-2007	1961-2006	Jan 57 - Nov 08	
Other data						
Oil Prices					Jan 57 - Mar 09	
Exchange Rates					1973-2007	
Interest Rates (US 6 month Treasury Bill)						

Tables Monthly data

Table A2. Wheat (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.02	0.007	0.029	0.01
Random intercept variance	0.037	0.005	0.035	0.011
Lagged own volatility	0.268	0.046	0.097	0.042
Lagged aggvolatility	0.24	0.095	0.351	0.092
Oil volatility	0.054	0.037	0.196	0.076
Trend	0.3	0.078	0.06	0.064
Ex rate volatility			0.043	0.03
Mean intercept	3.178	1.537	2.982	1.576
y(-1)	0.514	0.28	0.563	0.283
y(-2)	-0.099	0.255	-0.111	0.269
Seasonal	0.012	0.022	0.009	0.028

Table A3. Maize (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.035	0.009	0.04	0.015
Random intercept variance	0.016	0.011	0.021	0.018
Lagged own volatility	0.128	0.071	0.051	0.035
Lagged aggvolatility	0.3	0.041	0.155	0.049
Oil volatility	0.163	0.054	0.163	0.057
Trend	0.431	0.059	0.068	0.041
Ex rate volatility			0.112	0.062
Mean intercept	1.932	1.144	1.958	1.148
y(-1)	0.765	0.246	0.728	0.255
y(-2)	-0.145	0.242	-0.114	0.254
Seasonal	0.009	0.017	0.011	0.024

Table A4. Rice (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.025	0.007	0.026	0.009
Random intercept variance	0.039	0.007	0.038	0.009
Lagged own volatility	0.293	0.037	0.311	0.07
Lagged aggvolatility	0.079	0.025	0.118	0.071
Oil volatility	0.095	0.037	0.301	0.071
Trend	0.064	0.043	0.053	0.056
Ex rate volatility			0.078	0.055
Mean intercept	3.247	1.588	2.975	1.79
y(-1)	0.589	0.257	0.677	0.299
y(-2)	-0.099	0.236	-0.144	0.277
Seasonal	-0.004	0.023	0.005	0.027

Table A5. Soybean (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.032	0.006	0.035	0.009
Random intercept variance	0.03	0.008	0.035	0.01
Lagged own volatility	0.199	0.032	0.232	0.073
Lagged aggvolatility	0.369	0.105	0.189	0.055
Oil volatility	0.033	0.03	0.086	0.081
Trend	0.1	0.062	-0.236	0.057
Ex rate volatility			0.201	0.104
Mean intercept	2.938	1.496	3.098	1.602
y(-1)	0.627	0.271	0.614	0.289
y(-2)	-0.129	0.255	-0.142	0.272
Seasonal	0.006	0.021	0.005	0.027

Table A6. Soya Oil (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.02	0.01	0.012	0.008
Random intercept variance	0.05	0.007	0.057	0.005
Lagged own volatility	0.226	0.033	0.134	0.069
Lagged aggvolatility	0.169	0.047	0.139	0.068
Oil volatility	0.104	0.042	0.19	0.108
Trend	-0.076	0.057	-0.338	0.104
Ex rate volatility			0.358	0.113
Mean intercept	3.936	1.592	4.621	1.78
y(-1)	0.521	0.229	0.469	0.244
y(-2)	-0.119	0.208	-0.168	0.223
Seasonal	-0.001	0.025	-0.009	0.031

Table A7. Rape (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.018	0.011	0.018	0.011
Random intercept variance	0.055	0.008	0.052	0.007
Lagged own volatility	0.107	0.039	0.111	0.052
Lagged aggvolatility	0.263	0.083	0.244	0.023
Oil volatility	0.039	0.023	0.098	0.074
Trend	-0.296	0.075	-0.4	0.079
Ex rate volatility			0.16	0.12
Mean intercept	4.428	1.75	4.412	1.844
y(-1)	0.522	0.242	0.528	0.256
y(-2)	-0.183	0.226	-0.187	0.239
Seasonal	0.003	0.028	0.002	0.03

Table A8. Palm (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.012	0.008	0.011	0.009
Random intercept variance	0.069	0.004	0.069	0.005
Lagged own volatility	0.266	0.044	0.209	0.068
Lagged aggvolatility	0.207	0.044	0.186	0.064
Oil volatility	0.164	0.06	0.154	0.066
Trend	-0.212	0.065	-0.298	0.069
Ex rate volatility			0.259	0.084
Mean intercept	4.616	1.553	4.67	1.541
y(-1)	0.433	0.228	0.437	0.225
y(-2)	-0.172	0.2	-0.184	0.199
Seasonal	0.017	0.032	0.016	0.033

Table A9. Poultry (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.005	0.003	0.005	0.003
Random intercept variance	0.02	0.002	0.02	0.002
Lagged own volatility	0.217	0.038	0.095	0.069
Lagged aggvolatility	0.115	0.034	0.037	0.025
Oil volatility	0.031	0.015	0.037	0.018
Trend	-0.188	0.08	-0.149	0.111
Ex rate volatility			0.13	0.048
Mean intercept	2.863	1.975	2.799	1.91
y(-1)	0.475	0.421	0.484	0.409
y(-2)	-0.118	0.387	-0.113	0.387
Seasonal	-0.012	0.022	-0.013	0.023

Table A10. Pigmeat (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.097	0.002	0.098	0.002
Random intercept variance	0.004	0.003	0.004	0.003
Lagged own volatility	0.124	0.068	0.087	0.029
Lagged aggvolatility	0.059	0.036	0.062	0.029
Oil volatility	0.094	0.045	0.302	0.046
Trend	-0.141	0.096	-0.154	0.047
Ex rate volatility			0.06	0.036
Mean intercept	0.887	0.541	0.895	0.54
y(-1)	0.868	0.189	0.862	0.18
y(-2)	-0.083	0.195	-0.078	0.186
Seasonal	0.025	0.027	0.025	0.026

Table A11. Beef (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.019	0.009	0.021	0.008
Random intercept variance	0.022	0.009	0.029	0.007
Lagged own volatility	0.197	0.049	0.259	0.098
Lagged aggvolatility	0.055	0.041	0.123	0.034
Oil volatility	0.028	0.023	0.035	0.026
Trend	0.273	0.107	-0.176	0.058
Ex rate volatility			0.050	0.041
Mean intercept	3.261	1.949	3.166	1.656
y(-1)	0.534	0.365	0.587	0.322
y(-2)	-0.150	0.346	-0.184	0.300
Seasonal	-0.003	0.024	0.004	0.024

Table A12. Butter (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.056	0.009	0.064	0.01
Random intercept variance	0.059	0.011	0.058	0.012
Lagged own volatility	0.397	0.107	0.326	0.108
Lagged aggvolatility	0.126	0.053	0.062	0.048
Oil volatility	0.181	0.104	0.155	0.062
Trend	0.032	0.068	-0.288	0.097
Ex rate volatility			0.16	0.077
Mean intercept	4.601	1.39	4.466	1.517
y(-1)	0.057	0.218	0.056	0.236
y(-2)	0.052	0.198	0.038	0.22
Seasonal	0.01	0.029	0.003	0.035

Table A13. SMP (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.037	0.015	0.033	0.009
Random intercept variance	0.05	0.012	0.038	0.009
Lagged own volatility	0.518	0.146	0.529	0.098
Lagged aggvolatility	0.234	0.092	0.12	0.07
Oil volatility	0.377	0.129	0.283	0.097
Trend	-0.703	0.273	-0.477	0.147
Ex rate volatility			0.216	0.061
Mean intercept	2.232	2.532	2.256	2.676
y(-1)	0.62	0.389	0.609	0.414
y(-2)	0.077	0.36	0.085	0.386
Seasonal	-0.001	0.029	0	0.031

Table A14. WMP (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.013	0.007	0.013	0.008
Random intercept variance	0.033	0.005	0.035	0.006
Lagged own volatility	0.507	0.1	0.46	0.174
Lagged aggvolatility	0.077	0.037	0.156	0.084
Oil volatility	0.18	0.067	0.076	0.032
Trend	-0.148	0.097	-0.084	0.145
Ex rate volatility			0.337	0.213
Mean intercept	2.682	3.261	2.883	3.289
y(-1)	0.588	0.45	0.566	0.444
y(-2)	0.051	0.401	0.047	0.394
Seasonal	0.002	0.034	0.003	0.034

Table A15. Cheese (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.014	0.006	0.016	0.007
Random intercept variance	0.027	0.005	0.026	0.006
Lagged own volatility	0.351	0.062	0.478	0.134
Lagged aggvolatility	0.163	0.052	0.068	0.045
Oil volatility	0.18	0.026	0.226	0.037
Trend	-0.044	0.058	-0.068	0.105
Ex rate volatility			0.125	0.075
Mean intercept	3.171	3.661	3.103	3.746
y(-1)	0.433	0.475	0.448	0.495
y(-2)	0.165	0.434	0.159	0.449
Seasonal	0.002	0.031	0.002	0.03

Table A16 Cocoa (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.031	0.013	0.03	0.014
Random intercept variance	0.041	0.012	0.046	0.014
Lagged own volatility	0.2	0.109	0.206	0.099
Lagged aggvolatility	0.088	0.048	0.037	0.032
Oil volatility	0.311	0.22	0.089	0.06
Trend	0.082	0.14	-0.195	0.08
Ex rate volatility			0.083	0.059
Mean intercept	4.633	2.945	4.499	1.984
y(-1)	0.436	0.36	0.527	0.254
y(-2)	-0.044	0.346	-0.116	0.242
Seasonal	-0.002	0.04	0	0.03

Table A17 Coffee (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.025	0.007	0.033	0.012
Random intercept variance	0.051	0.007	0.07	0.01
Lagged own volatility	0.496	0.1	0.492	0.077
Lagged aggvolatility	0.181	0.066	0.038	0.029
Oil volatility	0.106	0.061	0.108	0.056
Trend	0.858	0.109	0.102	0.063
Ex rate volatility			0.076	0.057
Mean intercept	2.025	1.645	2.487	1.318
y(-1)	0.468	0.266	0.393	0.262
y(-2)	0.088	0.235	0.065	0.228
Seasonal	0.011	0.021	0.027	0.036

Table A18 Tea (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.046	0.006	0.037	0.008
Random intercept variance	0.044	0.008	0.055	0.008
Lagged own volatility	0.375	0.06	0.385	0.1
Lagged aggvolatility	0.085	0.045	0.161	0.066
Oil volatility	0.035	0.028	0.046	0.036
Trend	-0.098	0.031	0.03	0.08
Ex rate volatility			0.028	0.025
Mean intercept	3.935	1.292	3.982	1.648
y(-1)	0.568	0.22	0.503	0.267
y(-2)	-0.277	0.206	-0.222	0.243
Seasonal	0.015	0.027	0.022	0.035

Table A19 Sugar (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.056	0.014	0.047	0.02
Random intercept variance	0.06	0.015	0.064	0.019
Lagged own volatility	0.251	0.043	0.253	0.08
Lagged aggvolatility	0.099	0.048	0.088	0.061
Oil volatility	0.102	0.067	0.141	0.072
Trend	-0.234	0.047	-0.38	0.081
Ex rate volatility			0.306	0.111
Mean intercept	1.147	0.513	1.22	0.654
y(-1)	0.629	0.183	0.584	0.219
y(-2)	-0.093	0.172	-0.078	0.205
Seasonal	0.013	0.029	0.006	0.035

Table A20. Cotton (Monthly)

Parameter	Mean	Stdv	Mean	Stdv
Error variance	0.017	0.007	0.039	0.004
Random intercept variance	0.023	0.008	0.004	0.006
Lagged own volatility	0.253	0.12	0.181	0.043
Lagged aggvolatility	0.203	0.085	0.119	0.097
Oil volatility	0.133	0.048	0.219	0.11
Trend	0.364	0.134	0.004	0.047
Ex rate volatility			0.071	0.037
Mean intercept	1.523	1.205	0.741	0.606
y(-1)	0.813	0.288	1.156	0.254
y(-2)	-0.198	0.272	-0.338	0.254
Seasonal	0.005	0.017	0.007	0.016

Table A21. (Monthly with stocks)

	Wheat		Maize		Soyabean	
Parameter	Mean	Stdv	Mean	Stdv	Mean	Stdv
Error variance	0.019	0.011	0.04	0.01	0.016	0.008
Random intercept	0.037	0.01	0.017	0.013	0.043	0.006
Lagged own volatility	0.1	0.071	0.064	0.039	0.076	0.066
Lagged aggregate	0.02	0.017	0.109	0.07	0.101	0.054
Stocks	-0.11	0.031	-0.128	0.073	-0.324	0.111
Trend	0.338	0.164	0.441	0.164	0.045	0.035
Ex rate volatility	0.238	0.124	0.34	0.124	0.059	0.049
Oil price vol	0.1	0.071	0.064	0.039	0.076	0.066
Mean intercept	3.274	1.773	1.538	1.569	4.009	1.86
y(-1)	0.459	0.293	0.712	0.365	0.488	0.287
y(-2)	-0.059	0.278	-0.02	0.366	-0.109	0.272
Seasonal	-0.014	0.03	0.015	0.031	-0.006	0.029

Table A22. Panel results

	Stocks included (9 commodittes)		Stocks not included (11 commodities)	
Parameter	Mean	Stdv	Mean	Stdv
Lagged price volatility	0.392	0.064	0.392	0.063
Stock levels	-0.103	0.055		
Export concentration	-0.07	0.104	-0.008	0.099
Yeilds	0.414	0.233	0.487	0.219
Exchange rate volatility	0.301	0.283	0.297	0.278
Oil Price Volatility	0.081	0.054	0.077	0.055
Intercepts				
Wheat	-0.834	0.064	-0.833	0.07
Maize	-0.764	0.057	-0.763	0.061
Rice	-0.85	0.091	-0.852	0.093
Soybeans	-0.793	0.074	-0.794	0.08
Rapeseed	-0.647	0.076	-0.649	0.086
Palm Oil	-0.454	0.076	-0.457	0.086
Cocoa			-0.549	0.076
Coffee	-0.363	0.102	-0.362	0.108
Tea			-0.458	0.095
Sugar	-0.148	0.068	-0.148	0.07
Cotton	-0.845	0.078	-0.845	0.08
Pooled Trend	-0.083	0.042	-0.116	0.041
Trends varying across Commodities				
Volatility Determinants				
Lagged price volatility	0.357	0.066	0.344	0.065
Stock levels	-0.075	0.054		
Export concentration	-0.01	0.136	0.042	0.125
Yeilds	0.521	0.366	0.672	0.337
Exchange rate volatility	0.298	0.28	0.296	0.276
Oil Price Volatility	0.074	0.052	0.07	0.052
Intercepts				
Wheat	-0.833	0.067	-0.833	0.072
Maize	-0.765	0.06	-0.763	0.062
Rice	-0.853	0.093	-0.854	0.094
Soybeans	-0.794	0.075	-0.793	0.081
Rapeseed	-0.647	0.076	-0.647	0.082
Palm Oil	-0.455	0.077	-0.455	0.083
Cocoa			-0.548	0.075
Coffee	-0.361	0.101	-0.364	0.107
Tea			-0.458	0.093
Sugar	-0.148	0.068	-0.148	0.07
Cotton	-0.843	0.08	-0.844	0.084
Trends				
Wheat	-0.094	0.107	-0.122	0.105
Maize	-0.122	0.093	-0.165	0.089
Rice	-0.14	0.117	-0.195	0.111
Soybeans	-0.129	0.112	-0.192	0.102
Rapeseed	-0.231	0.123	-0.313	0.114
Palm Oil	-0.22	0.14	-0.324	0.125
Cocoa			-0.232	0.091
Coffee	0.027	0.115	0.012	0.117
Tea			-0.081	0.117
Sugar	-0.164	0.076	-0.196	0.075
Cotton	-0.098	0.103	-0.146	0.101

APPENDIX B: TECHNICAL APPENDIX

B.1 Random Parameter Models with Time Varying Volatility

For a given price series y_t (or logged series which will be used throughout this report) where $t = 1.....T$, it is proposed that the following autoregressive model with a random walk intercept is used:

$$\theta(L)y_t = \alpha_t + \delta' d_t + e_t \qquad \text{(b1)}$$

Where $\theta(L) = \sum_{i=0}^{k} \theta_i L^i$ (a lag operator of finite length) and:

$$\alpha_t = \alpha_{t-1} + v_t \qquad \text{(b2)}$$

where d_t is a vector of deterministic variables[16] that are able to capture the seasonality and e_t and v_t are assumed to be independently normally distributed. The series can then be decomposed into its components:

$$y_t = Level_t + Seasonal_t + Cycle_t \qquad \text{(b3)}$$

$$Level: \mu_t = \theta(L)^{-1}(1-L)^{-1} v_t \qquad \text{(b4)}$$

$$Seasonal: s_t = \delta'\theta(L)^{-1} d_t \qquad \text{(b5)}$$

$$Cycle: (y_t - a_t - s_t) = \theta(L)^{-1} e_t \qquad \text{(b6)}$$

Therefore, this allows the separate analysis of the non-stationary component μ_t and the stationary component $(y_t - \mu_t)$. The overall volatility of the series is governed by the two variances $h = (h_v, h_e)$ along with the autoregressive parameters. The observed volatility is produced by the errors e_t, v_t (which are assumed to be iid normal)

The inverted lag operator has the representation:

$$\theta(L)^{-1} = \sum_{i=0}^{\infty} \gamma_i L^i \qquad \text{(b7)}$$

In the absence of stochastic volatility, the volatility in each of the series is governed by:

$$Var(\Delta\mu_t) = \left(\sum_{j=0}^{\infty} \gamma_i^{\,2} \right) h_v \qquad \text{(b8)}$$

[16] In this case we examined both standard seasonal dummies along with the seasonal effects variables in Harvey (1989, p.41). In virtually variables we found little evidence of seasonality. For the results presented in this report, we continue to include the first fundamental frequency. However, in nearly all cases this was not significant. We continue to include it for consistency across models. However, removing the seasonal dummies would make little difference to the results presented here.

$$Var(y_t - \mu_t) = \left(\sum_{j=0}^{\infty} \gamma_i^2 \right) h_e \quad \text{(b9)}$$

For a stationary series $h_v = 0$, in which case only $Var(y_t - \mu_t)$ is of interest. The proposed framework is able to cope with stationary or non-stationary series, since there is no requirement that $h_v > 0$ within the model. For the purposes of this study, the distinction between two volatilities will be made as follows:

$Var(\Delta\mu_t)$: *volatility in mean*

$Var(y_t - a_t - s_t)$: *volatility in cycle*

The model can be extended by conditioning the variances on a set of explanatory variables in the following way:

$$\ln h_{v,t} = \ln(h_v) + \lambda_v' z_t \quad \text{(b10)}$$

$$\ln h_{e,t} = \ln(h_e) + \lambda_e' z_t \quad \text{(b11)}$$

Where z_t is a vector of variables as outlined in the main text in Section 3.1.

The two measures of volatility at a particular time then become:

$$Var(\Delta\mu_t) = \left(\sum_{j=0}^{\infty} \gamma_i^2 \right) h_{v,t} \quad \text{(b12)}$$

$$Var(y_t - \mu_t) = \left(\sum_{j=0}^{\infty} \gamma_i^2 \right) h_{e,t} \quad \text{(b13)}$$

(where these can be aggregated to overall measure of volatility).

Restrictions and Identification

In the framework outlined above, equations b12 and b13 imply that the underlying volatility is governed by:

$$h_{v,t} = h_v \exp(\lambda_v' z_t) \quad \text{(b14)}$$

$$h_{e,t} = h_e \exp(\lambda_e' z_t) \quad \text{(b15)}$$

If λ_v or λ_e are equal to zero then the volatility in the long or short run component are constants. However, in the situation where h_v or h_e or are zero then the associated parameters λ_v or λ_e become unidentified. This does not in itself preclude estimation within a Bayesian framework. However, unless the posterior densities of h_v and h_e and are both heavily concentrated away from zero, then the standard error of the lambda coefficients will be very large. If a series can be modelled in a way where the variance could be attributed either to stationary or non-stationary shocks, then the associated standard deviation in the estimates of the lambda coefficients will be large, and determining whether the shocks in the variable in question are significant will be very difficult. In this work we avoid this problem by assuming $\lambda_v = \lambda_e = \lambda$. This implies that the long run and short run variances are proportional, but these variances can vary across in t. Since the values of h_v and h_e will not be close to zero simultaneously (since the all the series have variation) the standard errors in the lambda coefficients will be smaller. This is obviously at a cost. If the shocks to volatility (z_t) impacted differently on the long and short run components, then clearly there would be bias in the results. However, arguably, it is reasonable to assume that shocks in volatility are likely to co-vary across both the permanent and transitory components (should they both exist). Thus, while this assumption is essentially required for identification, it is highly plausible from an economic point of view.

B.2 Estimation

Denoting the parameters that are to be estimated as Ω, the data to be explained as Y and the explanatory data as X, the likelihood function can be viewed as the probability density of Y conditional on X and Ω. Therefore, the likelihood function can be denoted as $f(Y|\Omega,X)$. For prior distributions on Ω, $f(\Omega)$, the posterior distribution is denoted as $f(\Omega|Y,X)$ and obeys:

$$f(\Omega|Y,X)\,\alpha\, f(Y|\Omega,X)\,f(\Omega) \qquad \text{(b16)}$$

Where α denotes proportionality. For the random parameter models, the parameters of interest are:

$$\Omega_* = \left(\{\theta_j\},\lambda_v,\lambda_e,h_v,h_e\right) \qquad \text{(b17)}$$

Normal priors are adopted for the parameters $\{\theta_j\},\lambda_v,\lambda_e$ where the mean is zero, with a large variance so as to reflect diffuse prior knowledge.[17] For the parameters h_v and h_e inverse gamma priors can be used, as is standard in Bayesian analysis.

For any values of $\Omega = (\lambda_v,\lambda_e,h_v,h_e)$ the Kalman Filter can produce optimal estimates of $\{\theta_j\}$, and standard errors for these parameters, along with the value of the likelihood function. Thus, in effect $\{\theta_j\}$ are ignored in the estimation of Ω since they are viewed as latent variables that are generated for any given values of Ω but are not required for the likelihood function. Estimations of the posterior distributions are then obtained using a random walk Metropolis-Hastings algorithm (see Koop, 2003, p97) to simulate the posterior distribution. The estimates of Ω(Ω) that are then produced are the mean of the simulated parameters and the standard deviations for the simulated values can likewise be obtained. The estimates for $\{\theta_j\}$ along with the standard errors are then obtained using the values $\overline{\Omega}$ within the Kalman Filter.[18]

For the Panel Data a Bayesian approach to estimation is also used. In this case we use Gibbs Sampling.[19] The parameters are simply,

$$\Omega = (\{\beta_{0i}\},\{\beta_{1i}\},\lambda_v,\lambda,\Sigma) \qquad \text{(b18)}$$

Where Σ is the variance covariance matrix associated with the errors in equation (4) within the main text.

[17] Note that the priors for the autoregressive coefficients are set within the Kalman Filter.

[18] Note that these point estimates are therefore conditional on the plug in estimates and strictly speaking do not reflect the mean and variance of these parameters from a Bayesian perspective.

[19] A good coverage of Gibbs Sampling is given in many textbooks. The estimation procedure of this panel can be viewed as a seemingly unrelated regression with cross equation restrictions. The details of how to estimate this model are in Koop (2003) Chapter 6.

Commodity speculation and commodity investment

CHRISTOPHER L. GILBERT[1]

[1] CIFREM and Department of Economics, University of Trento, Italy and Department of Economics, Birkbeck College, University of London, England. The initial version of this paper was prepared for the conference 'The Globalization of Primary Commodity Markets', Stockholm, 22–23 October 2007, organized in conjunction with the publication of Radetzki (2007, 2008). I am grateful to SNS, Stockholm, for support. I am grateful to Isabel Figuerola-Ferretti, Hilary Till and an anonymous referee for comments on an earlier draft. All errors remain my own. Address for correspondence: Dipartimento di Economia, Università degli Studi di Trento, Via Inama 5, 38100 Trento, Italy; cgilbert@economia.unitn.it

1. INTRODUCTION

Most major primary commodities are actively traded on futures markets and the prices discovered in these markets form the basis for transactions prices in international commerce. Transactors in futures markets are generally classified as either hedgers or speculators and the exchanges are seen as transferring price exposure from the hedgers to speculators in exchange for a risk premium. Speculators take a view, either on the basis of information or through the use of more or less sophisticated trend-spotting procedures, on the prospects of the particular commodities in which they take positions. They provide the liquidity which allows hedgers to find counterparties. However, over the past two decades, a third class of transactors has become important. These are investors who regard commodity futures as an asset class, comparable to equities, bonds, real estate and emerging market assets and who take positions on commodities as a group based on the risk-return properties of portfolios containing commodity futures relative to those confined to traditional asset classes. As Masters (2008) testified, their behaviour is very different from that of traditional speculators, and it is therefore possible that this will result in different effects on market prices.

The sums of money invested by this third group of commodity investors may be very substantial. According to many commentators, this class of inventors has come to dominate the commodity futures markets with the consequence that fundamental movements have been relegated to a minor, supporting, role. Commodity markets have become akin to foreign exchange markets where the weight of money outweighs the relative competitiveness (Purchasing Power Parity) fundamental. In June 2008 testimony to the U.S. Congress, George Soros asserted that investment in instruments linked to commodity indices had become the "elephant in the room" and argued that investment in commodity futures might exaggerate price rises (Soros, 2008). These comments were echoed by the British peer Meghnad Desai who further claimed that the 2008 oil price rises were speculative and appeared to be a financial bubble.[2] One might paraphrase this view as stating that, in effect, the funds have become the fundamentals.

Over the past two decades, investment in commodities through managed commodity futures funds or using other vehicles has become a large, popular and profitable activity. The principles of, and problems with, commodity investment are well understood in the financial community, and have been set out in a number of recent practitioner-oriented publications (see Gregoriou *et al*., 2004; Till and Eagleeye, 2007; and Fabozzi *et al*., 2008a). There have been fewer discussions of commodity investing which succeed in bridging the industry-finance gap (see Geman, 2005; and Radetzki, 2007, 2008). Perhaps as a result, commodity investors continue to be regarded with suspicion by other market participants and by outside commentators who see their activities as distorting the operation of the markets. Some politicians have followed Lord Desai in suggesting that these actors may be at least partially responsible, directly or indirectly, for recent high commodity price levels and have called for restrictions or limitations on futures trading. In this paper, I discuss of the mechanics of commodity speculation and investment and consider its effects on the cooperation of the underlying physical markets.

In section 2, I distinguish between the various actors in commodity futures trading and ask whether the widely-used *Commitments of Traders* data, made available by the Commodity Futures Trading Commission (the CFTC), is informative in relation to these distinctions. In section 3, I discuss actors normally thought of as speculators (Commodity

[2] Act now to price the bubble of a high oil price, *Financial Times*, 6 June 2006.

Pool Operators, hedge funds and other traditional speculators) while section 4 looks at index-based investment. Section 5 looks at the returns on index-based investment and suggests that these returns may be lower in the future than has been the case over recent years. In section 6 I summarize the evidence on the effects of speculation on futures prices and volatility, and in section 7, I present evidence on the effects of index-based investments on prices. Section 8 contains conclusions.

2. INSTRUMENTS AND ACTORS

Futures exchanges facilitate both commodity speculation and commodity investment. They do this in three ways:

a) Futures enable separation of ownership of the physical commodity from assumption of the price exposure. It is possible to speculate or invest by buying the physical commodity but this will usually be very costly. When a speculator or investor takes a long futures position, ownership of the physical commodity remains with a merchant or producer who has a corresponding short position in the future. Use of futures avoids the trouble and costs of managing the physical position.
b) Because one can only sell a physical commodity if one already owns it, it is difficult to take a short position in a purely physical market. Futures makes this straightforward – the costs of being long and short are identical.
c) Purchase of a physical commodity requires full cash payment at the time of purchase. It is possible for the speculator or investor to lever his position by taking a bank loan using the commodity as collateral but it is likely that the bank, conscious of the price risk, will only offer a fraction of the value. The purchaser of a futures contract will not be required to make any initial payment (a futures contract has zero value at the time of contracting) but will be required to make a deposit of initial margin, typically 10 percent of the value of position for a client of good standing – see Edwards and Ma (1992) and Hull (2006). Futures therefore allow much higher leverage than physicals.

Futures contracts can only be traded on the exchange which originates them – contrast this with equities which can be traded on multiple platforms. Much speculation and investment takes place off exchanges through OTC (‘over the counter’) rather than exchange contracts, in particular in the form of commodity swaps. An OTC contract can either be an exchange ‘look alike’, in which case it differs from an exchange future only in that it is not intermediated through the exchange clearing house, or may have a different contract specification (e.g. delivery date or location).

Exchange-traded funds (ETFs) and commodity index certificates (the OTC analogue of ETFs) are two specific instruments which facilitate commodity investment. Commodity ETFs are funds which invest in commodity futures but whose price is directly quoted on an exchange. They may either restrict themselves to specific commodities – ETFs are currently available for crude oil, gold and silver – or aim to replicate the returns on a commodity futures index. They have the same structure as closed end funds in equities. Certificates are legal obligations, typically issues by banks, which yield a return defined by an underlying set of commodity futures investments. They have a structure closer to that of open end funds in equities (Engelke and Yuan, 2008; and Fabozzi *et al*., 2008b, p.13).

Swaps are portfolios of OTC futures. In a commodity swap, the long party receives payments in proportion to the gains on a portfolio of futures contracts and pays either a fixed or floating interest rate. OTC contracts have the advantage that they can be designed to suit client requirements, but the disadvantage that they can only be closed out through the original counterparty, i.e. swaps are non-fungible. Importantly, commodity swaps imply counterparty risk as well as commodity price risk. In a swap, the counterparty (usually a bank) will typically offset the net position in its swap book on exchange markets, and the swap will be marked to market against the exchange forward curve. Many institutional investors find it convenient to take on commodity exposure through a swap structure leaving the counterparty to manage the offsetting futures investments. Commodity swaps are currently the most important instrument by which investors take positions on commodity futures indices (ITF, 2008, p.22).

Edwards and Ma (1992, p.11) state "Futures contracts are bought and sold by a large number of individuals and businesses, and for a variety of purposes". This remains true. Broadly, we may delineate four classes of actors:

a) Hedgers: These are 'commercials' in CFTC terminology. They have an exposure to the price of the physical commodity (long in the case of producers and merchants with inventory, short in the case of consumers) which they offset (usually partially) by taking an opposite position in the futures market.
b) Speculators: They take positions, generally short term based on views about likely price movements. Speculators may be divided between those who trade on market fundamentals and those who trade on a technical basis, i.e. on the basis of past trends or other, more complicated, price patterns. Hedge funds and Commodity Trading Advisors (CTAs) (see below) typically fall into this category. Many speculative trades are 'spread' rather than 'outright' trades, that is to say they involve taking offsetting positions on related contracts (generally different maturities for the same future).
c) Investors: Investors take positions (usually long and usually indirectly) in commodity futures as a component of a diversified portfolio. This is the class of actors which appears to have grown dramatically over the two most recent decades.
d) Locals: Originally pit traders with modest capital but now mainly screen traders often operating from trading 'arcades', locals provide liquidity by 'scalping' high frequency price movements driven by fluctuations in trading volume and size. Many of their positions will also be spreads rather than outrights. Locals may also arbitrage across markets or exchanges.
e) Index providers: Banks or other financial institutions who facilitate commodity investment by providing suitable instruments, typically ETFs, commodity certificates or swaps. These institutions will generally offset much of their net position by taking offsetting positions on the futures markets.

These categories are easier to separate in principle than in practice. A producer or consumer who chooses not to hedge, or who hedges on a 'discretionary' basis, is implicitly taking a speculative position. Some locals may hold significant outright positions over time. Long term investors will take speculative views on commodities versus other asset classes, and on specific groups of commodities (metals, energy etc.). Some agents have mixed motives.

As already noted, many positions will be held through intermediaries:

- US legislation defines a commodity pool as an investment vehicle which takes long or short futures positions. A Commodity Pool Operator (CPO) operates a commodity pool. Commodity Trading Advisors (CTAs) advise on and manage futures accounts in CPOs on behalf of investors. A CPO investment is a straightforward means of investing in a portfolio of commodity futures.
- Hedge funds invest on behalf of rich individuals. Some of these investments are likely to be in commodity futures or swaps. 'Funds of funds' are hedge funds, or CPOs which

invest in other hedge funds or CPOs, generating greater diversification albeit at the cost of a second level of fees. A small number of hedge funds are focussed specifically on traditional commodities, generally with an emphasis on energy and non-ferrous metals.
- Exchanges offer ETFs defined either in terms of specific commodities or commodity indices. Banks offer certificates with returns tied to or related to the same indices.

The CFTC requires brokers to report all positions held by traders with positions exceeding a specified size, and also to report the aggregate of all smaller ('non-reporting') positions. These positions are published in anonymous and summary form in the weekly CFTC *Commitments of Traders* (COT) report. The CFTC classifies reporting traders as either 'commercial' or 'non-commercial' depending whether or not they have a commercial interest in the underlying physical commodity. Commentators, both academic and in the industry, routinely interpret commercial positions as hedges, non-commercial positions as large speculative positions and non-reporting positions as small speculative positions – see Edwards and Ma (1992). Upperman (2006) provides a guide to trading on the basis of the COT reports.

It is widely perceived that, as the consequence of the increased diversity of futures actors and the increased complexity of their activities, the COT data may fail to fully represent futures market activity. Many institutions reporting positions as hedges, and which are therefore classified as commercial, are held by commodity swap dealers to offset positions which, if held directly as commodity futures, would have counted as non-commercial. As the CFTC itself noted "… trading practices have evolved to such an extent that, today, a significant proportion of long-side open interest in a number of major physical commodity futures contracts is held by so-called non-traditional hedgers (e.g. swap dealers) … This has raised questions as to whether the COT report can reliably be used to assess overall futures activity …" (CFTC, 2006, p.2).

Responding to these concerns, the CFTC now issues a supplementary report for twelve agricultural futures markets which distinguish positions held by institutions identified as index providers. However, they have chosen not to provide this additional information for energy and metals futures, at least for the present, on the grounds that offsetting may involve taking positions on non-US exchanges and because many swap dealers in metals and energy futures have physical activities on their own account making it difficult to separated hedging from speculative activities. See CFTC (2006). I make use of the data from the supplementary reports in the analysis that follows.

3. CPOs, HEDGE FUNDS AND OTHER TRADITIONAL SPECULATORS

Commodity speculation has traditionally been thought of as undertaken by individuals – the proverbial New York cab drivers and Belgian dentists. Their activities are likely to be small in relation to the entire market and are reflected in the non-reporting columns of the COT reports.[3] There is no suggestion that this category of speculation has grown markedly over recent decades. Instead, commodity speculation has tended to be channelled through 'funds', in particular CPOs and hedge funds. The growth in fund activity may reflect the increasing number of highly wealthy individuals and the difficulty in obtaining high returns in what has been, until recently, a low inflation environment.

[3] i.e. Brokers report the aggregate of these positions to the CFTC, not the positions themselves.

Table 1. 2002 Funds snapshot

	Number	Median assets (USDm)	Total assets (USDbn)	Median fee structure
CPOs	1 510	13	162	2% + 9%
Hedge funds	2 357	36	1 580	1% + 20%
Funds of funds	597	34	343	1% + 20%

Note: CPOs are funds operated by CTAs. Total assets may double count money invested through funds of funds. Fee structure is fixed + percentage of profits.

Source: Liang (2004).

Table 1, taken from Liang (2004), gives a snapshot of money under management in CPOs, hedge funds and funds of funds in 2002. These figures almost certainly exaggerate the amount of money estimated in 'traditional commodities'. There are two reasons for the overstatement in the aggregate fund figures:

- Most hedge funds invest across the entire range of asset classes. Instruments relating to traditional commodity markets are likely to account for only a small proportion of these investments.
- US CPOs and CTAs are regulated under the Commodity Exchange Act (CEA) which defines a commodity future as any futures contract traded on a futures exchange.[4] The commodity futures asset class therefore also includes financial futures as well as futures on traditional commodities. These are much more important in aggregate than futures on commodities.

Within the commodity class, energy futures have traditionally had the highest weight and agricultural futures the lowest weight. Metals are intermediate. Fabozzi *et al*. (2008b) state that in 2007 there were around 450 hedge funds with energy and commodity-related trading strategies. Schneeweis *et al*., (2008) offer a lower estimate of around USD 50bn in managed futures investment in 2002 rising to USD 160bn by the third quarter of 2006. Eling (2008) suggests a 2007 figure of UD$135bn under CTA management. There is no reporting requirement on positions held on non-U.S. exchanges, and this prevents out obtaining a complete picture of participation in global futures markets.

Irwin and Holt (2004), who use data deriving from a study undertaken by the CFTC on large positions on US futures exchanges over a six month period in 1994, provide the most comprehensive evidence on commodity allocations of CPOs and large hedge funds. Table 3, taken from Irwin and Holt (2004), gives percentage allocations on a gross and net volume (i.e. offsetting long and short positions) basis and confirms the heavy concentration on financial futures (including gold futures). Note, however, that positions in agricultural futures are comparable with those in energy. It is unfortunate that more recent data of this type are unavailable.[5]

[4] The CFTC is responsible for regulation of what the CEA defines as commodity futures markets. It is unclear whether the CFTC or the Securities and Exchanges Commission (SEC) has responsibility for regulating futures on individual equities. The CEA is codified at 7 USC Section 1.

[5] Gupta and Wilkens (2007) have suggested quantification of CTA exposure through estimation of the betas of CTA returns. Their estimates are broadly in line with those reported in Table 2 but suggest lower weights for agriculturals.

Table 2. Composition of large CPO and large hedge fund futures portfolios

April - October 1994					
	Gross volume	Net volume		Gross volume	Net volume
	%	%		%	%
Coffee	1.6	1.7	Gold	25.7	8.0
Copper	2.9	3.0	Live hogs	7.4	0.9
Corn	5.4	5.7	Natural gas	0.9	4.5
Cotton	2.3	2.6	S&P 500	5.5	7.1
Crude oil	4.0	8.4	Soybeans	6.8	6.1
Deutschemark	8.2	7.3	Treasury bonds	23.2	21.8
Eurodollar	6.0	22.9			

Source: Irwin and Holt (2004).

The estimates in Table 2 suggest around 30 percent of commodity fund investments were in traditional commodities in 1994. Combining the estimates from Tables 1 and 2, and making the heroic assumptions that the same allocations apply to CTAs and hedge funds and that these proportions were unchanged from 1994 to 2002, we may estimate that commodities accounted for that approximately USD 50bn of the USD 162bn managed by CTAs in 2002. (It is difficult to make a comparable judgement for hedge funds since their assets are not entirely, and perhaps not mainly, invested in futures).

Irwin and Holt (2009) also present the same numbers as a proportion of total trading volume on the relevant exchanges and I reproduce these numbers (again relating to 1994) as Table 3. At times when funds take large positions, these amounted to between one quarter and one half of total trading volume. Positions of this order are sufficiently high to have a significant market impact.

Table 3. Large CTA and large hedge fund futures portfolios as a share of total volume

April - October 1994				
	Gross volume		Net volume	
	Average	Maximum	Average	Maximum
	%	%	%	%
Coffee	6.9	26.7	5.9	26.7
Copper	11.1	39.8	9.3	34.6
Corn	7.0	23.0	6.0	23.0
Cotton	12.9	39.4	11.1	39.4
Crude oil	5.4	19.5	4.4	16.3
Deutschemark	5.3	23.1	4.8	20.1
Eurodollar	7.2	28.5	5.3	23.6
Gold	8.6	24.7	7.3	24.7
Live hogs	11.6	47.8	9.4	47.8
Natural gas	14.0	54.4	12.2	53.6
S&P 500	3.7	14.9	3.2	12.0
Soybeans	6.7	12.6	6.0	21.6
Treasury bonds	2.4	10.3	1.8	7.5

Source: Irwin and Holt (2004), Table 8.3.

CTAs are obliged, under the CEA, to disclose their investment strategies. The most important distinction among CTAs is between the majority, which follow 'passive' allocation strategies and the much smaller minority which adopt discretionary strategies. Passive strategies rely on trend identification and extrapolation – once an upward trend is identified, the fund will take a long position in the asset and *vice versa* for a downward trend. Trends are generally identified by application of more or less sophisticated moving average procedures – see Taylor (2005). CTAs compete on the predictive power of their trend extraction procedures and also on the extent of their activity – whether they always take a position in a particular future or whether they can be out of the market for that future for extended periods.

Hedge funds are both more diverse and less transparent than CTAs. They are not obliged to report their investment strategies which must therefore be inferred from performance. They will also typically be opportunistic and hence may not follow consistent strategies over time. I do not attempt to quantify their activities or importance in this discussion.

4. COMMODITY INDEX INVESTORS

The driving rationale of investment in commodity futures is that commodities may be considered as a distinct 'asset class', and seen in this light, have favourable risk-return characteristics. The claim that commodities form a distinct asset class, analogous with the equity, fixed interest and real estate asset classes, supposes that the class is fairly homogeneous so that it may be spanned by a small number of representative positions. Specifically, this requires that the class have a unique risk premium which is not replicable by combining other asset classes (see Scherer and He, 2008). Given this premise, the claim that commodities form an asset class which is interesting to investors relies on their exhibiting a sufficiently high excess return and sufficiently low correlations with other asset classes such that, when added to portfolio, the overall risk-return characteristics of the portfolio improve (see Bodie and Rosansky 1980; Jaffee, 1989; Gorton and Rouwenhorst, 2006; and, for a summary, Woodward, 2008).

Index funds set out to replicate a particular commodity futures index in the same way that equity tracking funds aim to replicate the returns on an equities index, such as the S&P500 or the FTSE100. The most widely followed commodity futures indices are the S&P GSCI and the DJ-AIG index. The S&P GSCI is weighted in relation to world production of the commodity averaged over the previous five years.[6] These are quantity weights and hence imply that the higher the price of the commodity future, the greater its share in the S&P GSCI. Recent high energy prices imply a very large energy weighting – 71 percent in September 2008. The DJ-AIG Index weights the different commodities primarily in terms of the liquidity of the futures contracts (i.e. futures volume and open interest), but in addition considers production. Averaging is again over five years. Importantly, the DJ-AIG Index also aims for diversification and limits the share of any one commodity group to one third of the total. The September 2008 energy share fell just short of this limit.[7] September 2008 weightings of these two indices are charted in Figure 1.

[6] http://www2.goldmansachs.com/gsci/#passive

[7] http://www.djindexes.com/mdsidx/index.cfm?event=showAigIntro Raab (2007) argues that returns on energy futures tend to be more highly correlated with returns on financial assets, implying that an over high energy weight reduces the diversification benefits of commodity investment.

Figure 1. Commodity composition, S&P GSCI and DJ-AIG commodity indices, September 2008

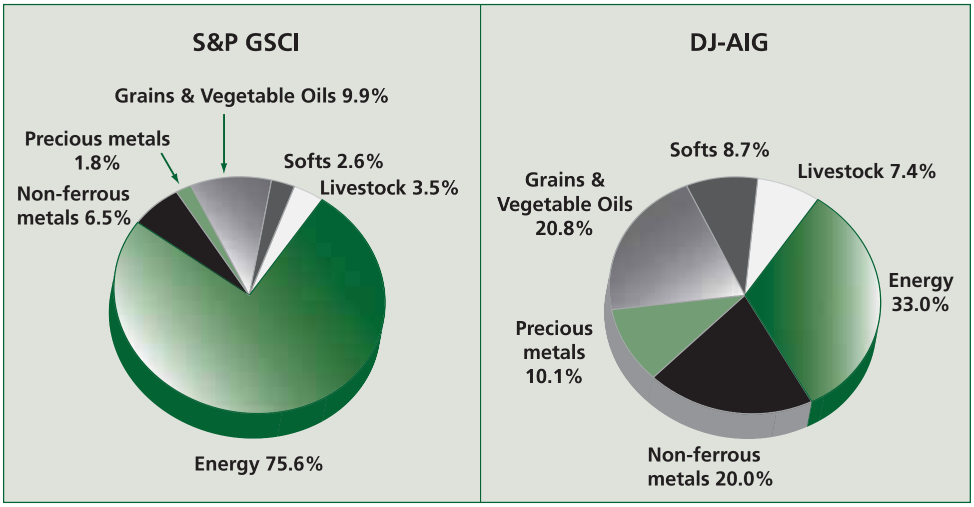


Table 4. Index fund values and shares

Index Fund Values and Shares				
	31 Dec 2007		30 June 2008	
	$bn	Share %	$bn	Share %
Crude oil	39.1	31.1	51.0	26.6
Gasoline	4.5	22.9	8.0	23.9
Heating oil	7.8	34.8	10.0	34.5
Natural gas	10.8	16.8	17.0	14.7
Copper	2.8	49.9	4.4	41.7
Gold	7.3	15.9	9.0	22.7
Silver	1.8	15.5	2.3	20.1
Corn	7.6	25.8	13.1	27.4
Soybeans	8.7	26.1	10.9	20.8
Soybean oil	2.1	24.8	2.6	21.7
Wheat	9.3	38.2	9.7	41.9
Cocoa	0.4	11.3	0.8	14.1
Coffee	2.2	26.0	3.1	25.6
Cotton	2.6	33.0	2.9	21.5
Sugar	3.2	29.0	4.9	31.1
Feeder cattle	0.4	23.2	0.6	30.7
Live cattle	4.5	48.4	6.5	41.8
Lean hogs	2.1	43.6	3.2	40.6
Other U.S. markets	0.7		1.4	
Total (U.S. markets)	117.9	26.8	161.5	25.8
Non-U.S. markets	28.1		38.4	
Overall total	146.0		199.9	

Source: columns 1 and 3 CFTC (2008) valued at front position closing prices; columns 2 and 4, CFTC, *Commitment of Traders* reports. The wheat figures aggregate positions on the Chicago Board of Trade and the Kansas City Board of Trade. Open interest is valued at the closing price of the front contract. The aggregate share relates to positions on U.S. exchanges for the listed commodities. Except in the final two rows, figures relate only to positions held on U.S. exchanges.

The sums of money invested by this third group of commodity investors may be very substantial. Using official non-public information, the CFTC estimated the notional value of positions held by index-funds to the USD 146bn at end December 2007 as USD 146bn (USD 118bn on U.S. exchanges) rising to USD 200bn at the end of June 2008 (USD 161bn on US exchanges). See CFTC (2008). Table 4 summarizes these data for the eleven commodities covered in the CFTC's special call on commodity swap and index providers, reported in CFTC (2008).[8]

Of the USD 161bn of commodity index business in U.S. markets at the end of June 30 2008, approximately 24 percent was held by index funds, 42 percent by institutional investors, 9 percent by sovereign wealth funds and the remaining 25 percent by other traders (CFTC, 2008). The table also gives the shares of the index funds' net positions in total open interest. These average 26–27 percent, but are much higher for copper, crude oil, wheat, live cattle and lean hogs.

5. COMMODITY INDEX INVESTMENT RETURNS

Over the long term, the trend in physical commodity prices is determined by the trend in production costs. Two opposing factors are at work here:

- Productivity changes take place in the agriculture, mining and energy industries just as they do in manufacturing. The difference is that, while in manufacturing, much of these productivity advances show up as quality improvements (a 2008 automobile is quieter, more fuel efficient and safer than a 1978 automobile), in the commodities industries, productivity advance shows up entirely in lower prices (a barrel of oil in 2008 is identical to a 1978 barrel) (see Lipsey, 1994). Productivity advances thus tend to put measured prices onto a downward trend.
- Metals and energy are non-renewable. Companies will exploit the highest grade and most accessible deposits before lower grade and more remote deposits. As these low cost deposits become exhausted, average extraction costs rise (Hotelling, 1931).

The first of these effects was dominant over the twentieth century and prices fell in real terms at around 2 percent per annum. A long buy-hold strategy for physical commodities would therefore not only have been expensive in terms of warehousing and financing costs but would also have yielded poor financial returns. This may change in the future if production does become constrained by lack of resources, as may already be the case with petroleum.

The returns from investing in commodity futures are more complicated. The returns from a long portfolio of commodity futures have four components – see Lewis (2007):

a) The spot or holding return.
b) The roll yield.
c) The collateral yield; and,
d) (Depending on the definition of the portfolio) the recomposition yield.

[8] Twelve contracts since wheat is traded on both the Chicago Board of Trade and the Kansas City Board of Trade.

The spot return is the appreciation or depreciation of the different futures contracts held in the portfolio. The roll return arises from selling short dated positions and moving into longer dated positions in the same future. The collateral yield is the risk-free rate of return earned on the investor's margin account. If the investment is unlevered, this will be the riskless return on the sum invested. Recomposition yield arises from periodic redefinition of the basket of commodities underlying the index. The total return is the sum of the four components. The final component, which may be important, is discretionary and hence is generally ignored. The excess return on a constant composition index is the sum of the first two components.

Consider first the holding (spot) return on the rolled futures position. This will differ from the spot return on the physical commodity by exclusion of the expected element in the latter. In practice, commodity price movements are largely unexpected with the result that movements in commodity futures prices are highly correlated with spot price movements (Gorton and Rouwenhorst, 2006). A second way of making the same point is that, if futures prices were unbiased, this return element would have expected value of zero. However, if speculators (and investors) are net long and commodity risk is not completely diversifiable, long futures positions can earn a risk premium. The evidence is emphatic that, over the long term, spot returns have contributed little to overall returns on rolled commodity futures positions (see Beenen, 2005; and Erb *et al.*, 2008). However, they were very important over the commodity boom of the first decade of the current century.

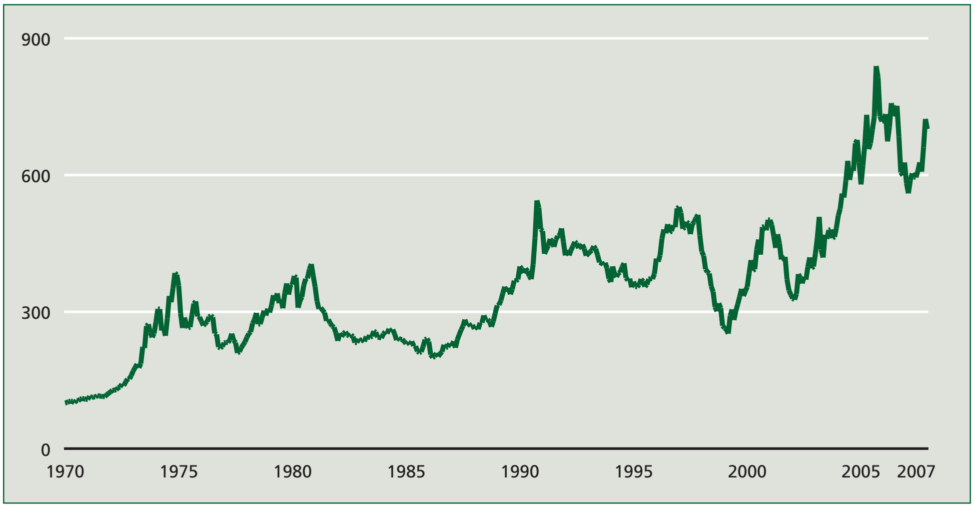
Roll returns will be positive when markets are in backwardation (i.e. when short dated positions are at a premium to longer dated positions) and negative in contango markets. The long term contribution of roll returns therefore depends on the extent to which "normal backwardation" (Keynes, 1930) prevails. The evidence on this is mixed. On the one hand, Erb and Harvey (2006) have shown that roll returns account for over 90 percent of total excess returns on rolled futures on specific commodities over the period December 1982 to May 2004 (see also Erb *et al.*, 2008). On the other hand, there is little general evidence for normal backwardation – see Kolb (1992), who states "normal backwardation is not normal", and also Scherer and He (2008). The reconciliation of these conflicting pieces of evidence may be that, either by accident, design or evolution, commodity futures indices have been weighted towards those commodities with the highest excess returns and hence the highest roll returns. Energy products have dominated this list.

Rebalancing yield is important since commodity indices rarely retain a constant composition over time (see Erb and Harvey, 2006). Portfolios which rebalance so as to capture backwardation tend to out-perform passive strategies (see Gorton and Rouwenhorst, 2006). Different portfolios might rebalance in different ways, so this return component appears to be discretionary rather than directly implied by the asset returns. As already noted, it is generally ignored in calculating index returns.[9]

Figure 2 charts the S&P GSCI from its notional inception in 1970 to the end of 2007. A long investment in a GSCI fund would have shown handsome positive returns over the periods of rising oil prices in the early and late nineteen seventies (1971–74 average 36 percent, 1978–79 average 21 percent) and from 1999 until late 2005 (average 18 percent). The index was flat or declining during the recession of the first half of the nineteen eighties

[9] Backwardation is associated with shortage and hence high prices, and so rebalancing towards constant value shares will tend to generate a positive return over time provided prices mean revert. This observation motivates Erb and Harvey (2005) to measure the rebalancing yield as the difference between the (weighted) geometric and arithmetic returns on the portfolio assets – a constant value portfolio will return the latter while a portfolio which is constant in terms of the number of contracts will return the latter. See also Erb at al. (2008).

Figure 2. S&P GSCI Excess return index, January 1970 – December 2007



(1980–86 average -6 percent) but then recovered sharply in the latter half of the eighties (1987–90 average 21 percent). The 1990s were a second period of largely flat or negative returns (1991–98 average -5 percent). The index was down 19 percent in 2006 but has recovered part of this loss in 2007. Over the entire period of 27 years, excess returns averaged 8.1 percent with a standard deviation of 23.0 percent, implying a Sharpe ratio of 0.35. Recomposition has not been important for the S&P GSCI so little is lost by supposing constant composition.

Commodity investments are generally justified more in terms of their contribution to overall portfolio returns than as attractive stand alone investments. Gorton and Rouwenhorst (2005) analyze data from July 1957 to December 2004, which is a longer period than commodity index investments have been available. They report returns which compare favourably with those on equities although with slightly greater risk, and which dominate bonds in terms of the Sharpe ratio (see Table 5). Over the period they consider, the commodity returns have a statistically insignificant (0.05) correlation with equities and a low but significant negative (-0.15) correlation with bond returns. These calculations suggest that investment in a long passive commodity fund could have bought diversification of an equities portfolio at a lower cost than through bonds.

Despite these positive statistics, it seems possible that the investment community may be exaggerating the likely portfolio benefits from investment in commodities. The danger is that, as investors buy large long dated futures positions, they will pull up the prices of the long dates relative to those of the short dates and hence drive markets into contango. Such developments will depress or even nullify the roll returns from commodity investments without reducing risk.[10]

[10] "Index buying is based on a misconception. Commodity indexes are not a productive use of capital. When the idea was first promoted, there was a rationale for it. Commodity futures were selling at discounts from cash and institutions could pick up additional returns from this so-called 'backwardation'. Financial institutions were indirectly providing capital to producers who sold their products forward in order to finance production. That was a legitimate investment opportunity. But the field got crowded and that profit opportunity disappeared. Nevertheless, the asset class continues to attract additional investment just because it has turned out to be more profitable than other asset classes. It is a classic case of a misconception that is liable to be self-reinforcing in both directions." (Soros, 2008, p.3).

Table 5. Risk return characteristics

	Equities	Bonds	S&P GSCI
Average return	5.6%	2.2%	5.2%
Standard deviation	14.9%	8.5%	12.1%
Sharpe ratio	0.38	0.26	0.43
Annualized monthly returns, July 1957 – December 2004			

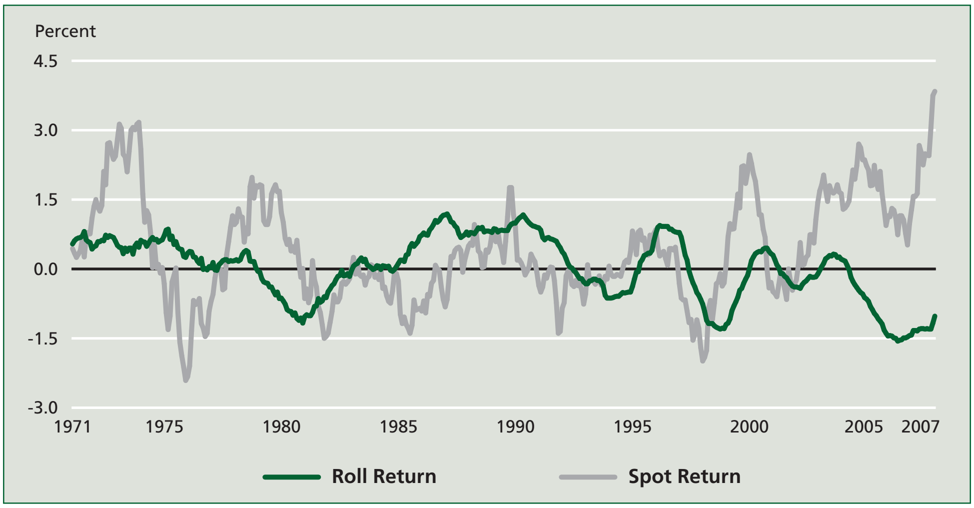
Source: Gorton and Rouwenhorst (2006).

Evidence for this may be seen by decomposing the excess return on the S&P GSCI into its spot and roll return component as in Figure 3 which charts centred 25 month averages. Visually it seems apparent that while spot returns have been very favourable over the past decade, roll returns have been generally negative. The two sets of returns appear uncorrelated, so if the commodity boom draws to a close and roll returns remain negative, commodity futures investments will perform poorly.[11] If this view is correct, the risk-return characteristics that Gorton and Rouwenhorst (2006) and others have estimated for commodity investments over a historical period in which such investments were not easily available is likely to over-estimate the returns realizable in the current environment in which these investments have become straight-forward. Profitable investment in commodity futures will likely depend on adoption of an active investment strategy rather than simply tracking a standard index.

6. SPECULATION, VOLATILITY AND EXTRAPOLATIVE BEHAVIOUR

Finance theory distinguishes between informed and uninformed speculation (Bagehot, 1971; O'Hara, 1995, ch.3). According to this theory, informed speculation should have price effects as this is the way in which private information becomes impounded in publicly-

Figure 3. S&P GSCI Spot and roll returns (25 month centred moving averages), January 1971 – December 2007



[11] The statistics are suggestive rather than conclusive. Roll returns averaged - 5.4% over the eight years 2000–07 as against 0.1% in the 10 years 1990-99. The *t* statistic on a difference in means test is 2.05 which is just significant at the 5% level.

quoted prices. Uninformed speculation should either not have such effects, or in less liquid markets, should not have persistent effects. If uninformed trades do move a market price away from its fundamental value, informed traders, who know the fundamental value of the asset, will take advantage of the profitable trading opportunity with the result that the price will return to its fundamental value. The informed speculators stabilize in the manner set out by Friedman (1953).

Despite this, economists and policy-makers both worry that trend-following can result in herd behaviour. CTAs operate by identifying trends and positioning themselves accordingly – see section 3. There is therefore a concern that a chance upward movement in a price may be taken as indicative of a positive trend resulting in further buying and hence driving the price further upwards, despite an absence of any fundamental justification. The result will be a speculative bubble. Negative bubbles are also possible.

There are two standard responses to this type of argument:

- First there is the Friedmanite argument that, in an efficient market, supply and demand fundamentals will rapidly re-assert themselves as informed fundamentals-based traders taking contrarian positions. However, De Long *et al.,* (1990) show that informed traders may not act in this way if they have short time horizons (perhaps as the result of performance targets or reporting requirements) and if there are sufficiently many uninformed trend-spotting speculators. If these conditions apply, the informed traders will bet on continuation of the trend even though they acknowledge it is contrary to fundamentals. The 1999–2000 internet equities bubble appears to fit this description.
- Trends are only completely clear *ex post* and this leaves considerable scope for disagreements between different CTAs as to whether or not a particular market does exhibit a trend at any moment in time. In aggregate, speculators will therefore generally not take a consistent position on one side of the market of the other. This argument may often be correct, but in those cases in which speculators are unanimous that a trend does exist, their behaviour may reinforce this trend.

The existence and extent of trend-following behaviour may in principle be ascertained by regressing CTA-CPO positions on price changes over the previous days. These data are not, however, publically available and we therefore need to rely on studies undertaken by the regulatory agencies. Kodres (1994), Kodres and Prisker (1996), Irwin and Yoshimaru (1999) and Irwin and Holt (2004) fall into this category. Using the CTC's confidential sample already discussed in section 3, Irwin and Holt (2004) find that the net trading volume of large hedge funds and CTAs in six of the twelve futures markets they consider is significantly and positively related to price movements over the previous five days.[12] However, the degree of explanation is low. Irwin and Yoshimaru (1999) report very similar results for CTA-CPO positions.[13] In summary, the empirical evidence is consistent with the existence of trend-following behaviour but also indicates that this generally be swamped by other influences.

Can speculation of this type result in commodity price bubbles? A natural strategy is to regress price changes on the changes in the COT net non-commercial positions. However, the results of such regressions are difficult to interpret. Firstly, the commercial/non-commercial dichotomization no longer accords with contemporary market developments – see section 2.

[12] Copper, corn, cotton, gold, live hogs and natural gas. There is a significant negative relationship for Eurodollar futures.

[13] One can perform the same exercise for the entire non-commercial category, as in Dale and Zyren (1996), but interpretation is problematic as this category has become contaminated over recent years by the growth of index trading – see the discussion of the COT reports in section 2.

Secondly, futures positions identically sum to zero. Since aggregate non-reporting positions show only modest variability, there is necessarily a strong negative correlation between net commercial and net non-commercial positions. This makes it difficult to distinguish between the effects of changes in commercial and non-commercial decisions. If current period positions are used as regressors, severe identification issues arise.[14]

There is a clear and well-established (positive) link, observed across the entire range of financial markets, between trading volumes and price volatility so it should therefore not be surprising that an increase in non-commercial positions increases futures volatility (see Chang *et al*.,1997; Bollerslev and Jubinski, 1999; and Irwin and Holt, 2004). Identification and collinearity issues also arise in this context but, because it seems likely that there will be only a modest feedback from price volatility to the positions themselves, endogeneity issues may be less acute. Irwin and Holt (2004), using their 1994 CFTC dataset, find significant positive coefficients linking the trading activity of large hedge funds and CTAs to futures volatility for nine of the thirteen markets they examine. (The coefficients are positive but statistically insignificant for the remaining four markets).

An alternative, indirect, approach is to attempt to estimate the profitability of speculative positions. Reversing the Friedmanite argument, we might suppose that, to the extent that speculators have made profits, they must have had a stabilizing impact on prices (see Hartzmark, 1987; and Leuthold *et al*., 1994). This inference is tendentious. Speculative profits can be highly variable both across markets and over time, implying that we would need a large sample to justify any such inference. Irwin and Holt (2004) note this difficulty but also report a large (USD 400m) overall trading profit from the six month period they consider. What they do not emphasize is that this profit was due entirely to profits in just two markets, and that in one of these (coffee), these profits resulted almost entirely from a double frost episode in Brazil which speculators could not possibly have anticipated – they were simply lucky to have been long at the right time.[15]

In general terms, the clear existence of bubbles in other asset markets, most notably equities and real estate, over the past decade makes it difficult to assert that efficient markets will always eliminate bubble behaviour. Moreover, commodity markets are characterized by very low short run elasticities of both production and consumption, despite the fact that long run supply elasticities are probably high. In a tight market in which only minimal stocks are held, the long run cost-related price becomes irrelevant and market equilibrium price ceases to be well-defined, not in the sense that the market does not clear, but in the sense that it will be very difficult to assess the price at which the market will clear on the basis of longer term fundamental factors. Fundamentals-based analysis may show where the price will finish but this will provide very little guide as to where it will go in the interim. This indeterminacy allows weight of the speculative money to determine the level of prices.

7. EFFECTS OF INDEX-BASED INVESTMENT

There has been less research on the effects of index-based investment in part because it is still a relatively new phenomenon, in part because the distinction between investment and speculations is not yet standard but, most importantly, because of lack

[14] Gilbert (2000) sets out a model in which speculators (non-commercials) have private information. Conditional on this information, the futures price is uninformative. Hedgers (commercials) attempt to infer this information from the futures price but are unable to do so completely because of the presence of noise traders (non-reporting traders). The consequence is that, following a positive signal, speculators bid positions away from hedgers.

[15] This episode was discussed by Brunetti and Gilbert (1997) who made similar calculations.

of publically available data which allows index-based investment to be distinguished from speculation.

In this section, I report results of Granger non-causality tests which makes use of the CFTC's supplementary COT reports, discussed above in section 2, and which allow one to distinguish between positions held by index providers and those of other non-commercial traders. Here, I consider the effects of these positions in the four Chicago Board of Trade[16] agricultural markets covered in the COT supplementary reports – corn (maize), soybean soybean oil and wheat. The tests are conducted within a third order Vector AutoRegression (VAR) framework

$$r_t = \alpha_0 + \sum_{j=1}^{3} \alpha_j r_{t-j} + \sum_{j=1}^{3} \beta_j x_{t-j} + \sum_{j=1}^{3} \gamma_j z_{t-j} + \varepsilon_t \qquad (1)$$

where R_t is the week-on-week change in the price of the nearby contract on the Chicago Board of Trade,[16] x_t is the weekly change in futures positions of index providers and z_t is the weekly change in futures positions of other non-commercial traders.

The VAR framework defined by equation (1) allows us to test two sets of hypotheses. The first two hypotheses is changes in the index and non-commercial positions respectively do not affect returns

$$H_0^1 : \beta_1 = \beta_2 = \beta_3 = 0 \quad H_0^2 : \gamma_1 = \gamma_2 = \gamma_3 = 0$$

These correspond to standard Granger non-causality tests – see Stock and Watson (2003, chs. 13 and 14). Conditional on rejection of either of these null hypotheses, we may examine persistence may by looking at the sum of the coefficients. Specifically, the test $H_0^3 : \sum_{j=1}^{3} \beta_j = 0$ looks at persistence of the effects of changes in index positions and the test $H_0^4 : \sum_{j=1}^{3} \gamma_j = 0$ relates to persistence of the effects of changes in non-commercial positions. (In each case, the alternative hypothesis is the negation of the null). Table 7 reports the test results.[17]

The first row of the table gives the Granger non-causality tests for the index positions. Rejection of the null hypothesis H_0^1, indicated at the conventional 95% level by a tail probability of less than 5 percent, implies that changes in index positions cause (in the sense of Granger-cause) futures price returns over the following weeks. A rejection is obtained for soybeans but nor for the other three commodities. The second row reports the same test for the changes in net non-commercial positions. Here the null hypothesis H_0^2 is not rejected in any of the four cases considered. Since we have rejected H_0^1 for the case of soybeans, we may look at the persistence of this effect. The estimated VAR shows that the sum of these coefficients is positive, and the test of H_0^3 establishes the statistical significance of this impact. The data therefore indicate that changes in index positions had a persistent positive impact on soybean prices over the sample considered. However, there is no evidence for similar effects in the other three commodities examined.

[16] I follow the convention of rolling on the first day of the delivery month. Price changes are always measured in relation to the same contract (i.e. in a roll week the price change is relative to what was previously the second position).

[17] The coefficient estimates are uninteresting and are omitted.

Table 6. Granger non-causality tests for CBOT agricultural futures

	Index and Other Non-Commercial Positions			
	Corn	Soybeans	Soybean Oil	Wheat
H_0^2 $F_{3,125}$	0.50	3.53	1.91	0.92
H_0^2 $F_{3,125}$	[68.2%]	[1.7%]	[13.2%]	[43.5%]
	0.23	1.22	0.17	0.82
	[87.1%]	[30.6%]	[91.5%]	[48.7%]
	- 0.413	5.374	- 2.652	0.769
H_0^3 $\Sigma\beta_j$	0.35	10.35	1.09	0.15
$F_{1,125}$				
	[55.4%]	[0.2%]	[29.9%]	[69.8%]
	- 0.078	0.932	- 0.169	- 1.019
H_0^4 $\Sigma\gamma_j$	0.06	3.51	0.12	1.07
$F_{1,125}$				
	[80.0%]	[6.4%]	[73.3%]	[30.2%]
R^2	0.053	0.096	0.068	0.039

The table reports the test outcomes for the five tests outlined in the text. Tail probabilities are given parenthetically.
Sample: 31 January 2007, weekly, to 26 August 2008. Estimation by OLS.

Failure to reject the null hypothesis of no effect should not be taken as implying that neither changes in index positions nor those in non-commercial positions affect futures returns. According to the Efficient Markets Hypothesis, we should expect the price effects of position changes to be contemporaneous. This implies that Granger non-causality tests of the type reported here probably lack power. Increased power might be obtained by looking at the contemporaneous correlations. The correlations between returns and changes in index positions range from 0.06 for wheat to 0.38 for soybeans. The correlations between returns and changes in non-commercial positions are higher: 0.40 for wheat to 0.57 for soybeans. However, interpretation of these correlations is problematic since causation might also run from returns to position changes.

Overall, therefore, there is weak evidence that index investment may have been partially responsible for raising at least some commodity prices during the recent boom.

8. CONCLUSIONS

The traditional futures market distinction between hedgers and speculators no longer corresponds closely with the differences in types of actors in commodity markets. In particular, the traditional distinction fails to acknowledge the emergence of index-based investment which now accounts for 20 percent–50 percent of total open interest in many important U.S. commodity markets. This has been acknowledged by the U.S. commodities futures regulator, the CFTC, which has gone some way to providing additional information, although currently only for agricultural markets.

Traditional speculators are often trend followers, moving from one market to another as the opportunities arise. They may either be long or short, but typically they hold positions for only short periods of time. Index-based investors aim to track the returns one of other of two major commodity futures indices, or sub-indices of these indices. Funds are therefore allocated in largely predetermined proportions across the different commodity markets reflecting index composition. These indices only give positive weights and hence index investors are always long. Investors are motivated to improve the risk-return characteristics of their overall portfolios, in which commodities will typically form a small component, rather than in the risk-return properties of the commodity sub-portfolio or its individual commodity components. They tend to hold for long periods implying that the index-provider will need to roll offsetting futures positions as they approach expiration. By contrast, speculators will seldom roll positions.

The returns to commodity futures investment differ from those obtained from investing in the physical commodity. In addition to the spot returns, the investor also earns a roll return when the position is rolled (positive if the commodity is in backwardation, negative if in contango), the risk free rate of interest on the collateral posted against the position and also a recomposition return if the index is reweighted. Spot returns have generally been positive over the most recent decade as the consequence of the commodity boom but roll returns have tended to decline and become negative. It seems possible that, despite overall high prices, growing investment in commodity futures has pushed markets into contango. If this conjecture turn out to be correct, commodity investors are likely to be disappointed by future returns.

Finance theory indicates that, although informed speculation should have an impact on prices, since this is the way in which information becomes impounded in prices, uninformed speculation should not have any price effect. If uninformed speculation takes the market price away from its fundamentally-determined level, contrarian fundamental-based traders should take advantage of the resulting profit opportunities thereby retuning the price to its fair value. This may happen, but the other possibility is that a chance movement in price may attract trend-following speculators who exacerbate the departure of the price from its fundamental value. This will lead to prices exploding upwards or downwards, albeit generally only for short periods of time. In another paper (Gilbert, 2010) I show that the copper nonmarket has been characterized by so-called weakly explosive behaviour of this sort consistent with the view that uninformed speculation can be destabilizing. The paper concludes that commodity prices have not always reflected market fundamentals, and that there may have been elements of speculative froth.

The same argument implies that index-based investment should not have any effect, or more weakly any persistent effect, on commodity futures prices. I have tested this hypothesis using data on the four agricultural commodities treaded on the Chicago Board of Trade for which the CFTC provides position data on the positions of index providers. In the case of soybeans, there does appear to be evidence that changes in index positions have had a positive and persistent effect on futures returns. Data for the other three commodities examined fail to support this hypothesis. Overall, there is weak evidence for the contention that index investment contributed to the recent commodity price boom.

None of this implies that either speculation or commodity investment have been a major factor in the commodity boom of the first decade of the century. On the other hand, it is too simple to rule out the possibility that these activities may have affected prices in particular markets at particular periods of time. It is indeed possible that some of these effects have been substantial and some persistent. These observations will probably not surprise market participants. The urgent agenda is to incorporate them into the models which economists use to discuss the operation of these markets.

REFERENCES

Bagehot, W. [pseud.] 1971. The only game in town. *Financial Analysts Journal*, 27: 12–14.

Beenen, J. 2005. Commodity investing: A pension fund perspective. *Futures Industry* (September–October 2005): 18–22.

Bodie, Z. & Rosansky, V.I. 1980. Risk and return in commodity futures. *Journal of Portfolio Management*, 4: 26–29.

Bollerslev, T. & Jubinski, D. 1999. Equity trading volume and volatility: Latent information arrivals and common long-run dependencies, *Journal of Business and Economic Statistics*, 17: 9–21.

Brunetti, C. & Gilbert, C.L. 1997. Speculation, hedging and volatility in the coffee market, 1993–96. *Occasional Paper*, Department of Economics, Queen Mary & Westfield College.

CFTC. 2006. *Commission Actions in Response to the 'Comprehensive Review of the Commitments of Traders Reporting Program'*, June 21, 2006, Washington, DC, CFTC.

CFTC. 2008. *Staff Report on Commodity Swap Dealers and Index Traders with Commission Recommendations*, Washington, DC, CFTC.

Chang, E.C., Pinegar, J. & Schacter, B. 1997. Interday variations in volume, variance, and participation of large speculators. *Journal of Banking and Finance*, 21: 797–910.

Dale, C. & Zyren, J. 1996. Non-commercial trading in the energy futures market. *Petroleum Marketing Monthly*, May: 13–24.

De Long, J.B., Shleifer, A., Summers, L.H. & Waldman, R.J. 1990. Positive feedback investment strategies and destabilizing rational expectations. *Journal of Finance*, 45: 379–95.

Edwards, F.M. & Ma, C.W. 1992. *Futures and Options*. New York, McGraw-Hill.

Eling, M. (2008), Commodity Trading Advisors: A review of historical performance, *In* Fabozzi *et al*., (2008a), 626–47.

Engelke, L. & Yuan, J.C. 2008. Types of commodity investment, *In* F.J Fabozzi, R. Füss & D.G. Kaiser, eds. *The Handbook of Commodity Investing*, pp. 549–69. Hoboken, NJ, Wiley.

Erb, C. & Harvey, C.R. 2006. The strategic and practical value of commodity futures. *Financial Analysts Journal*, 62: 69–97.

Erb, C., Harvey, C.R. & Kempe, C. 2008. Performance characteristics of commodity futures, In F.J Fabozzi, R. Füss & D.G. Kaiser, eds. *The Handbook of Commodity Investing*, pp. 203–26. Hoboken, NJ, Wiley.

Fabozzi, F.J., Füss, R. & Kaiser, D.G. 2008a. *The Handbook of Commodity Investing*, Hoboken, NJ, Wiley.

Fabozzi, F.J., Füss, R. & Kaiser, D.G. 2008b. A primer on commodity investing, In F.J Fabozzi, R. Füss & D.G. Kaiser, eds. *The Handbook of Commodity Investing*, pp. 3–37. Hoboken, NJ, Wiley.

Friedman, M. 1953. *Essays in Positive Economics*, Chicago, University of Chicago Press, 157–203.

Geman, H. 2005. *Commodities and Commodity Derivatives*. Hoboken, NJ, Wiley.

Gilbert, C.L. 2000. *Informed futures market speculation: an analysis of the Commitments of Traders reports for the New York 'C' coffee contract*. Vrije Universiteit, Amsterdam, processed.

Gilbert, C.L. 2008. *High food prices: What were the causes*?, paper given at the conference The Food Crisis of 2008: Lessons for the Future, Wye College, 28 October.

Gilbert, C.L. 2010. *Speculative Influences on Commodity Futures Prices 2006–08*. Discussion Paper #197, UNCTAD/OSG/DP/2010/1, Geneva, UNCTAD.

Gorton, G. & Rouwenhorst, K.G. 2006. Facts and fantasies about commodity futures. *Financial Analysts Journal*, 62: 47–68.

Gregoriou, G.N., Karavas, V.N., Lhabitant, F.S. & Rouah, F. 2004. *Commodity Trading Advisors: Risk, Performance Analysis and Selection*. Hoboken, NJ, Wiley.

Gupta, B. & Wilkens, K. 2007. An evaluation of the commodity exposure in Commodity Trading Advisers. In Till and Eagleeye, eds. *Intelligent Commodity Investing*, pp.177–86. London, Risk Books.

Hotelling, H. 1931. The economics of exhaustible resources. *Journal of Political Economy*, 39: 137–75.

Hull, J.C. 2006. *Options, Futures and Other Derivatives* (6th edition), Upper Saddle Rover, NJ, Prentice Hall.

Interagency Task Force on Commodity Markets (ITF). 2008. *Interim Report of the ITF*, Washington, DC, CFTC.

Irwin, S.H. & Holt, B.R. 2004. The effect of large hedge fund and CTA trading on futures market volatility, *In* G.N. Gregoriou, V.N. Karavas, F.S. L'Habitant & F. Rouah, eds. *Commodity Trading Advisors*: *Risk, Performance Analysis and Selection*, pp. 151–182. New York, NY, John Wiley and Sons.

Irwin, S.H. & Yoshimaru, S. 1999. Managed futures, positive feedback trading, and futures price volatility. *Journal of Futures Markets*, 19: 759–76.

Jaffee, J.F. 1989. Gold and gold stocks as investments for institutional portfolios. *Financial Analysts Journal*, 45: 53–60.

Keynes, J.M. 1930. *Treatise on Money*, London, Macmillan.

Kodres. L. 1994. *The existence and impact of destabilizing positive feedback traders: evidence from the S&P 500 index futures market*. Working Paper, Washington, DC, Board of Governors of the Federal Reserve System.

Kodres, L. & Prisker, M. 1996. Directionally-similar position trading and herding by large futures participants, In *Risk Measurement and Systematic Risk: Proceedings of a Joint*

Central Bank Research Conference, Washington, DC, Board of Governors of the Federal Reserve System.

Kolb, R.W. 1992. Is normal backwardation normal? *Journal of Futures Markets*, 12: 75–91.

Lewis, M. 2007. Structural shifts in commodity-index investing, *In* Till and Eagleeye, eds. *Intelligent Commodity Investing*, pp. 213–39. London, Risk Books.

Liang, B. 2004. On the performance of alternative investments: CTAs, hedge funds, and funds-of-funds. *Journal of Investment Management*, 2: 76–93.

Lipsey, R.E. 1994. *Quality change and other influences on measures of export prices of manufactured goods*. Policy Research Working Paper, 1348, Washington, DC, World Bank, International Economics Department.

Masters, M.W. 2008. Testimony before the U.S. Senate Committee of Homeland Security and Government Affairs, Washington, DC, 20 May 2008.

O'Hara, M. 1995. *Market Microstructure Theory*, Oxford, Blackwell.

Raab, D.M. 2007. Index fundamentals, *In* Till and Eagleeye, eds. *Intelligent Commodity Investing*, pp. 189–211. London, Risk Books.

Radetzki, M. 2007. *Råvarumarknaden*, Stockholm, SNS Förlag.

Radetzki, M. 2008. *A Handbook of Primary Commodity Markets*, Cambridge, Cambridge University Press. [English language version of Radetzki (2007)].

Scherer, V. & He, L. 2008. The diversification benefits of commodity futures indexes: a mean-variance spanning test, In F.J. Fabozzi, R. Fuss, & D.G. Kaiser, eds. *The Handbook of Commodity Investing*, pp. 241–65. Hoboken, NJ, Wiley.

Schneeweis, T., Gupta, R. & Remillard, J. 2008. CTA-managed futures strategy benchmarks, In F.J. Fabozzi, R. Fuss, & D.G. Kaiser, eds., *The Handbook of Commodity Investing*, pp. 266–310. Hoboken, NJ, Wiley.

Soros, G. 2008. Testimony before the U.S. Senate Commerce Committee Oversight Hearing on FTC Advanced Rulemaking on Oil Market Manipulation, Washington, DC, June 4.

Stock, J.H. & Watson, M.J. 2003. *Introduction to Econometrics*, Boston, Addison Wesley.

Taylor, S.J. 2005. *Asset Price Dynamics: Volatility and Prediction*. Princeton, Princeton University Press.

Till, H. & Eagleeye, J. 2007. *Intelligent Commodity Investing*. London, Risk Books.

Upperman, F. 2006. *Positions of Traders*. Hoboken, NJ, Wiley.

Woodward, J.D. 2008. Commodity futures investments: a review of strategic motivations and tactical opportunities, *In* F.J. Fabozzi, R. Fuss, & D.G. Kaiser, eds. *The Handbook of Commodity Investing*, pp. 56-80, Hoboken, NJ, Wiley.

Examining the dynamic relation between spot and futures prices of agricultural commodities[1]

Manuel A. Hernandez and Maximo Torero[2]

[1] We gratefully acknowledge helpful discussions with Miguel Robles.

[2] International Food Policy Research Institute (IFPRI), m.a.hernandez@cgiar.org and m.torero@cgiar.org.

1. THE RELATIONSHIP BETWEEN SPOT AND FUTURES PRICES

Considering that the futures price is the price specified in an agreement (futures contract) to deliver a specified quantity of a commodity at a specific future date while the spot price is the cash price for immediate purchase and sale of the commodity, we should expect a close relationship between the prices of futures contracts and spot prices. In particular, an explicit relation between spot and futures prices can be derived from the non-arbitrage theory.

Following Pindyck (2001), let $\gamma_{t,T}$ denote the capitalized flow of marginal convenience yield over the period t to t+T.[3] Then, to avoid arbitrage opportunities, the following condition must hold,

$$F_{t,T} = (1 + r_t) P_t - (\gamma_{t,T} - k_T) \quad (1)$$

where $F_{t,T}$ is the futures price of a (agricultural) commodity at time t for delivery at t+T, P_t is the spot price at t, r_T is the risk-free T-period interest rate, and k_T is the per-unit cost of physical storage.

To see why equation (1) must be satisfied, note that the stochastic return of holding a unit of the agricultural commodity from t to t+T is equal to $(P_{t+T} - P_t) + \gamma_{t,T} - k_T$.
If a farmer also sells a futures contract at t (i.e. takes a short position), the return of this future contract is $F_{t,T} - P_{t+T}$. So his total non-stochastic return at T is equal to $F_{t,T} - P_t + \gamma_{t,T} - k_T$ Then, the non-arbitrage condition requires this total return to equal the risk-free rate times the price of the commodity at t, i.e. $r_T P_t$, from which equation (1) follows.

Two implications can be derived from equation (1). First, the futures price could be greater or less than the spot price depending on the net (of storage costs) marginal convenience yield $\gamma_{t,T}$-k_T. If the net marginal convenience yield is positive, the spot price will exceed the futures price (futures market exhibits *strong backwardation*) while if then net marginal convenience yield is negative, the spot price will be less than the futures price (the futures market is in *contango*). Second, spot and futures prices should move together across time to avoid arbitrage opportunities. That is, we expect price movements in spot and futures markets to be correlated.

From the asset pricing theory, we can also establish a relationship between the futures price and the expected future spot price. Assume that at time t a farmer buys one unit of a commodity at price P_t, which he plans to hold until t+T and then sell it for P_{t+T}. The expected return of this investment is given by $E_t(P_{t+T}) - P_t + \gamma_{t,T} - k_T = \rho_T P_t$. Since P_{t+T} is unknown at t, this return is risky and must equal the risk-adjusted discount rate times the price of the commodity at t, i.e. $\rho_T P_t$. Hence,

$$E_t(P_{t+T}) - P_t + \gamma_{t,T} - k_T = \rho_T P_t \quad (2)$$

Substituting (1) into (2), we obtain,

(3)

[3] The convenience yield is the flow of benefits from holding the physical commodity. Inventory holders of a commodity, for example, may obtain extra profits from temporary local shortages. In general, the convenience yield will increase with market volatility because the option value of keeping the commodity increases with a higher volatility.

$$F_{t,T} = E_t\left(P_{t+T}\right) - \left(\left(\rho_T - r_T\right)P_t\right) \qquad (3)$$

It follows that the futures price is a biased estimate of the future spot price because of the risk premium $\rho_T - r_T$. More specifically, the futures price should typically be lower than the expected future spot price due to the positive risk premium (i.e. $\rho_T > r_T$). As pointed by Pindyck, holding the commodity alone entails risk and as a reward for that risk, we expect the spot price at $t+T$ to be above the current futures price. But, besides these explicit relationships between spot, futures and expected future spot prices, described in (1) and (3), do the theory provide any insights about the direction of causality between spot and futures prices?

Provided that futures markets are generally considered to perform two major roles in commodity markets, a risk-transfer role and, in particular, an informative or price discovery role, we might be tempted to assume that futures markets dominate spot markets. The risk-transfer role results from the fact that a futures market is a place where risks are reallocated between hedgers (producers) and speculators. Producers are then willing to compensate speculators for sharing the risks inherent to their productive activity. Futures prices also transmit information to all economic agents, especially to uninformed producers who, in turn, may base their supply decisions on the futures price. It can also be argued that physical traders use futures prices as a reference to price their commodities due to the greater transparency and (often) greater liquidity of commodity futures over physical commodities.[4]

However, as sustained by Garbade and Silber (1983), the price discovery function of futures markets hinges on whether new information is actually reflected first in changes in futures prices or in spot prices. Identifying the direction of causality between spot and futures prices appears then to be an empirical issue. This study attempts to do so by using recent price data of corn, two varieties of wheat and soybeans to examine causal links between spot and futures markets. We address the following specific questions: Do changes in futures prices lead changes in spot prices? Or, do price changes in spot markets lead price changes in futures markets? Or, are there bidirectional information flows between spot and futures markets?

It is worth mentioning that previous studies have found that spot prices in commodity markets seem to be discovered in futures markets (i.e. that spot prices move towards futures prices). For example, Garbade and Silver (1983) in their study of price movements and price discovery in futures and cash markets for seven different storable commodities, including corn and wheat, and Brorsen, Bailey and Richardson (1984) in their analysis of cash and futures cotton prices.[5] Crain and Lee (1996) also find that the wheat futures market carries out its price discovery role by transferring volatility to the spot market.

The present analysis intends then to extend these previous studies by examining causal relationships in spot and futures markets in more recent years, with much more developed futures commodity markets. As a reference, the average daily volume of corn futures traded in the CBOT has increased by more than 280 percent in the last forty years. In the 1970s, less than 20,000 futures contracts were traded on average every day while in the present

[4] The informative role of futures markets could also have a stabilizing effect on spot prices, as sustained by Danthine (1978). Other studies that analyze in detail the role and impact of futures trading in commodity markets, under alternative settings, include McKinnon (1967), Turnovsky (1983), Kawai (1983a, 1983b), and Chari, Jagannathan and Jones (1990).

[5] Other related studies include Tomek and Gray (1970) and Martin and Garcia (1981), but they are more focused on the price-forecasting role of futures commodity prices over spot prices and do not explicitly carry out Granger causality tests.

decade more than 76,000 futures contracts are traded on average every day in a regular session.

This study also intends to contribute to the debate on alternative instruments to address volatility in grain markets, after the 2007–2008 food crisis. von Braun and Torero (2008, 2009), for example, have recently proposed the implementation of a global virtual reserve to minimize speculative attacks and avoid excessive price spikes in food commodity markets through signals and (if necessary) market assessment in the exchange of futures. Determining whether spot prices do in fact move towards futures prices is crucial for the viability of this innovative instrument.

Next, we describe the data used to analyze causal relations between spot and futures prices. As noted, we focus on corn, two varieties of wheat and soybeans, which are among the most important agricultural commodities.

2. DATA

The spot data used in the analysis are weekly (Friday) prices obtained from the FAO International Commodity Prices Database. The specific products considered are US No.2 yellow corn, No.2 hard red winter wheat, No.2 soft red winter wheat and No.1 yellow soybeans.[6] The sample period is from January 1994 to June 2009 for corn and soybeans and from January 1998 to June 2009 for the two varieties of wheat. All prices are in US dollars per metric tonne.

The futures data are closing prices of futures contracts traded on each Friday over the same time period. In the case of corn, soft wheat and soybeans, the prices correspond to futures contracts traded on the Chicago Board of Trade (CBOT) with deliverable grades at par US No.2 yellow, No.2 soft red and No.1 yellow, respectively; in the case of hard wheat, the prices correspond to contracts traded in the Kansas City Board of Trade (KCBT) where the wheat deliverable grade at par is precisely US No.2 hard red. The CBOT is the world's oldest futures and options exchange and a leading agricultural futures exchange. The KCBT is the largest free market for hard red winter wheat. The futures data was obtained from the historical end-of-day data of the Chicago Mercantile Exchange Group (CME DataMine) and the futures database of the Commodity Research Bureau (CRB Infotech CD).

Since futures contracts with different maturities are traded every day, the data was compiled using prices from the nearby contract, as in Crain and Lee (1996). The nearby contract is generally the most liquid contract. To avoid registering prices during the settlement month or expiration date, the nearby contract considered is the one whose delivery period is at least one month ahead. Futures prices are denoted in US cents per bushel so they were converted into USD per tonne for comparison purposes with spot prices.[7]

Figures 1 to 4 show the evolution, in real terms, of spot and futures prices for the four agricultural commodities during the entire sample period. Two patterns emerge from these

[6] Hard red winter wheat accounts for around 45 percent of total US wheat production and is primarily used for bread making. Soft red winter wheat, in turn, accounts for around 20 percent of total US wheat production and is primarily used to make cakes, cookies, snack foods, crackers and pastries.

[7] Recall that agricultural futures contracts are standardized with regards to the quantity, quality, time and place of delivery and the only negotiable variable in the contract is price. A CBOT corn, wheat or soybean futures contract, as well as a KCBT wheat futures contract, represents 5,000 bushels of the corresponding commodity. For corn, 5,000 bushels are around 127 tonne and for the other commodities 5,000 bushels are around 136 tonne.

figures. First, futures markets exhibit strong backwardation, i.e. the spot price is on average higher than the price of the nearby futures contract. More specifically, the corn spot price has generally been 10 dollars higher per tonne than the futures price during the past 15 years. For hard and soft wheat, the average difference between spot and futures prices has been around 18 and 4 dollars, respectively, while for soybeans the price difference has been 11 dollars. Note also the price hike of 2007-mid 2008 due to the recent food crisis.[8] The second pattern that emerges is the strong correlation of price movements in spot and futures markets, as predicted by the non-arbitrage theory. Moreover, the futures market seems to dominate the spot market or, equivalently, changes in spot prices echo changes in futures prices. So a first look at the data suggests that prices are first discovered in the futures market and then the discovered price is passed on to the spot market.

Figure 1 Corn: Weekly spot and futures prices, 1994–2009 (Prices deflated by US CPI, January 1994=1)

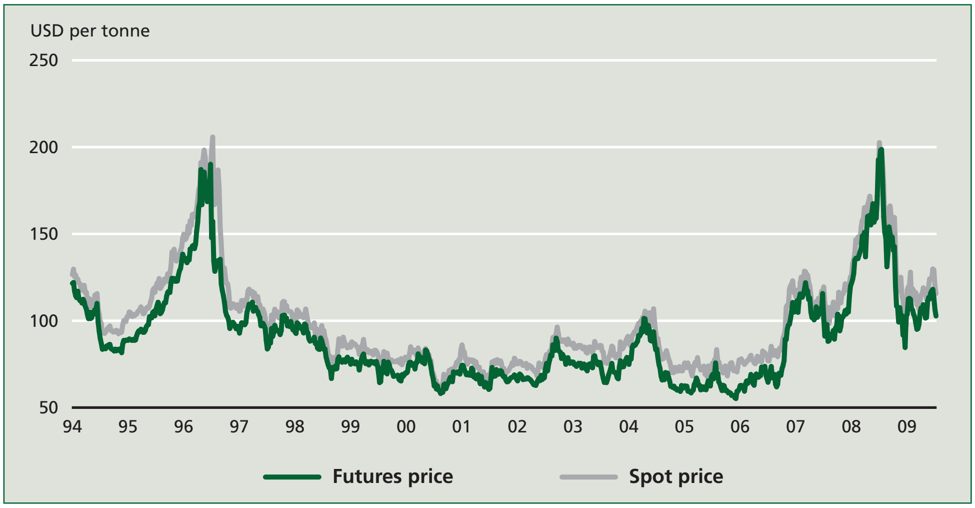
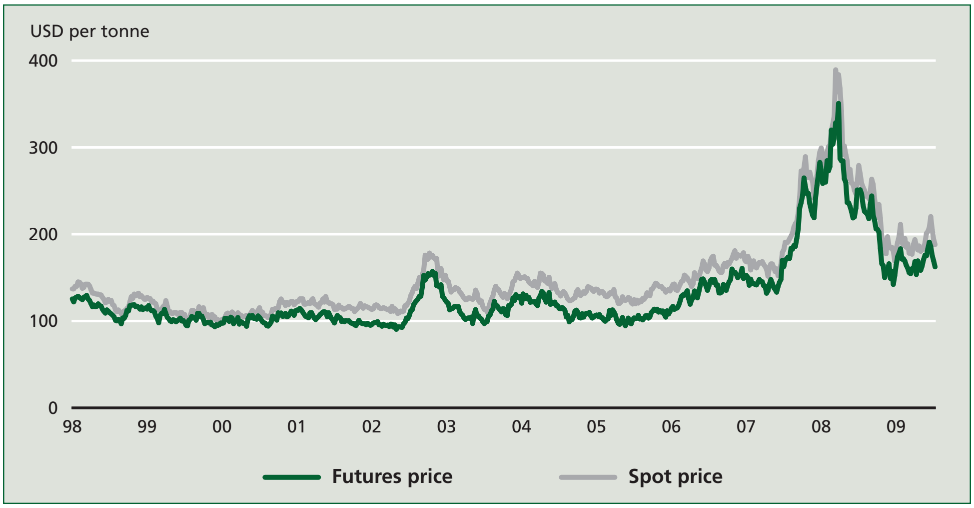


Figure 2 Hard wheat: Weekly spot and futures prices, 1998–2009 (Prices deflated by US CPI, January 1998=1)



[8] Corn and soybean prices also rose considerably in the mid 90s due to the crop price shock of that period. Similarly, soybean prices showed a rapid increase in the end of 2003 and beginning of 2004 because of harvest shortages and an increase in export demand.

The volatility in the spot and futures markets analyzed also appears to be highly correlated, as shown in Figures 5 to 8. The volatility measure is the standard deviation of prices for each month in the sample period. As can be seen, the spot and futures volatility rise and fall in a similar manner, with peaks during the price spikes observed in the previous figures. However, in this case, it is less clear whether changes in volatility in the spot market echo changes in the futures market. Besides, spot prices are generally more volatile than futures prices, probably due to the higher transparency of the latter.[9]

Figure 3 Soft wheat: Weekly spot and futures prices, 1998–2009 (Prices deflated by US CPI, January 1998=1)

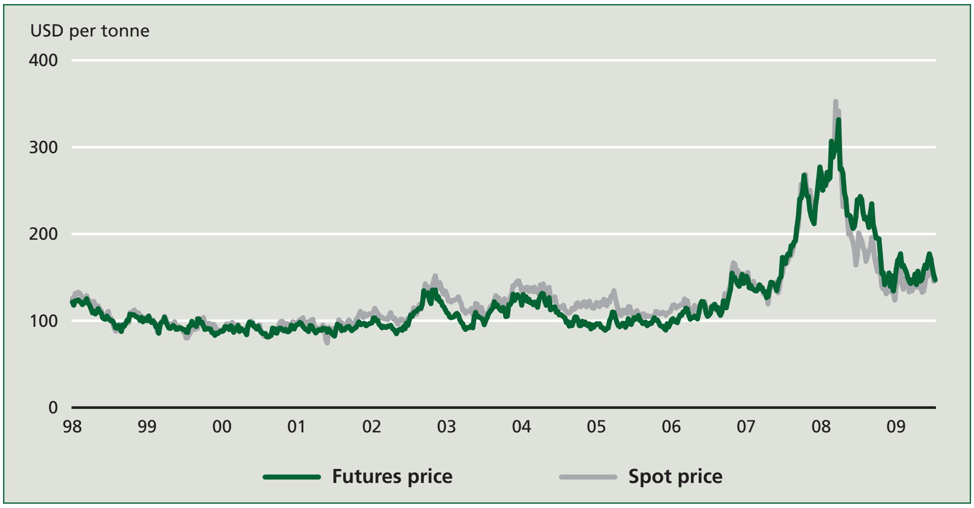
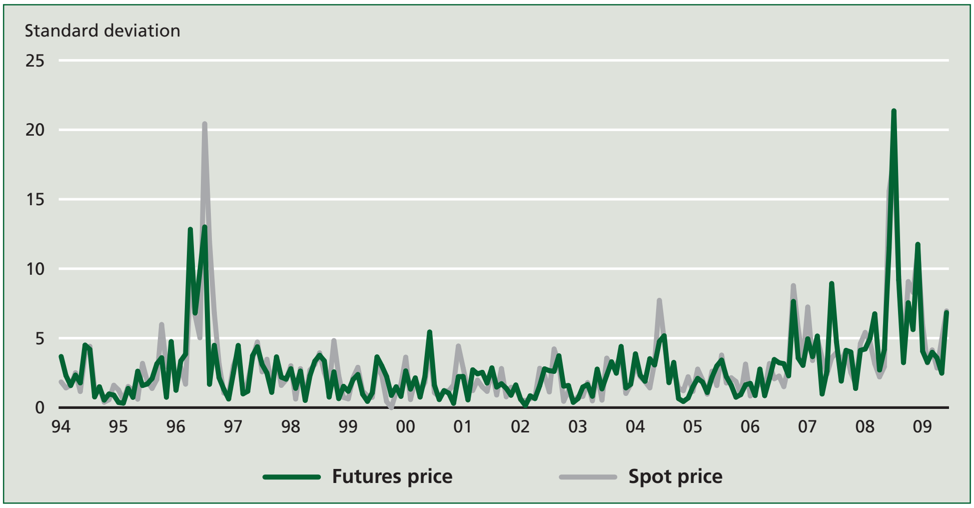


Figure 4 Soybeans: Weekly spot and futures prices, 1994–2009 (Prices deflated by US CPI, January 1994=1)

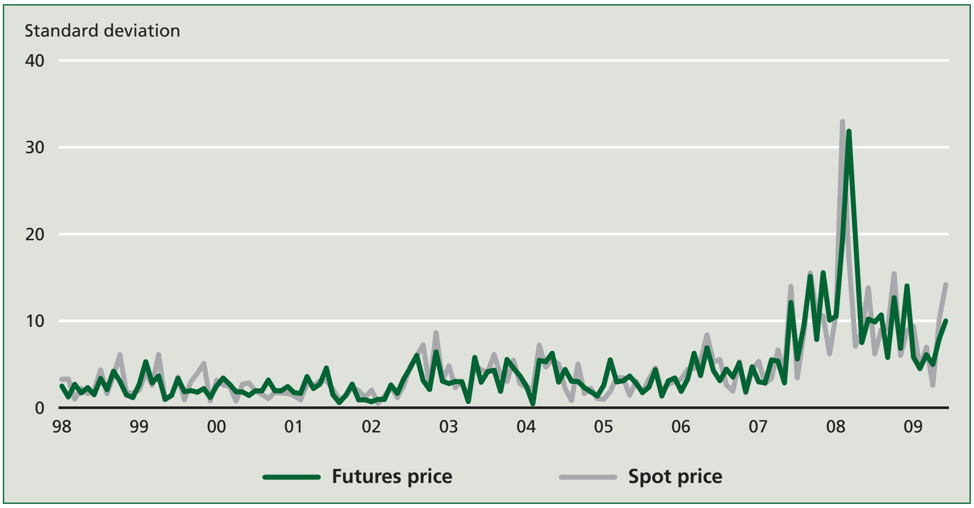
9 Levene's test statistic for equality of variances between spot and futures prices indicates that the differences in volatility are in the majority of cases not significantly different within each year and over the entire sample period.

Figure 5 Corn: Monthly volatility in spot and futures prices, 1994–2009



Note: Monthly volatility based on weekly spot and futures prices.

Figure 6 Hard Wheat: Monthly volatility in spot and futures prices, 1998–2009



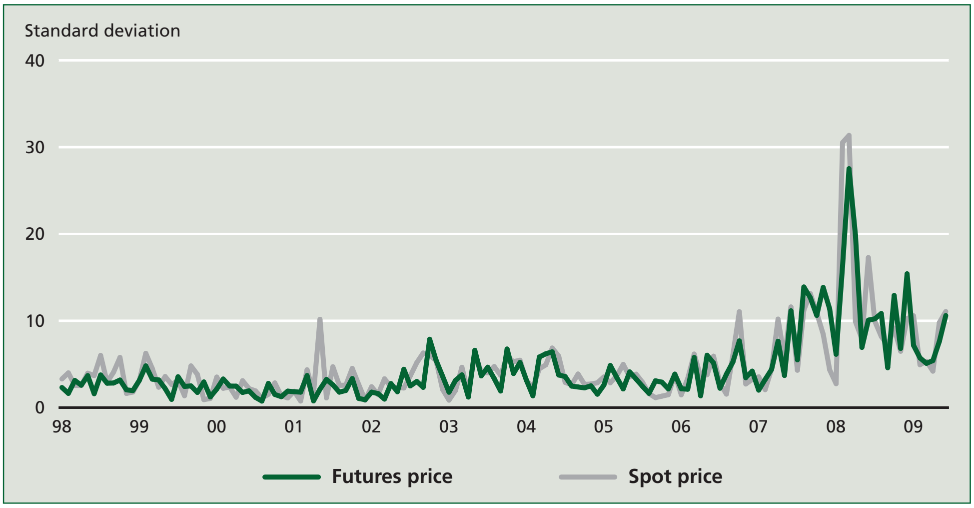
Note: Monthly volatility based on weekly spot and futures prices.

3. CAUSALITY TESTS

In order to formally analyze the dynamic relation between spot and futures prices, linear and nonlinear (nonparametric) Granger causality tests were conducted (refer to the Appendix for technical details on the methodology). These tests allow us to examine whether changes in the price of futures contracts lead changes in spot prices and/or whether changes in spot prices lead changes in futures prices. The idea is to make some inferences about the direction of information flows between spot and futures markets.

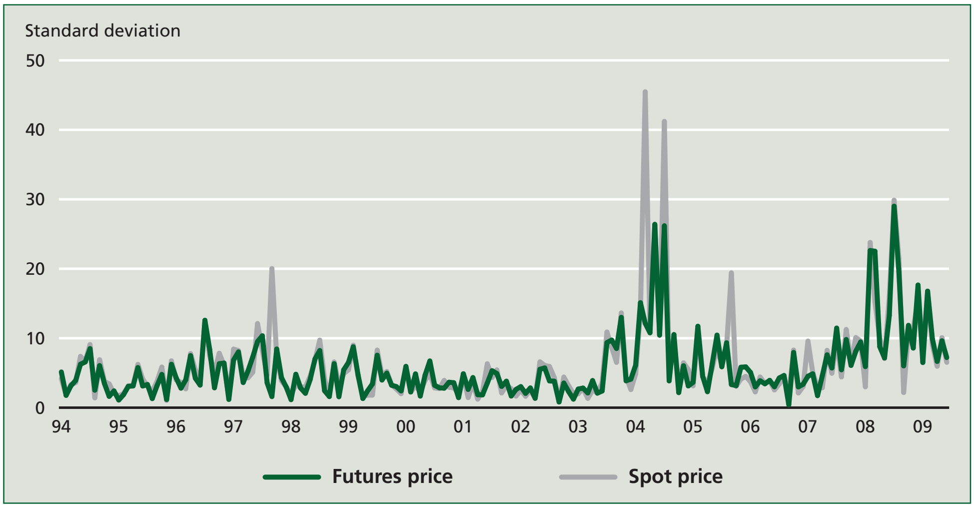
The analysis was conducted on spot and futures returns since the logs of spot and futures prices of all four agricultural commodities were found to be non stationary (see Table A.1). The spot return of a commodity is defined as $RS_t = \ln S_t - \ln S_{t-1}$, where

Figure 7. Soft Wheat: Monthly volatility in spot and futures prices, 1998–2009



Note: Monthly volatility based on weekly spot and futures prices.

Figure 8. Soybeans: Monthly volatility in spot and futures prices, 1994–2009



Note: Monthly volatility based on weekly spot and futures prices.

S_t is the price in the spot market at time (week) t, while the futures return is defined as $RF_t = \ln F_t - \ln F_{t-1}$, where F_t is the futures price at time t. Causal relations were also examined on the volatility of spot and futures returns. The measure of volatility used is the absolute deviation of the return from the sample average, as in Crain and Lee (1996). So the spot volatility of a commodity at time t is given by $VS_t = \left|RS_t - \overline{RS}\right|$ while the futures volatility is equal to $VF_t = \left|RF_t - \overline{RF}\right|$, where $\overline{RS}$ and $\overline{RF}$ are the corresponding sample averages.

Linear Granger causality test

The linear Granger causality test examines whether past values of one variable can help explain current values of a second variable, conditional on past values of the second variable. Intuitively, it determines if past values of the first variable contain additional information on the current value of the second variable that is not contained in past values of the latter. If so, the first variable is said to Granger-cause the second variable. In this case, we evaluate if futures returns Granger-cause spot returns (i.e. if the return in the spot market at time t is related to past returns in the futures market, conditional on past spot returns) and/or if spot returns Granger-cause futures returns. Similarly, if volatility in the futures market Granger-cause volatility in the spot market and/or if volatility in the spot market Granger-cause volatility in the futures market.

Linear causality tests were performed over the entire sample period as well as on sample subperiods to analyze if the dynamic relation between corn spot and futures prices has changed across time. Prices for agricultural commodities are inherently subject to demand and supply shocks and it is possible that these structural changes affect the dynamic relation of spot and futures prices. Additionally, this relationship might be affected by changes in the relative importance of different trading mechanisms or, as argued by Crain and Lee (1996), by changes in farm policies.

The test results for spot and futures returns for all four agricultural commodities and for the whole sample period are presented in Table 1. The upper section of the table reports the F-statistic for the null hypothesis that futures returns do not Granger-cause spot returns while the lower section reports the F-statistic for the null that spot returns do not Granger-cause futures returns. Similar to previous studies, test results for different lag structures are included (1 to 10 lags). As can be seen, the null hypothesis that the returns in futures markets do not Granger-cause the returns in spot markets is uniformly rejected at the 1 percent significance level in all four cases and for all lags with the F-statistic decreasing as the number of lags increases. In contrast, only in the case of corn, spot returns Granger-cause futures returns for lag 1 at a 1 percent significance level and for lags 7 and 8 at a 5 percent significance level.

These results are consistent with previous studies and suggest that futures markets dominate spot markets for the commodities analyzed or, equivalently, that the spot price is discovered in the futures market. The return in the spot market today is significantly related to past returns in the futures market up to at least ten weeks ago while the impact of past spot returns on today's futures return is almost zero. The information flow from futures to spot markets also appears to have intensified in the past years since the causal relationship is remarkably strong in comparison to previous studies. This apparent increase in information flows could be related to the increase in the relative importance of electronic trading of futures contracts over open auction trading during the past years, which result in more transparent and widely accessible prices.

When segmenting the sample by 2-year periods, as shown in Tables A.2 to A.5, we still find strong evidence that futures markets dominate spot markets across all time periods, specifically for the two varieties of wheat and corn. In the case of soybeans, the evidence is less clear although returns in the futures market lead returns in the spot market more often than the reverse. A similar pattern is observed when dividing the sample into subperiods corresponding to the different farm programs in the US (i.e. 1990, 1996, 2002 and 2008 Farm Bills). The causal relationship from futures to spot markets do not seem to have been much affected by the farm programs. Refer to Tables A.6 to A.9 for details.

Another way to examine if the causal link between spot and futures returns have changed across time, is to conduct rolling Granger causality tests, as in Robles, Torero and von Braun (2009) and Cooke and Robles (2009). Repeated tests over 104-week (2-year) periods were carried out by rolling the subsample period one week ahead until the available data was exhausted. The results of this procedure for each agricultural commodity are presented in Figures 9 to 12. Again, it is clear that futures returns Granger-cause spot returns, at least

Table 1. Granger causality tests of weekly returns in spot and futures markets, 1994–2009

Lags	H_0: Futures returns do not Granger-cause spot returns			
	Corn	Hard wheat	Soft wheat	Soybeans
1	167.47***	263.03***	169.85***	15.44***
2	116.20***	186.92***	106.61***	21.24***
3	77.58***	135.27***	75.33***	20.74***
4	58.56***	100.84***	57.92***	16.93***
5	48.65***	79.91***	46.38***	14.57***
6	40.63***	65.92***	38.36***	12.41***
7	34.76***	56.21***	32.90***	11.51***
8	30.95***	49.91***	29.37***	10.35***
9	27.62***	44.64***	26.09***	9.38***
10	24.80***	40.89***	23.44***	9.05***
	H_0: Spot returns do not Granger-cause futures returns			
	Corn	Hard wheat	Soft wheat	Soybeans
1	6.10***	2.20	0.40	0.55
2	2.09	0.02	0.01	0.47
3	2.24*	0.11	0.27	1.75
4	2.08*	0.97	1.50	1.41
5	1.66	1.32	1.59	1.28
6	1.59	1.21	1.64	1.06
7	2.12**	1.45	1.76*	0.96
8	1.97**	1.21	1.46	1.06
9	1.58	1.10	1.25	1.04
10	1.45	1.21	1.21	1.03

* 10%, ** 5%, *** 1% significance. F statistic reported.

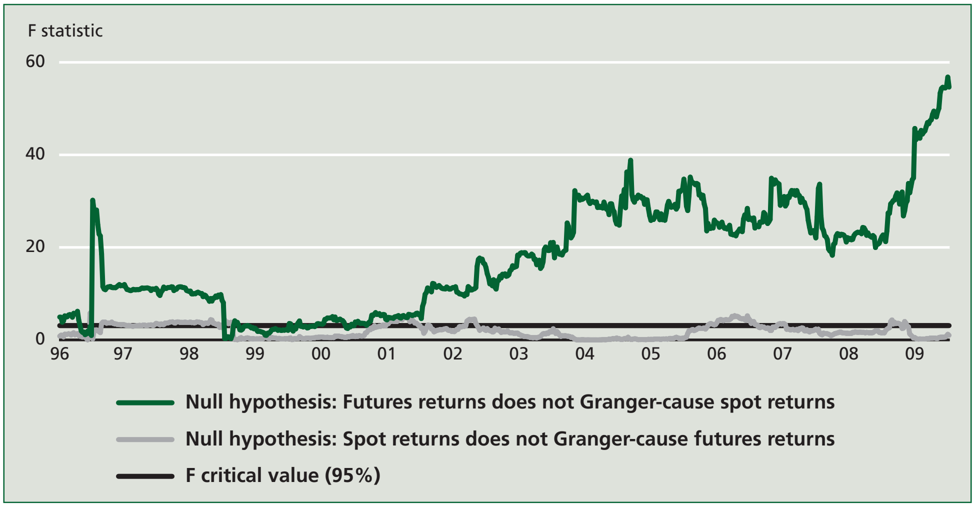
Note: The Schwartz Bayesian Criterion (SBC) suggests lag structures of 2, 3, 2 and 3 for corn, hard wheat, soft wheat and soybeans, respectively. The Akaike Information Criterion (AIC) suggests lag structures of 8, 3, 4 and 5, respectively.
Period of analysis January 1994– July 2009 for corn and soybeans, and
January 1998 – July 2009 for hard and soft wheat.

for hard and soft wheat and corn. Note also that in all four cases spot returns do not seem to Granger-cause futures returns across all sample subperiods.

A similar causality analysis was conducted for each commodity to explore how volatility in one market is related to volatility in the other. The test results for the whole sample period and for models including 1 to 10 lag structures are reported in Table 2. The upper section of table shows the F-statistic for the null hypothesis that futures volatility do not Granger-cause spot volatility while the lower section reports the F-statistic for the null that spot volatility do not Granger-cause futures volatility. As in the case of returns, when considering the whole sample period, the null hypothesis that futures volatility do not Granger-cause spot volatility is uniformly rejected at the 1 percent significance level in all four cases and basically for all lag structures. The F-statistic also decreases as the number of lags increases.

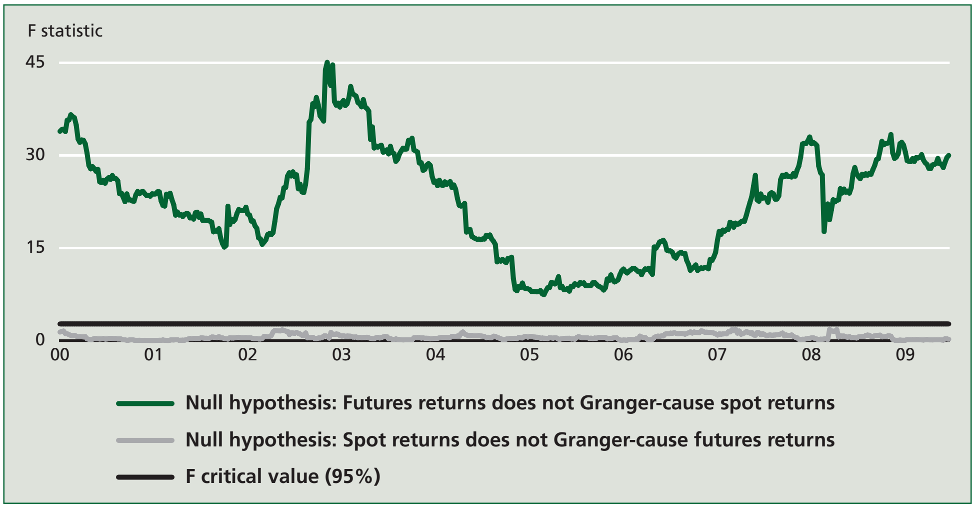
However, except for soybeans, spot volatility also seems to Granger-cause futures volatility for several lag levels at the 1 percent and 5 percent significance level. Furthermore, in the

Figure 9. Corn: Rolling Granger causality tests of weekly returns in spot and futures markets, 1994–2009



Note: A lag structure of 2 is assumed according to the Schwartz Bayesian Criterion (SBC).

Figure 10. Hard wheat: Rolling Granger causality tests of weekly returns in spot and futures markets, 2000–2009

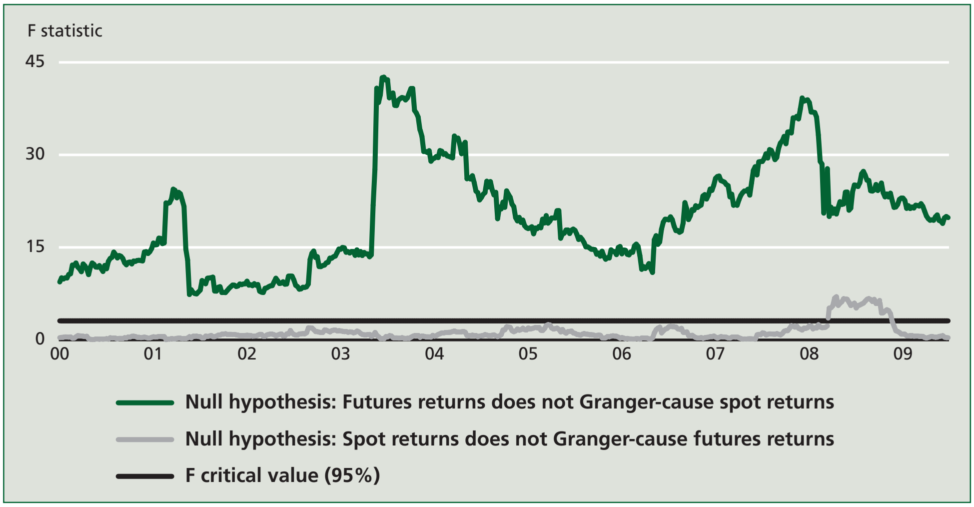


Note: A lag structure of 3 is assumed according to the Schwartz Bayesian Criterion (SBC).

case of hard wheat, the causal link from spot to futures volatility is robust to all lag structures considered. But the impact of past spot volatility on today's futures volatility is not as strong and persistent as the impact of past futures volatility on today's spot volatility. Overall, these findings suggest that futures markets also carry out their price discovery role by transferring volatility to spot markets, although the results are not as conclusive as in the case of returns.

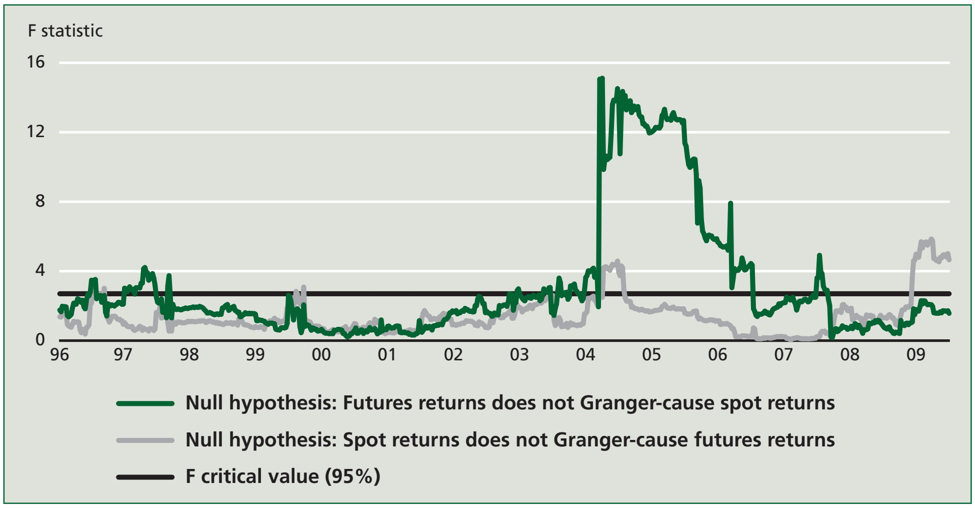
The analysis by sample subperiods also reveals that volatility in the futures market leads volatility in the spot market more often than the reverse, particularly for corn and soybeans (see Tables A.10 to A.13). Similar results are obtained when dividing the sample by different farm programs in the US, as shown in Tables A.14 to A.17. In the case of

Figure 11. Soft wheat: Rolling Granger causality tests of weekly returns in spot and futures markets, 2000–2009



Note: A lag structure of 2 is assumed according to the Schwartz Bayesian Criterion (SBC).

Figure 12. Soybeans: Rolling Granger causality tests of weekly returns in spot and futures markets, 1996–2009



Note: A lag structure of 3 is assumed according to the Schwartz Bayesian Criterion (SBC).

corn, the causal link from futures to spot markets seems quite robust across most farm programs.

The rolling Granger causality tests, reported in Figures 13 to 16, indicate that the volatility transfer from spot to futures markets is very weak for all commodities. More specifically, under this estimation procedure, the transfer of volatility from futures to spot markets is more recurrent than the reverse, but there are also several subperiods where both markets result disjoint from each other.

Table 2. Granger causality tests of weekly volatility in spot and futures markets, 1994–2009

Lags	H_o: Futures volatility do not Granger-cause spot volatility			
	Corn	Hard wheat	Soft wheat	Soybeans
1	85.85***	33.40***	18.11***	1.32
2	50.54***	20.71***	7.05***	5.66***
3	33.52***	16.69***	4.58***	4.98***
4	24.72***	11.29***	4.28***	5.27***
5	19.04***	9.51***	4.05***	4.22***
6	18.92***	8.11***	3.51***	3.52***
7	16.39***	6.98***	3.14***	3.30***
8	14.88***	6.38***	3.17***	2.84***
9	13.21***	5.36***	2.75***	2.63***
10	12.51***	5.46***	2.33***	2.51***
	H_0: Spot volatility do not Granger-cause futures volatility			
	Corn	Hard wheat	Soft wheat	Soybeans
1	7.02***	6.74***	10.88***	0.14
2	1.15	4.62***	7.03***	0.13
3	0.53	7.74***	4.67***	0.14
4	4.41***	5.13***	3.16**	0.11
5	3.04***	4.90***	2.38**	0.35
6	2.35**	4.22***	1.74	0.43
7	2.08**	3.63***	1.6	0.87
8	2.01**	3.24***	1.41	0.91
9	2.06**	3.05***	1.42	1.58
10	1.57	4.08***	2.01**	1.42

* 10%, ** 5%, *** 1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests lag structures of 2, 1, 1 and 2 for corn, hard wheat, soft wheat and soybeans, respectively. The Akaike Information Criterion (AIC) suggests lag structures of 10, 10, 2 and 5, respectively. Period of analysis January

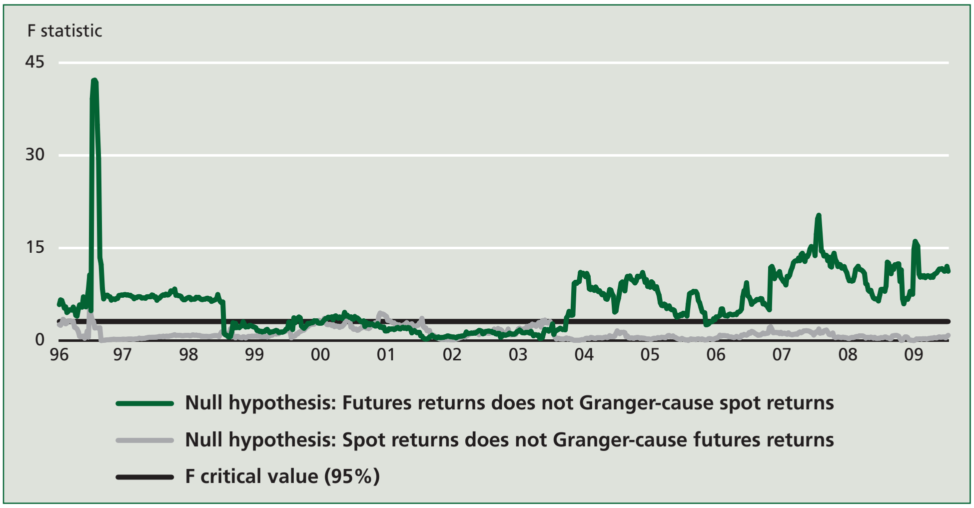
Nonparametric Granger causality test

The linear Granger causality tests support the price discovery role of futures markets or, alternatively, that changes in spot prices echo changes in futures prices. The evidence is clearer when analyzing returns than when analyzing volatility in spot and futures markets. Linear causality tests have high power in identifying linear causal relations but their power against nonlinear causal links might be low, as pointed by Hiemstra and Jones (1994). Nonlinear dynamic relations might arise, for example, when allowing for heterogeneous market participants or different types of risk-averse agents in spot and futures markets.

Considering, then, that linear causality tests might overlook nonlinear dynamic relations between spot and futures prices, the nonparametric causality test proposed by Diks and Panchenko (2006) was conducted.[10] In particular, we want to out rule the possibility of

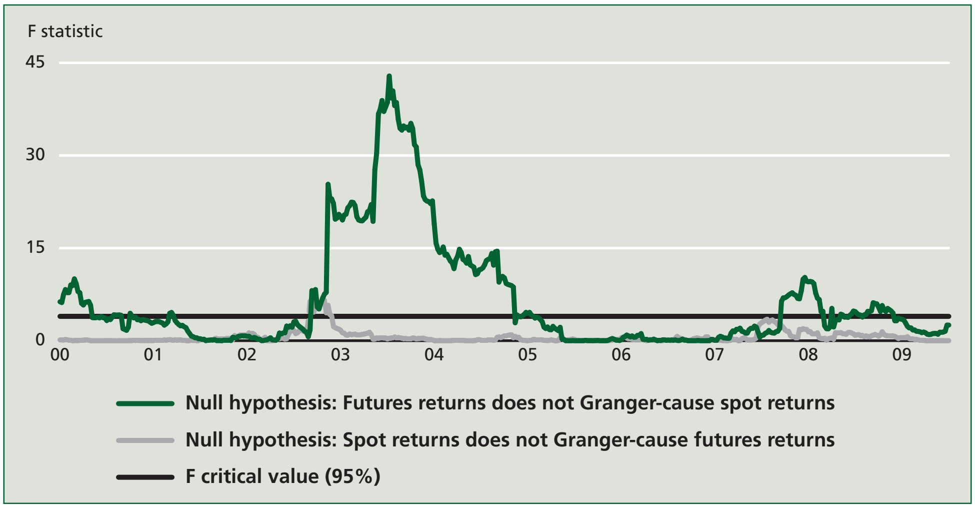
[10] For further details on the nonparametric causality test implemented refer to the Appendix.

Figure 13. Corn: Rolling Granger causality tests of weekly volatility in spot and futures markets, 1996–2009



Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. A lag structure of 2 is assumed according to the Schwartz Bayesian Criterion (SBC).

Figure 14. Hard wheat: Rolling Granger causality tests of weekly volatility in spot and futures markets, 2000–2009



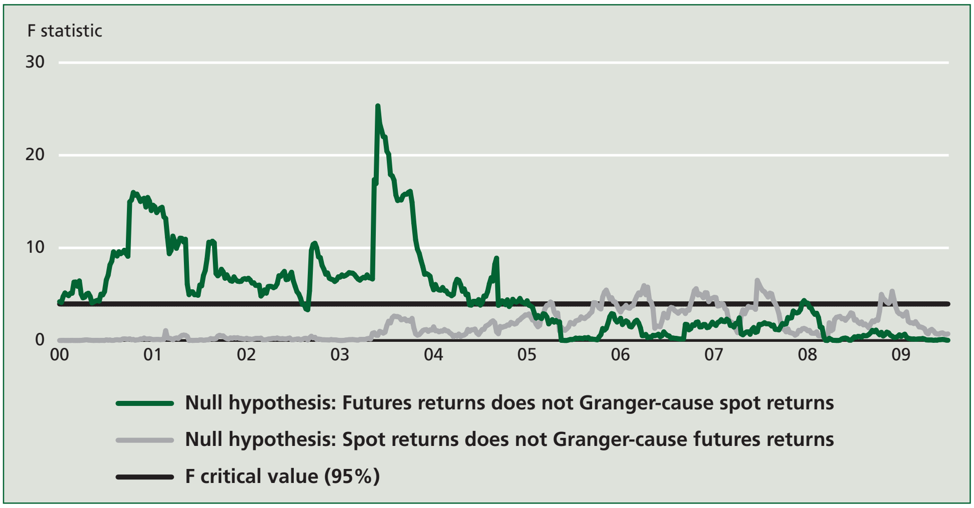
Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. A lag structure of 1 is assumed according to the Schwartz Bayesian Criterion (SBC).

nonlinear causality from changes in spot prices to changes in futures prices, provided that there is not major evidence of linear causality in this direction.[11]

To remove any linear dependence, the nonparametric causality test was applied to the residuals of VAR models with spot and futures returns and spot and futures volatility for

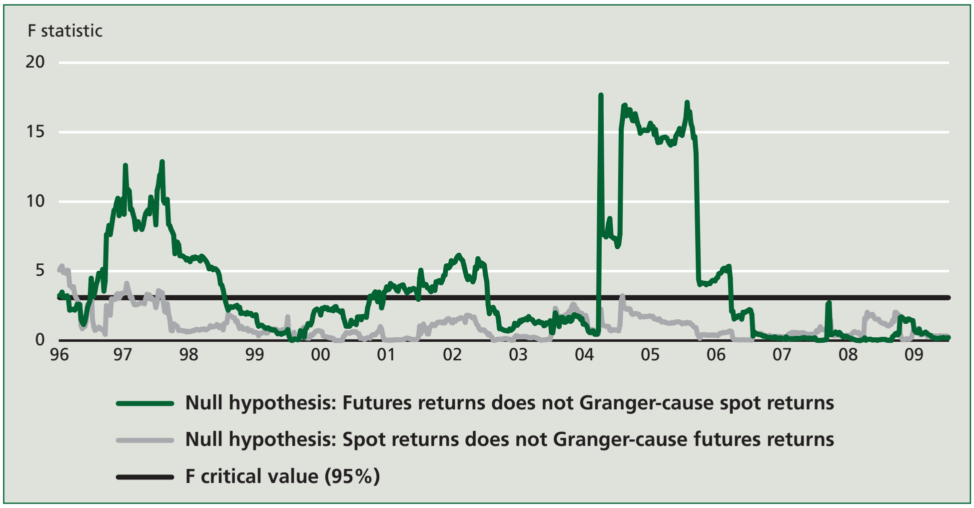
[11] It is worth to note that identifying a specific source of nonlinear dependence between spot and futures prices is beyond the scope of this study.

Figure 15. Soft Wheat: Rolling Granger causality tests of weekly volatility in spot and futures markets, 2000–2009



Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. A lag structure of 1 is assumed according to the Schwartz Bayesian Criterion (SBC).

Figure 16. Rolling Granger causality tests of weekly volatility in spot and futures markets, 1996-2009



Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. A lag structure of 2 is assumed according to the Schwartz Bayesian Criterion (SBC).

each commodity. Tables 3 and 4 report the *T* values for Diks and Panchenko's test statistic applied to the returns and their volatility, respectively, in both directions and for different lag lengths (1 to 10 lags). Causality tests on sample subperiods were not performed in this case because the nonparametric test relies on asymptotic theory.

Even after removing the linear dependence, futures returns Granger-cause spot returns, particularly for corn and hard wheat. For soft wheat, the causal relationship goes in the reverse direction while for soybeans there are bidirectional information flows. In terms of

Table 3. Nonparametric Granger causality tests of weekly returns in spot and futures markets, 1994-2009

$l_x = l_y$	H$_o$: Futures returns do not Granger-cause spot returns			
	Corn	Hard wheat	Soft wheat	Soybeans
1	2.96***	1.61**	0.50	1.69**
2	3.17***	2.71***	1.07	3.10***
3	3.32***	3.30***	1.16	3.63***
4	2.86***	2.95***	1.25*	4.20***
5	1.94**	2.85***	1.12	3.72***
6	1.70**	2.87***	0.95	3.31***
7	1.70**	2.59***	0.56	3.12***
8	1.67**	2.19**	0.69	2.64***
9	1.70**	2.11**	0.05	2.32***
10	1.60**	1.61**	0.29	2.17**
	H$_0$: Spot returns do not Granger-cause futures returns			
	Corn	Hard wheat	Soft wheat	Soybeans
1	2.41***	2.02**	3.13***	1.67**
2	1.24	1.88**	3.03***	1.65**
3	1.89**	1.92**	2.94***	1.74**
4	2.12**	2.02**	3.05***	1.79**
5	1.36*	1.38*	2.52***	2.24**
6	0.87	1.42*	2.09**	2.35***
7	1.02	1.15	1.67**	2.59***
8	0.98	1.53*	1.71**	2.37***
9	1.40*	1.23	1.43*	1.87**
10	1.08	1.37*	1.66**	1.57*

* 10%, ** 5%, *** 1% significance. Diks and Panchenko's (1996) T ratios reported.

Note: Bandwidth values set according to the time series length and considering a conditional heteroskedastic process with one lag dependence (Diks and Panchenko, 2006). Period of analysis January 1994 – July 2009 for corn and soybeans, and January 1998 – July 2009 for hard and soft wheat.

volatility, futures markets seem to transfer volatility to spot markets for all four commodities, but there is also volatility transfer from spot to futures markets for soft wheat and soybeans. In sum, the nonparametric results provide little evidence of nonlinear causality from changes in spot prices to changes in futures prices. If there is any nonlinear causal relation, it is from futures to spot markets, at least for corn and hard wheat.

4. CONCLUSIONS

The causality tests performed indicate that the futures markets analyzed generally dominate the spot markets. Price changes in futures markets lead price changes in spot markets more often than the reverse, especially when examining returns. These findings support then the price discovery role of futures markets. Compared to previous studies, the identified causal link also appears to be stronger and more persistent. This suggests that the information

Table 4. Nonparametric Granger causality tests of weekly returns in spot and futures markets, 1994-2009

$l_x = l_y$	Corn	Hard wheat	Soft wheat	Soybeans
	H_o: Futures volatility do not Granger-cause spot volatility			
	Corn	Hard wheat	Soft wheat	Soybeans
1	4.60***	3.09***	2.37***	1.91**
2	3.29***	2.74***	1.96**	2.29**
3	2.79***	3.56***	2.33***	1.53*
4	2.54***	3.79***	2.93***	2.02**
5	2.20**	3.39***	2.37***	2.02**
6	2.02**	3.12***	2.35***	1.47*
7	1.16	2.64***	1.48*	1.82**
8	0.60	2.55***	1.29*	1.48*
9	0.91	2.16**	1.60**	1.29*
10	1.07	1.84**	1.50*	1.39
	H_0: Spot volatility do not Granger-cause volatility returns			
	Corn	Hard wheat	Soft wheat	Soybeans
1	2.95***	1.34*	2.46***	1.17
2	2.12**	1.17	2.03**	1.92**
3	1.64*	1.39*	2.47***	2.12**
4	0.63	0.59	2.18**	1.94**
5	0.54	0.93	2.70***	1.82**
6	0.96	0.77	2.38***	1.60*
7	0.62	0.75	1.98**	1.62*
8	0.63	1.40*	2.17**	1.24
9	0.50	1.31*	2.18**	1.45*
10	0.56	1.35*	1.81**	0.97

*10%, **5%, ***1% significance. Diks and Panchenko's (1996) T ratios reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. Bandwidth values set according to the time series length and considering a conditional heteroskedastic process with one lag dependence (Diks and Panchenko, 2006). Period of analysis January 1994 – July 2009 for corn and soybeans, and January 1998 – July 2009 for hard and soft wheat.

flow from futures to spot markets has intensified in the past 15 years, probably due to the increase in the relative importance of electronic trading of futures contracts over open auction trading, which result in more transparent and widely accessible prices.

This result has important implications for alternative instruments recommended to address volatility in grain markets, after the recent food crisis. In particular, von Braun and Torero (2008, 2009) have proposed the implementation of a global virtual reserve to minimize speculative attacks and avoid excessive spikes in spot prices. The idea is to specify a price band that would be a signal (threat) to speculators that a market assessment is likely if futures prices exceed the upper limit of this band. If despite the signal, there is evidence of an excessive price spike, a progressive number of short sales in the futures market (at market prices) will then be executed so futures and eventually spot prices will decline to reasonable levels. The fact that spot prices move towards futures prices supports the viability of this innovative intervention mechanism.

REFERENCES

Brorsen, B.W., Bailey, D. & Richardson, J.W. 1984. Investigation of price discovery and efficiency for cash and futures cotton prices. *Western Journal of Agricultural Economics*, 9(1): 170–176.

Chari, V.V., Jagannathan, R. & Jones, L. 1990. Price stability and futures trading in commodities. *Quarterly Journal of Economics*, 105(2): 527–534.

Cooke, B. & Robles, M. 2009. *Recent food prices movements: A time series analysis*. IFPRI Working Paper.

Crain, S. & Lee, J.H. 1996. Volatility in wheat spot and futures markets, 1950–1993: Government farm programs, seasonality, and causality. *Journal of Finance*, 51(1): 325–343.

Danthine, J.P. 1978. Information, futures prices, and stabilizing speculation. *Journal of Economic Theory*, 17(1): 79–98.

Diks, C. & Panchenko,V. 2006. A new statistic and practical guidelines for nonparametric Granger Causality testing. *Journal of Economic Dynamics and Control*, 30(9–10): 1647–1669.

Enders, W. 2004. *Applied Econometric Time Series*. Hoboken, New Jersey, John Wiley & Sons.

Garbade, K. & Silber, W. 1983. Price movements and price discovery in futures and cash markets. *Review of Economics and Statistics*, 65(2): 289–297.

Hiemstra, C. & Jones, J. 1994. Testing for linear and nonlinear Granger Causality in the stock price - Volume relation. *Journal of Finance*, 49(5): 1639–1664.

Kawai, M. 1983a. Spot and futures prices of nonstorable commodities under rational expectations. *Quarterly Journal of Economics*, 98:2 (1983a), 235–254.

______________.1983b. Price volatility of storable commodities under rational expectations in spot and futures markets. *International Economic Review*, 24(2): 435–459.

Martin, L. & Garcia, P. 1981. The price-forecasting performance of futures markets for live cattle and hogs: A disaggregated analysis. *American Journal of Agricultural Economics*, 63(2): 209–215.

McKinnon, R. 1967. Futures markets, buffer stocks, and income stability for primary producers. *Journal of Political Economy*, 75(6): 844–861.

Pindyck, R.S. 2001. The dynamics of commodity spot and futures markets: A primer. *The Energy Journal*, 22(3): 1–29.

Robles, M., Torero, M. & von Braun, J. 2009. When speculation matters. *IFPRI Issue Brief* 57 (February).

Tomek, W. & Gray, R. 1970. Temporal relationships among prices on commodity futures markets: Their allocative and stabilizing roles. *American Journal of Agricultural Economics*, 52(3): 372–380.

Turnovsky, S. 1983. The Determination of Spot and Futures Prices with Storable Commodities. *Econometrica*, 51(5): 1363–1387.

von Braun, J. & Torero, M. 2008. Physical and virtual global food reserves to protect the poor and prevent market failure. *IFPRI Policy Brief 4*, June.

______________. Implementing physical and virtual food reserves to protect the Poor and Prevent Market Failure. *IFPRI Policy Brief 10* (February 2009).

APPENDIX: GRANGER CAUSALITY TESTS

This appendix describes in detail the linear and nonlinear (nonparametric) Granger causality tests performed in the study. The order of integration of both spot and futures prices of all four agricultural commodities was first examined using the Augmented Dickey-Fuller (ADF) unit-root test, after taking logs. The ADF tests included a constant and the appropriate lag length was selected according to the Schwartz Bayesian Criterion (SBC). Formally, the following test equation was estimated for each spot and futures commodity price,

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{i=2}^{p} \gamma_i \Delta y_{t-i+1} + \varepsilon_t \qquad \text{(A.1)}$$

where $\Delta y_t = y_t - y_{t-1}$, is the log of the spot (S_t) or futures price (F_t) at time (week) t, p is the lag length used, and ε_t is the error term. Testing the null hypothesis that the series has a unit root or is integrated of order 1, i.e. I(1), is equivalent to testing if $\beta = 0$. Both the log of spot and futures prices of each commodity are found to be I(1), suggesting the use of first differences in the causality analysis.

As a robustness check, Perron's unit-root test in the presence of structural breaks was performed on the log of spot and futures prices, provided that if a series has a structural change (as suspected due to the crop price shock during the mid 90s or the recent food crisis) the ADF statistic is biased towards the non-rejection of a unit root. The test results also provide strong evidence for the unit root hypothesis.[12]

Causality tests were then carried out on the (weekly) returns of the spot and futures prices of each commodity, defined as $RS_t = \ln S_t - \ln S_{t-1}$ and $RF_t = \ln F_t - \ln F_{t-1}$, respectively. Both returns are found to be I(0) for all four commodities, as expected. Causality links were also examined on the volatility of the spot and futures returns. Following Crain and Lee (1996), volatility is measured as the absolute deviation of the return from the sample average. So the volatility of the spot return at time t is given by $VS_t = \left| RS_t - \overline{RS} \right|$ where $\overline{RS}$ is the sample average. The volatility of the futures return at time t, in turn, is defined as $VF_t = \left| RF_t - \overline{RF} \right|$. The volatility measures are also found to be I(0) in all cases.

Linear Granger causality test

The linear Granger causality test conducted basically consists in examining whether the return in the spot market at time t is related to past returns in the futures market, conditional on past spot returns, and/or whether futures returns are related to past spot returns, conditional on past futures returns. More specifically, the following regression model was estimated for each commodity to analyze the relationship between RS_t and p lagged values of RS_t and RF_t.

$$RS_t = a_0 + \sum_{k=1}^{p} a_{1k} RS_{t-k} + \sum_{k=1}^{p} a_{2k} RF_{t-k} + e_t \qquad \text{(A.2)}$$

As in previous studies, the model was estimated for different lag lengths considering also that the Schwartz Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC)

[12] For further details on testing for unit roots in the presence of a structural change refer to Enders (2004).

suggested different lag structures within each commodity.[13] The F-statistic for the null hypothesis that the lagged coefficients of RF_t are equal to zero was used to test if RF_t do not Granger-cause RS_t . Intuitively, it is tested whether past futures returns contain additional information on the current spot return that is not contained in past spot returns. Conversely, RF_t is the dependent variable to test whether RS_t do not Granger-cause RF_t .

A similar test was conducted for volatility. The regression model estimated for each commodity to examine if volatility in the spot market is related to past volatility in the futures market, conditional on past spot volatility, is given by,

$$VS_t = b_0 + \sum_{k=1}^{p} b_{1k} VS_{t-k} + \sum_{k=1}^{p} b_{2k} VF_{t-k} + u_t \qquad \text{(A.3)}$$

Again, the F-statistic for the null that the lagged coefficients of VF_t are equal to zero was used to test if VF_t do not Granger-cause VS_t. Similarly, VF_t is the left hand-side variable to test if VS_t do not Granger-cause VF_t.

Linear Granger causality tests of spot and futures returns and their volatility were also conducted on sample subperiods to analyze if the dynamic relation between spot and futures prices for each commodity has changed across time. It is possible that this relationship might be affected by structural changes in the dynamics of prices, by changes in the relative importance of different trading mechanisms, or by changes in farm policies as indicated by Crain and Lee (1996). In particular, the following additional estimations were carried out considering the frequency of the data and the sample size:

a. Causality tests for separate 2-year periods. 1994–1995; 1996–1997; 1998–1999; 2000–2001; 2002–2003; 2004–2005; 2006–2007; and 2008–2009 semester 1. Recall that for hard and soft wheat we do not have information for the years 1994 through 1997.
b. Causality tests for each sample subperiod corresponding to a different farm program in the US The first subperiod corresponds to the sample period during the 1990 Farm Bill (01/07/94 – 04/03/96); the second subperiod to the 1996 Farm Bill (04/04/96 – 05/12/02); the third subperiod to the 2002 Farm Bill (05/13/02 – 06/17/08); and the last subperiod to the 2008 Farm Bill (06/18/08 – 06/26/09). For hard and soft wheat, the 1996 Farm Bill subperiod corresponds to 01/02/98 – 05/12/02.
c. Rolling causality tests as in Robles, Torero and von Braun (2009) and Cooke and Robles (2009). Repeated tests over 104-week (2-year) periods by rolling the subsample period one week ahead until the available data is exhausted. The lag structure was set according to the Schwartz Bayesian Criterion (SBC). So, for example, in the case of corn spot and futures returns a total of 702 causality tests were conducted, as the period of analysis moved one week ahead every time, while in the case of hard wheat spot and futures returns a total of 493 causality tests were performed.

Nonparametric Granger causality test

As a complementary analysis, nonparametric Granger causality tests were performed on spot and futures returns of each commodity and their volatility to uncover potential

[13] The difference between the SBC and the AIC is the weight they give to the number of parameters (or complexity) of the model. The SBC has a larger penalty for having extra parameters (i.e. for lack of parsimony). Consequently, the AIC is designed to select the model that will predict best and is less concerned with having more parameters. The SBC is more concerned with selecting the true number of lags in an autoregressive (AR) process.

nonlinear dynamic relations between spot and futures markets. Traditional linear Granger causality tests have high power in identifying linear causal relations, but their power against nonlinear causal relations can be low (see Hiemstra and Jones, 1994). The nonparametric Granger causality test proposed by Diks and Panchenko (2006) was conducted. The authors argue that their causality test reduces the risk of over-rejection of the null hypothesis of non-causality, observed in the Hiemstra and Jones' widely-used test.[14]

Dicks and Panchenko's nonparametric causality test can be summarized as follows:[15] Consider two stationary series, $\{X_t\}$ and $\{Y_t\}$, such as the spot and futures returns or the volatility measures defined previously. When testing for Granger causality, the aim is to detect evidence against the null hypothesis H_0: $\{X_t\}$ do not Granger-cause $\{Y_t\}$. In a nonparametric setting, this null hypothesis is equivalent to testing for the conditional independence of Y_t on X_{t-1}, ... X_{t-lx}, given Y_{t-ly} ...., Y_{t-ly} that is

$$H_0 : \left| Y_t \left(X_{t-1}^{l_x} ; Y_{t-1}^{l_y} \right) \quad Y_t \right| Y_{t-1}^{l_y} \qquad \text{(A.4)}$$

where $X_{t-1}^{l_x} = \left(X_{t-l_x}, ..., X_{t-1} \right)$ and $Y_{t-1}^{l_y} = \left(Y_{t-l_y}, ..., Y_{t-1} \right)$. So the null is a statement about the invariant distribution of the $\left(l_x + l_y + 1 \right)$ -dimensional vector $W_t = \left(X_{t-1}^{l_x}, Y_{t-1}^{l_y}, Z_t \right)$, where $Z_t = Y_t$. .

For ease of notation, assume that $l_x = l_y = 1$ and drop the time index. Then, under the null, the conditional distribution of Z given $(X,Y) = (x,y)$ is the same as that of Z given only $Y = y$, and the joint probability density function $f_{X,Y,Z}(x,y,z)$ and its marginals must satisfy,

$$\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \frac{f_{Y,Z}(y,z)}{f_Y(y)} \qquad \text{(A.5)}$$

for each vector (x,y,z) in the support of (X,Y,Z). Diks and Panchenko further show that the null hypothesis implies,

$$q = E\left[f_{X,Y,Z}\left(X,Y,Z\right) f_Y(Y) - f_{X,Y}\left(X,Y\right) f_{Y,Z}\left(Y,Z\right) \right] \qquad \text{(A.6)}$$

If $\hat{f}_W(W_i)$ is a local density estimator of a d_w -variate random vector W at W_t, defined by $\hat{f}_W(W_i) = \frac{(2\in_n)^{-d_w}}{n-1} \sum_{j,j \neq i} I_{ij}^W$ where $I_{ij}^W = I\left(\left| W_i - W_j \right| < \in_n \right)$, $I(\cdot)$ is an indicator function and $\in_n$ is the band width, the estimator of q simplifies to,

$$T_n\left(\in_n\right) = \frac{n-1}{n(n-2)} \sum_i \left(\hat{f}_{X,Y,Z}\left(X_i Y_i Z_i\right) \hat{f}_Y\left(Y\right)_i - \hat{f}_{X,Y}\left(X_i Y_i\right) \hat{f}_{Y,Z}\left(Y_i Z_i\right) \right) \qquad \text{(A.7)}$$

[14] Considering that the null hypothesis of Granger non-causality can be rephrased in terms of conditional independence of two vectors X and Z given a third vector Y, Diks and Panchenko show that the Hiemstra and Jones test is sensitive to variations in the conditional distributions of X and Z that may be present under the null. To overcome this problem, they replace the global test statistic by an average of local conditional dependence measures.

[15] It is worth to mention that nonparametric causality tests detect nonlinear causal relationships with high power, but do not provide any guidance regarding the source of the nonlinear dependence. Identifying a specific nonlinear dynamic relationship between spot and futures markets is beyond the scope of the present study.

For a sequence of bandwidths $\in_n = Cn^{-\beta}$, with $C > 0$ and $\beta \in \begin{pmatrix} \frac{1}{4.1} \\ 3 \end{pmatrix}$, this test statistic satisfies,

$$\sqrt{n}\frac{T_n(\in_n) - q}{S_n} \xrightarrow{D} N(0,1) \qquad \text{(A.8)}$$

where S_n is the asymptotic variance of $T_n(\in_n)$.

To remove any linear dependence, the test in equation (A.8) was applied to the residuals of a VAR model with the pair of variables of interest for each agricultural commodity, i.e. spot and futures returns and spot and futures volatility. The tests were performed for different lag values, $l_x = l_y = 1, 2, \ldots\ldots.10$. Following Dicks and Panchenko (2006), the bandwidths were selected according to the time series length and considering a conditional heteroskedastic process with one lag dependence.[16] Since nonparametric tests rely on asymptotic theory, causality tests on sample subperiods were not performed in this case.

[16] We actually could not reject, at the 10% significance level, the presence of autoregressive conditional heteroskedasticty (ARCH) effects in the residuals of the estimated models for each commodity.

Table A.1. Augmented Dickey-Fuller (ADF) test for unit root variable

Variable	Corn	Hard wheat	Soft wheat	Soybeans
Log spot price	-2.054	-1.354	-1.975	-2.133
Log futures price	-2.269	-1.526	-1.629	-1.748
Spot return (first difference of log spot price)	-29.495***	-23.888***	-24.990 ***	-30.860***
Futures return (first difference of log futures price)	-30.609***	-25.824***	-25.542***	-28.496***
Spot volatility (absolute return deviations from sample average)	-9.144***	-6.443***	-10.339***	-13.363***
Futures volatility (absolute return deviations from sample average)	-10.808***	-15.227***	-15.797***	-8.321***

*10%, **5%, ***1% significance. ADF t statistic reported.
Note: The ADF tests include an intercept. The appropriate lag lengths were selected according to the Schwartz Bayesian Criterion (SBC).

Table A.2. Corn: Granger causality tests of weekly returns in spot and futures markets by 2-year periods, 1994–2009

Lags	H_o: Futures returns do not Granger-cause spot returns							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	10.86***	1.06	5.88**	21.07***	57.32***	47.85***	39.38***	65.85***
2	4.14**	10.58***	3.45**	11.32***	30.74***	25.56***	21.95***	52.94***
3	5.04***	7.04***	2.40*	7.28***	23.05***	19.46***	14.07***	34.31***
4	4.44***	5.65***	1.70	5.49***	17.56***	13.39***	11.03***	27.85***
5	3.71***	5.55***	2.36**	4.24***	14.79***	10.75***	8.78***	22.30***
6	3.40***	4.33***	2.15*	3.89***	13.56***	8.90***	7.45***	18.77***
7	2.60**	4.57***	1.83*	3.98***	11.67***	7.80***	6.82***	15.88***
8	2.33**	4.96***	1.54	3.69***	10.27***	7.09***	6.09***	15.68***
9	2.25**	4.75***	1.48	3.59***	9.82***	6.24***	5.36***	14.90***
10	1.98**	4.66***	1.39	3.23***	9.37***	5.67***	5.01***	13.27***
	H_o: Spot returns do not Granger-cause futures returns							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.80	7.95***	0.90	2.77*	0.66	6.06**	2.05	0.48
2	0.75	3.76**	0.58	1.84	0.01	3.72**	1.43	0.83
3	1.57	3.11**	0.29	2.82**	0.04	3.14**	1.03	0.53
4	1.36	2.32*	0.51	4.15***	0.12	2.32*	0.56	2.00*
5	1.12	2.19*	0.76	3.20***	0.45	2.25*	0.44	1.98*
6	0.77	1.79	0.73	3.50***	0.64	1.72	0.40	1.67
7	0.72	1.35	0.76	3.26***	0.72	1.79*	0.44	1.38
8	0.65	1.38	0.73	2.78***	0.86	1.37	0.40	1.46
9	0.96	0.93	0.91	2.41**	0.76	1.24	0.35	1.29
10	1.03	1.05	0.82	2.14**	1.14	1.29	0.56	1.30

*10%, **5%, ***1% significance. F statistic reported.
Note: The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) suggests a lag structure of 8.

Table A.3. Hard wheat: Granger causality tests of weekly returns in spot and futures markets by 2-year periods, 1998-2009

Lags	H$_o$: Futures returns do not Granger-cause spot returns					
	98–99	00–01	02–03	04–05	06–07	08–09s1
1	63.71***	31.47***	69.23***	30.98***	54.23***	26.03***
2	42.18***	32.67***	40.82***	15.71***	47.27***	20.73***
3	31.91***	21.06***	28.38***	10.18***	32.36***	18.96***
4	25.47***	15.85***	20.70***	7.93***	23.86***	14.97***
5	21.23***	13.62***	17.21***	6.17***	18.63***	11.47***
6	17.02***	10.87***	14.05***	6.71***	15.99***	9.81***
7	15.44***	10.60***	12.47***	6.11***	13.71***	7.72***
8	14.57***	10.59***	11.14***	5.36***	11.96***	7.47***
9	13.19***	9.90***	9.84***	4.55***	10.44***	6.79***
10	12.09***	8.75***	8.65***	4.79***	9.26***	6.11***
	H$_o$: Spot returns do not Granger-cause futures returns					
	98–99	00–01	02–03	04–05	06–07	08–09s1
1	0.13	4.43**	1.20	0.78	0.39	0.51
2	0.10	1.24	0.60	1.41	0.26	0.02
3	1.47	0.47	0.28	0.24	0.35	0.22
4	0.60	0.56	0.06	0.17	0.07	1.22
5	0.74	1.33	0.59	0.26	0.57	1.66
6	0.47	0.53	0.90	1.61	0.38	1.41
7	0.43	0.67	0.67	1.47	0.55	1.16
8	1.11	0.69	0.57	1.47	0.45	1.05
9	0.71	0.73	0.52	1.30	0.53	0.83
10	0.68	0.72	0.52	1.18	0.53	0.83

*10%, **5%, ***1% significance. F statistic reported.
Note: Both the Schwartz Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC) suggest a lag structure of 3.

Table A.4. Soft wheat: Granger causality tests of weekly returns in spot and futures markets by 2-year periods, 1998–2009

Lags	H_o: Futures returns do not Granger-cause spot returns					
	98–99	00–01	02–03	04–05	06–07	08–09s1
1	15.82***	14.19***	48.39***	29.32***	63.17***	16.58***
2	9.10***	9.08***	28.97***	15.77***	38.93***	11.01***
3	6.35***	5.89***	24.90***	10.50***	25.99***	9.24***
4	5.74***	4.59***	19.21***	8.08***	19.36***	7.82***
5	6.14***	3.64***	14.65***	6.92***	15.51***	5.98***
6	5.15***	3.13***	11.89***	6.15***	12.77***	5.15***
7	4.79***	3.12***	10.05***	6.21***	10.98***	4.34***
8	4.14***	2.80***	8.93***	5.31***	9.53***	4.16***
9	3.64***	2.41**	7.86***	5.08***	8.28***	4.20***
10	3.28***	1.92**	7.08***	4.62***	7.33***	3.74***
	H_o: Spot returns do not Granger-cause futures returns					
	98–99	00–01	02–03	04–05	06–07	08–09s1
1	0.00	0.11	0.00	0.11	0.02	0.27
2	0.38	0.70	0.45	0.47	1.98	0.01
3	0.85	0.39	1.38	0.26	2.29*	0.36
4	0.32	0.43	1.48	0.19	1.85	1.48
5	0.37	0.50	1.17	0.56	2.23*	1.60
6	0.52	1.05	1.06	0.85	1.86*	1.47
7	0.44	0.82	0.81	0.86	2.01*	1.09
8	0.49	0.72	1.47	1.15	1.74	0.82
9	0.79	0.97	1.36	1.24	1.52	0.72
10	0.55	0.83	1.37	1.04	1.48	0.80

*10%, **5%, ***1% significance. F statistic reported.

Note: The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) suggests a lag structure of 4.

Table A.5. Soybeans: Granger causality tests of weekly returns in spot and futures markets by 2-year periods, 1994–2009

Lags	H_o: Futures returns do not Granger-cause spot returns							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.01	1.60	0.33	1.29	3.76*	6.62***	0.34	2.42
2	2.42*	1.95	0.58	1.77	2.18	5.52***	0.87	1.73
3	1.77	1.85	0.57	1.71	2.90**	5.86***	0.71	1.43
4	1.31	1.74	0.46	1.21	2.42**	4.88***	0.57	1.01
5	1.12	1.38	2.31*	2.20*	2.53**	4.27***	0.87	0.68
6	1.13	1.13	2.05**	1.92*	2.02*	3.84***	1.26	1.34
7	0.91	1.24	2.08*	1.78*	1.69	3.28***	1.22	1.46
8	0.93	1.27	1.80	1.41	1.99*	3.14***	1.04	1.88*
9	0.79	1.20	1.62	1.24	2.00**	3.54***	0.91	2.00**
10	0.67	1.38	1.40	1.07	1.71*	3.69***	0.91	2.40**
	H_o: Spot returns do not Granger-cause futures returns							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.46	0.04	0.83	0.08	1.03	0.46	4.81**	10.83***
2	2.10	0.12	0.38	0.70	1.06	0.46	2.46*	4.70***
3	1.38	1.07	0.83	0.91	1.54	1.15	1.69	3.88***
4	1.33	1.23	0.71	0.73	1.30	0.84	1.91	3.14**
5	0.99	0.96	1.74	1.27	1.58	0.65	1.88	2.54**
6	1.10	0.82	1.51	1.25	1.31	0.51	2.21**	2.88***
7	0.90	0.67	1.48	1.20	0.99	0.52	2.00*	2.52**
8	1.02	0.63	1.28	1.03	0.94	0.49	1.71	2.86***
9	0.87	0.54	1.09	0.95	1.02	0.53	1.61	2.76***
10	0.73	0.76	0.90	0.85	0.81	0.79	1.76*	2.78***

*10%, **5%, ***1% significance. F statistic reported.

Note: The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 3 while the Akaike Information Criterion (AIC) suggests a lag structure of 5.

Table A.6. Corn: Granger causality tests of weekly returns in spot and futures markets by Farm Bill, 1994–2009

Lags	H_o: Futures returns do not Granger-cause spot returns			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	13.27***	5.74**	133.52***	53.59***
2	5.13***	12.16***	74.61***	49.29***
3	5.09***	7.50***	51.40***	31.40***
4	4.13***	6.32***	39.60***	26.13***
5	3.49***	6.60***	32.40***	19.68***
6	3.27***	5.24***	27.01***	16.86***
7	2.42**	4.67***	23.90***	14.30***
8	2.11**	4.65***	21.00***	13.68***
9	2.03**	4.39***	18.48***	13.92***
10	1.77*	3.93***	16.31***	12.71***
	H_o: Spot returns do not Granger-cause futures returns			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	1.83	11.25***	0.01	0.42
2	1.39	4.77***	1.47	1.37
3	1.82	3.60***	1.25	0.59
4	1.37	3.46***	0.68	2.12*
5	1.06	2.90***	1.08	1.12
6	0.84	2.33**	1.16	0.91
7	0.80	2.56***	1.16	0.79
8	0.75	2.61***	0.99	0.94
9	1.27	2.07**	0.90	0.92
10	1.18	1.93**	0.85	0.74

*10%, **5%, ***1% significance. F statistic reported.
Note: The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) structure of 8. The 1990 Farm Bill corresponds to the sample period
01/07/94 – 04/03/96; the 1996 Farm Bill to the sample period
04/04/96 – 05/12/02; the 2002 Farm Bill to the sample period
05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Table A.7. Hard wheat: Granger causality tests of weekly returns in spot and futures markets by Farm Bill, 1998–2009

Lags	H_o: Futures returns do not Granger-cause spot returns		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	97.83***	121.18***	31.97***
2	77.08***	83.08***	26.39***
3	54.29***	58.71***	20.93***
4	42.47***	43.92***	23.27***
5	36.06***	34.80***	18.94***
6	29.84***	28.86***	14.33***
7	27.93***	24.64***	11.10***
8	25.78***	21.65***	11.37***
9	23.49***	19.42***	14.66***
10	20.92***	18.54***	12.48***
	H_o: Spot returns do not Granger-cause futures returns		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	1.60	2.53	0.85
2	0.62	0.76	2.08
3	0.94	0.46	1.25
4	0.54	0.52	3.17**
5	0.73	0.56	2.80**
6	0.45	0.42	2.40**
7	0.43	0.71	2.23**
8	0.54	0.56	2.59**
9	0.39	0.71	2.38**
10	0.41	1.06	2.03*

*10%, **5%, ***1% significance. F statistic reported.
Note: Both the Schwartz Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC) suggest a lag structure of 3. The 1996 Farm Bill corresponds to the sample period 01/02/98 –05/12/02; the 2002 Farm Bill to the sample period 05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 –06/26/09.

Table A.8. Soft wheat: Granger causality tests of weekly returns in spot and futures markets by Farm Bill, 1998–2009

Lags	H_o: Futures returns do not Granger-cause spot returns		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	33.98***	103.52***	21.63***
2	20.91***	63.78***	16.79***
3	14.55***	43.93***	12.25***
4	11.07***	33.65***	14.57***
5	9.53***	26.90***	10.69***
6	8.05***	22.34***	9.20***
7	7.87***	19.34***	6.95***
8	7.21***	17.52***	6.35***
9	6.33***	15.60***	7.67***
10	5.38***	14.39***	6.57***
	H_o: Spot returns do not Granger-cause futures returns		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.15	0.01	2.11
2	0.53	1.50	1.16
3	0.08	0.91	0.95
4	0.31	1.09	3.35**
5	0.33	0.99	2.62**
6	0.65	1.04	2.37**
7	0.59	1.22	2.00*
8	0.51	1.08	1.83*
9	1.20	0.98	2.07*
10	0.95	0.91	2.25**

*10%, **5%, ***1% significance. F statistic reported.

Note: The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) suggests a lag structure of 4. The 1996 Farm Bill corresponds to the sample period 01/02/98 – 05/12/02; the 2002 Farm Bill to the sample period 05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Table A.9. Soybeans: Granger causality tests of weekly returns in spot and futures markets by Farm Bill, 1994–2009

Lags	H_o: Futures returns do not Granger-cause spot returns			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.03	3.07*	13.08***	2.67
2	2.41*	4.12**	12.05***	2.20
3	1.77	3.96***	12.58***	1.69
4	1.31	3.34***	10.53***	1.15
5	1.07	3.65***	9.37***	0.91
6	1.20	3.02***	8.19***	0.99
7	0.97	3.11***	7.35***	1.02
8	0.94	2.82***	6.93***	1.27
9	0.79	2.91***	6.83***	1.25
10	0.66	2.78***	6.87***	1.47
	H_o: Spot returns do not Granger-cause futures returns			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.06	0.16	0.03	9.29***
2	1.39	0.14	0.51	3.93**
3	0.89	2.07	1.45	3.54**
4	1.02	1.97	1.09	2.66**
5	0.77	2.06*	0.87	2.25*
6	1.08	1.67	0.75	2.15*
7	0.89	1.63	0.72	1.97*
8	0.98	1.41	0.74	2.24**
9	0.88	1.20	0.77	2.00*
10	0.73	1.26	0.97	2.10**

*10%, **5%, ***1% significance. F statistic reported.
Note: The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 3 while the Akaike Information Criterion (AIC) suggests a lag structure of 5. The 1990 Farm Bill corresponds to the sample period 01/07/94 –04/03/96; the 1996 Farm Bill to the sample period 04/04/96 – 05/12/02; the 2002 Farm Bill to the sample period 05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Table A.10. Corn: Granger causality tests of weekly volatility in spot and futures markets by 2-year periods, 1994–2009

Lags	H_o: Futures volatility do not Granger-cause spot volatility							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	10.72***	2.86*	0.01	0.98	20.62***	6.47***	17.63***	21.35***
2	6.06***	6.65***	3.15**	0.66	10.00***	4.28**	9.35***	11.15***
3	4.60***	4.93***	1.98	0.91	7.09***	3.4**	6.61***	7.30***
4	2.64**	3.94***	1.52	0.71	7.09***	2.30*	5.57***	5.60***
5	1.99*	2.93**	1.33	0.94	5.96***	2.19*	4.62***	3.70***
6	1.42	3.97***	1.10	0.79	4.34***	3.40***	4.47***	3.87***
7	1.33	3.54***	1.43	0.73	3.71***	3.29***	3.75***	3.26***
8	1.26	4.25***	1.37	0.71	3.28***	2.79***	3.45***	3.48***
9	1.20	4.10***	1.32	1.01	2.53***	2.52***	3.05***	3.60***
10	1.11	4.28***	1.20	1.03	2.77***	2.24**	3.66***	3.11***
	H_o: Spot volatility do not Granger-cause futures volatility							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	1.09	1.29	7.61***	0.28	1.12	0.37	0.46	0.35
2	2.55*	0.75	3.31**	0.18	0.04	0.39	0.30	0.25
3	4.36***	1.09	1.88	0.62	0.13	0.46	0.45	0.42
4	4.70***	0.84	2.48**	1.02	0.22	0.23	0.24	1.79
5	3.56***	0.75	2.52**	0.83	0.10	0.24	0.22	1.63
6	3.10***	0.92	2.66**	0.82	0.14	0.28	0.35	1.58
7	2.46**	1.33	2.36**	0.89	0.72	0.25	0.28	1.78
8	2.05**	1.38	2.03**	0.88	1.05	0.35	0.22	1.78*
9	1.97**	1.34	1.71*	1.02	1.00	0.77	0.31	1.78*
10	2.08**	1.33	1.52	0.89	1.05	0.74	0.36	1.51

*10%, **5%, ***1% significance. F statistic reported.
Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) suggests a lag structure of 10.

Table A.11. Hard wheat: Granger causality tests of weekly volatility in spot and futures markets by 2-year periods, 1998–2009

Lags	H_o: Futures volatility do not Granger-cause spot volatility					
	98-99	00-01	02-03	04-05	06-07	08-09s1
1	6.00**	0.78	22.53***	0.02	9.37***	0.29
2	2.98*	0.81	13.79***	0.07	6.66***	2.01
3	2.13*	1.85	8.93***	0.13	4.83***	2.92**
4	2.04*	1.98*	7.23***	1.49	3.72***	2.12*
5	3.89***	1.57	6.09***	1.27	3.51***	1.64
6	3.37***	1.65	4.92***	1.09	2.97***	1.35
7	2.68***	1.54	3.81***	0.95	2.42**	0.95
8	2.44**	1.32	3.29***	0.77	2.13**	1.15
9	2.26**	1.28	2.49***	1.06	2.29**	1.10
10	1.96**	1.17	2.51***	1.08	2.09**	1.51
	H_o: Spot volatility do not Granger-cause futures volatility					
	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.17	0.85	0.15	0.13	1.45	0.14
2	0.11	0.50	0.15	0.08	1.03	0.21
3	0.70	0.47	1.93	0.09	5.02***	1.63
4	0.63	0.60	2.55**	0.40	3.04**	2.02*
5	0.52	0.47	2.97**	0.84	3.00***	1.62
6	0.96	0.88	2.44**	0.69	2.78**	1.38
7	0.74	0.96	2.17**	1.09	2.67***	1.33
8	0.64	0.66	3.30***	0.96	2.57***	1.12
9	0.66	0.79	2.47***	0.76	2.70***	1.02
10	0.58	0.78	2.50***	0.70	2.68***	1.46

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 1 while the Akaike Information Criterion (AIC) suggests a lag structure of 10.

Table A.12. Soft wheat: Granger causality tests of weekly volatility in spot and futures markets by 2-year periods, 1998–2009

Lags	H$_o$: Futures volatility do not Granger-cause spot volatility					
	98-99	00-01	02-03	04-05	06-07	08-09s1
1	3.81**	6.73***	6.02**	2.15	3.93**	0.19
2	2.01	4.66***	3.07**	0.88	2.28	0.43
3	1.39	3.80***	2.38*	1.07	1.62	0.42
4	0.97	2.93**	1.80	2.65**	1.30	0.32
5	2.40**	2.17*	1.78	1.94*	1.01	0.44
6	2.05*	1.86*	1.47	1.76	0.83	0.81
7	1.74	1.38	1.27	1.60	0.80	1.35
8	1.39	1.30	1.17	1.29	0.83	1.47
9	1.22	1.61	1.07	1.25	1.31	1.58
10	1.11	1.52	0.89	1.60	1.33	1.78*
	H$_o$: Spot volatility do not Granger-cause futures volatility					
	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.00	0.14	1.13	3.54*	1.06	1.24
2	0.60	0.43	0.40	1.75	0.78	0.61
3	0.75	0.56	0.50	1.15	1.34	0.58
4	0.62	0.97	0.48	0.90	0.79	1.18
5	0.62	1.21	0.41	1.55	0.65	0.86
6	0.71	0.99	0.68	1.28	0.54	0.77
7	0.78	0.84	0.52	1.14	0.47	0.80
8	0.83	0.89	0.71	1.12	0.44	0.96
9	1.42	0.78	0.91	1.01	0.45	0.89
10	1.30	0.69	0.69	1.12	0.42	1.29

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 1 while the Akaike Information Criterion (AIC) suggests a lag structure of 2.

Table A.13. Soybeans: Granger causality tests of weekly volatility in spot and futures markets by 2-year periods, 1994–2009

Lags	H$_o$: Futures volatility do not Granger-cause spot volatility							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.66	5.27**	1.15	6.88***	0.03	5.66**	0.03	0.29
2	3.00**	5.91***	1.96	5.63***	1.27	4.66***	0.19	0.65
3	1.91	4.09***	1.24	4.74***	1.24	4.43***	0.39	0.38
4	2.79**	2.79**	1.27	3.49***	0.70	3.28***	0.55	0.26
5	2.56**	2.31**	1.17	3.53***	0.42	3.58***	0.43	0.26
6	2.22**	4.39***	1.10	2.84***	0.35	2.93***	0.39	0.27
7	1.91*	3.78***	0.97	2.80***	0.66	2.51**	0.41	0.23
8	1.71	3.28***	1.25	2.42**	1.08	2.25**	0.34	0.19
9	1.48	2.84***	1.12	2.28**	0.92	2.98***	0.31	0.28
10	1.29	2.89***	0.96	2.10**	0.87	3.84***	0.34	0.30
	H$_o$: Spot volatility do not Granger-cause futures volatility							
	94-95	96-97	98-99	00-01	02-03	04-05	06-07	08-09s1
1	0.01	0.51	0.22	1.64	0.38	0.13	0.52	0.18
2	4.90***	0.68	0.72	1.30	1.71	0.40	0.30	0.07
3	3.18**	0.34	0.42	1.80	1.21	0.23	0.49	0.39
4	3.55***	1.05	0.43	1.42	1.16	0.24	0.59	0.38
5	3.37***	0.82	0.46	1.47	1.08	0.46	0.70	0.30
6	3.21***	0.85	0.39	1.18	0.96	0.48	0.64	0.44
7	2.77***	0.80	0.33	1.57	1.11	0.51	0.56	0.38
8	2.39**	0.85	0.58	1.46	1.07	0.56	0.61	0.33
9	2.03**	0.82	0.62	1.51	0.96	1.00	0.54	0.51
10	1.75*	0.78	0.73	1.30	0.95	0.97	0.51	0.48

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion(AIC) suggests a lag structure of 5.

Table A.14. Corn: Granger causality tests of weekly volatility in spot and futures markets by Farm Bill, 1994–2009

Lags	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
	H_o: Futures returns do not Granger-cause spot returns			
1	8.47***	5.58**	44.60***	16.94***
2	4.89***	8.73***	23.17***	9.22***
3	3.93***	6.15***	15.30***	5.89***
4	2.32*	4.50***	12.18***	4.47***
5	1.75	3.45***	10.48***	3.17**
6	1.34	4.38***	10.30***	3.10***
7	1.15	3.75***	8.95***	2.85**
8	1.04	3.52***	7.79***	3.01***
9	1.05	3.30***	6.87***	2.84***
10	1.13	3.39***	7.76***	2.49**
	H_o: Spot returns do not Granger-cause futures returns			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	1.85	1.01	0.13	0.00
2	2.76*	0.36	0.30	0.08
3	3.76***	0.22	0.15	0.68
4	3.97***	1.46	0.13	1.19
5	2.99***	1.12	0.14	1.33
6	2.48**	1.39	0.23	1.20
7	2.20**	1.47	0.25	1.06
8	1.95*	1.31	0.33	1.06
9	1.86*	1.18	0.78	1.17
10	2.04**	1.03	0.87	0.97

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) suggests a lag structure of 10. The 1990 Farm Bill corresponds to the sample period 01/07/94 – 04/03/96; the 1996 Farm Bill to the sample period 04/04/96 – 05/12/02; the 2002 Farm Bill to the sample period 05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Table A.15. Hard wheat: Granger causality tests of weekly volatility in spot and futures markets by Farm Bill, 1998–2009

Lags	H_o: Futures volatility do not Granger-cause spot volatility		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	6.14***	16.55***	1.51
2	3.21**	13.96***	0.78
3	2.71**	11.47***	0.51
4	2.68**	8.18***	0.74
5	3.59***	6.41***	0.68
6	3.03***	5.55***	0.63
7	2.77***	4.22***	0.62
8	2.48***	4.00***	0.71
9	2.42***	3.53***	0.74
10	2.13**	3.40***	1.51
	H_o: Spot returns do not Granger-cause futures returns		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.31	2.22	0.11
2	0.58	1.30	0.19
3	0.74	8.63***	0.21
4	0.93	7.13***	0.24
5	0.88	7.25***	0.61
6	1.10	6.19***	0.54
7	1.03	5.36***	0.49
8	1.05	4.77***	0.42
9	1.13	4.18***	0.4
10	1.10	4.31***	1.07

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 1 while the AkaikeInformation Criterion (AIC) suggests a lag structure of 10. The1996 Farm Bill corresponds to the sample period 01/02/98 –05/12/02; the 2002 Farm Bill to the sample period 05/13/02 –06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Table A.16. Soft wheat: Granger causality tests of weekly volatility in spot and futures markets by Farm Bill, 1998–2009

Lags	H_o: Futures volatility do not Granger-cause spot volatility		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	10.58***	3.19*	0.39
2	5.84***	1.12	0.22
3	5.12***	0.86	0.15
4	3.70***	0.60	0.79
5	3.64***	0.57	1.36
6	3.27***	0.84	1.19
7	2.63***	0.81	1.28
8	2.41**	0.83	1.61
9	2.22**	0.77	1.45
10	1.88**	0.72	1.59
	H_o: Spot returns do not Granger-cause futures returns		
	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.07	10.52***	0.45
2	1.00	6.07***	0.34
3	0.91	5.70***	0.23
4	0.97	4.66***	0.16
5	0.92	3.91***	0.14
6	1.30	3.25***	0.36
7	1.38	2.89***	0.33
8	1.26	2.52***	0.27
9	1.50	2.11**	0.39
10	1.40	2.03**	0.95

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 1 while the Akaike Information Criterion (AIC) suggests a lag structure of 2. The 1996 Farm Bill corresponds to the sample period 01/02/98 – 05/12/02; the 2002 Farm Bill to the sample period 05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Table A.17. Soybeans: Granger causality tests of weekly returns in spot and futures markets by Farm Bill, 1994–2009

Lags	H_o: Futures volatility do not Granger-cause spot volatility			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.65	1.19	4.48**	0.05
2	2.31*	0.73	5.96***	1.72
3	1.48	0.75	4.95***	1.15
4	2.16*	0.51	4.00***	0.89
5	1.95*	0.56	3.65***	0.69
6	1.69	1.28	3.01***	0.78
7	1.45	1.44	2.58***	0.75
8	1.36	1.39	2.52***	0.67
9	1.17	1.32	2.71***	0.70
10	1.00	1.44	3.32***	0.66
	H_o: Spot volatility do not Granger-cause futures volatility			
	90 Farm Bill	96 Farm Bill	02 Farm Bill	08 Farm Bill
1	0.00	0.05	0.00	1.88
2	4.21**	2.45*	0.12	1.70
3	2.80**	1.85	0.05	2.20*
4	3.16**	1.40	0.09	1.64
5	2.83**	1.13	0.37	1.28
6	2.73**	1.01	0.41	1.41
7	2.33**	1.09	0.50	1.48
8	2.10**	1.30	0.61	1.28
9	1.87*	1.18	1.73*	1.33
10	1.61	1.32	1.56	1.38

*10%, **5%, ***1% significance. F statistic reported.

Note: Volatility measured as absolute deviations of weekly spot and futures returns from the sample average. The Schwartz Bayesian Criterion (SBC) suggests a lag structure of 2 while the Akaike Information Criterion (AIC) suggests a lag structure of 5. The 1990 Farm Bill corresponds to the sample period 01/07/94 – 04/03/96; the 1996 Farm Bill to the sample period 04/04/96 – 05/12/02; the 2002 Farm Bill to the sample period 05/13/02 – 06/17/08; and the 2008 Farm Bill to the sample period 06/18/08 – 06/26/09.

Management of rice reserve stocks in Asia: Analytical issues and country experience

C. Peter Timmer[1]

[1] Revised paper prepared for an FAO expert workshop on Institutions and Policies to Manage Global Market Risks and Price Spikes in Basic Food Commodities, Rome, 26-27 October 2009. I thank the workshop participants for a lively discussion and helpful comments. The author is Thomas D. Cabot Professor of Development Studies, emeritus, Harvard University. Contact at ptimmer63@gmail.com.

1. INTRODUCTION

Is there some way that the major Asian rice producing and consuming countries could manage their rice buffer stocks so that both national and global food security would improve? The recent experience with the 2007–08 world food crisis, where several Asian countries were seen to behave 'irresponsibly' with respect to keeping domestic rice reserves entirely for domestic consumers, makes the question directly relevant. Without questioning the right of sovereign countries to manage their food reserves any way they want, the question remains: is there any incentive system the international community could put in place that would lead to a better outcome in terms of food security for both the nations involved and globally?

To answer this question, it is necessary to understand the role of national grain reserves in both national and global food security. The grain reserves of Malaysia do not matter (except to Malaysia); it is a small country in world food markets. But the grain reserves, especially rice reserves, of China, India, Indonesia, Bangladesh, Thailand, and perhaps the Philippines and Viet Nam do matter, because they are big players in the world rice market. Their *national* decisions about rice reserves affect *global* food security.

This is not an easy question to answer, but it is crucial to lay out the basic issues that need to be addressed in order to answer it. If, for example, a modest set of incentive payments from the international community could alter the size and management of rice reserve stocks in the large Asian countries in an appropriate manner, the probability of a future world food crisis might be sharply reduced. That is clearly a goal worth pursuing.

This paper addresses the management of Asian rice reserves from three perspectives. First, following the analysis of Timmer and Dawe (2007), the basic benefits and costs of stabilizing rice prices in the large Asian countries are reviewed. Second, following Timmer (1995b), the Indonesian experience with managing domestic rice reserves on behalf of food security is reviewed in some detail, as careful analytical input went into the design and implementation of Indonesia's approach to using buffer stocks as the main 'balance wheel' for rice price stabilization after the country reached rice self-sufficiency in the mid-1980s. Third, recent country experiences with rice reserve levels are presented to compare national practices from the point of view of both domestic and global food security. Finally, some observations on how large Asian countries *should* manage their rice reserves are offered, including a potential role for donor coordination and financing.

2. RICE PRICE STABILIZATION: OBJECTIVES AND INSTRUMENTS

At first glance, food security strategies in Asia would seem to have been little influenced by economics. The dominance of rice in the diets of most Asians, coupled to the extreme price instability in the world market for rice, forced all Asian countries to buffer their domestic rice price from the world price. This clear violation of the border price paradigm, and the accompanying restrictions on openness to trade, seems to have escaped many advocates of the East Asian miracle, who saw the region's rapid growth as evidence in support of free trade (World Bank, 1993; Sharma and Morrison, 2009).

In fact, the Asian countries that have been most successful at providing food security to their citizens have based their strategies on two elements of their domestic food system over which they have some degree of policy control: the sectoral composition of income growth, and stability of food prices. Much has been written recently about the sectoral dimensions of pro-poor growth (Timmer, 2005a), but the role of stable food prices in food security has been largely ignored by the development profession. The world food crisis of 2007/08 provides motivation for putting food price stability back on the research and policy agenda.

2.1 Food security: Market outcomes or government action?

The modern escape from hunger to food security would not have been possible without the institutional and technological innovations that are at the heart of modern economic growth (Kuznets, 1966). However, the record of economic growth for the developing countries since the 1950s shows that even in countries with relatively low levels of per capita income, government interventions to enhance food security can lift the threat of hunger and famine. The countries most successful at this task are in East and Southeast Asia, although the experience in South Asia has been instructive as well (Timmer, 2000).

Because they are poor and devote a high share of their budget to food, consumers in poor countries are exposed to continued hunger and vulnerability to shocks that set off famines (Anderson and Roumasset, 1996). Still, several poor countries have taken public action to improve their food security. The typical approach reduces the numbers of the population facing daily hunger by raising the incomes of the poor, while simultaneously managing the food economy in ways that minimize the shocks that might trigger a famine, shocks that are usually felt via rapidly rising food prices. These countries, some of them quite poor, have managed the same 'escape from hunger' that Fogel (1991) documents for Europe during the nineteenth and early twentieth centuries. Stabilizing domestic food prices was a key part of their strategy.

In particular, Asian governments sought to stabilize rice prices. Engel's Law ensures that success in generating rapid economic growth that includes the poor is the long-run solution to food security. In the language of Dreze and Sen (1989), such economic growth provides 'growth-mediated security'. In the meantime, stabilization of food prices in Asia ensured that short-run fluctuations and shocks did not make the poor even more vulnerable to inadequate food intake than their low incomes required (Timmer, 1991a, 1996).

Most economists are highly dubious that such food price stability is financially feasible or economically desirable. This attitude was clearly expressed by Kym Anderson at the World Bank workshop on managing price instability in March, 2005, when he argued that "price instability is your friend." Price stabilization is not a key element of the 'support-led security' measures outlined by Dreze and Sen (1989). In a review of food security and the stochastic aspects of poverty, Anderson and Roumasset (1996, p. 62) essentially dismiss efforts to stabilize food prices using government interventions:

> Given the high costs of national price stabilization schemes (Newbery and Stiglitz, 1979, 1981; Behrman, 1984; Williams and Wright, 1991) and their effectiveness in stabilizing prices in rural areas, alternative policies decreasing local price instability need to be considered. The most cost-effective method for increasing price stability probably is to remove destabilizing government distortions. Government efforts to nationalize grain markets and to regulate prices across both space and time have the effect of eliminating the private marketing and storage sector. Rather than replacing private marketing, government efforts should be aimed at enhancing private markets through improving transportation, enforcing standards and measures in grain transactions, and implementing small-scale storage technology.

Although this condemnation of national price stabilization schemes might well be appropriate for much of the developing world, it badly misinterprets both the design and implementation of interventions to stabilize rice prices in East and Southeast Asia (Dawe, 2001; Timmer, 1991a, 1993, 1996, 2003; Timmer and Dawe, 2007). Several Asian countries have stabilized domestic rice prices while allowing the private sector to procure and distribute 95 percent of the crop. The growth benefits of Indonesia's rice price stabilization program easily exceeded the costs (Timmer, 1996, 2002). For food security in this region, the stabilization of domestic rice prices was in fact feasible in the context of an expanding role for an efficient private marketing sector. The resulting stability was not an impediment, but was actually conducive to economic growth. The stabilization scheme and economic growth worked in tandem to achieve food security as quickly as possible.

2.2 Economic case for rice price stabilization

Rice typically accounts for half the income of farm households that produce rice. On the consumption side (rural landless, farm households that grow other crops such as maize, urban poor), rice often accounts for 25–40 percent of household expenditures (Dawe, 2000). Therefore, changes in rice prices cause large changes in the purchasing power of the poor, some positive and some negative. All government leaders recognize these impacts, and most Asian countries have felt the need to stabilize their rice economies and lend some stability to the lives of the poor by keeping domestic rice prices more stable than border prices.

From 1970 to 1995, Indonesia managed this stabilization process while not deviating far from the long-run trend of prices in the world market (see below, and Timmer, 1996). During the financial crisis in 1998, the country lost control of rice prices, with dramatic impact on the poor: some of the poor gained, whereas many more lost. Based on econometric analysis of Indonesia's experience between 1978 and 2002, the elasticity of poverty incidence with respect to changes in the real rice price, controlling for economic growth, is between 0.32 and 0.45 (Timmer, 2006). This elasticity can be interpreted in two ways: in terms of levels and in terms of stability. The levels interpretation is obvious: higher rice prices increase poverty on net. However, the net effect, large as it is, masks even larger underlying effects: an increase in rice prices pushes some farmers above the poverty line, at the same time that it pushes even larger numbers of others below. This econometric result was confirmed dramatically in an 'out of sample' experiment: between early 2005 and early 2006 rice prices in Indonesia rose by more than 40 percent because of a government ban on rice imports. The result, which clearly stunned the government, was that the number of people below the poverty line increased by 4 million, even though economic growth for the year was nearly 6 percent (World Bank, 2006).

Therefore, in the short run, rice price fluctuations have large effects on poverty. Any government concerned about poverty needs to stabilize rice prices as well as connect the poor to rapid economic growth (or at least stop de-stabilizing rice prices). In the long run, however, the impact of stabilizing rice prices can be complicated and perverse.

For example, by implementing a simple policy objective of stabilizing the real domestic price of rice – the operational definition of food security in these societies – most Asian countries saw the level of protection of their rice farmers rise sharply from the 1970s to the mid-1990s (Timmer, 1993). Much of this divergence, however, was not a result of a conscious policy of raising the real price of rice domestically, but because the world price of rice has declined almost continuously since the mid-1970s. Most of these economies also had appreciating currencies relative to the US dollar, the currency in which world rice prices are quoted. Timmer (1993) found that for Japan, South Korea, Malaysia, the Philippines and Indonesia, changes in real domestic rice prices accounted for just 13 percent of changes in the nominal protection coefficient (NPC) on average, with 86 percent of changes in the NPC being a result of changes in the world price of rice or the real exchange rate.

The high levels of agricultural protection, and the failure to diversify and modernize their agricultural sectors, were largely unanticipated side-effects from the strategy of growth with stability. Efforts to reduce these high levels of agricultural protection, especially for rice farmers, by directly confronting the political forces defending this 'Asian' approach to food security have been repeatedly rebuffed since the 1980s. Because of this history, the special role of rice in Asian societies has powerfully influenced economics and politics throughout much of Asia. The influence is manifested in three ways:

First, rice is one of the most important commodities in Asia, especially in poor countries. It accounts for more than 70 percent of total caloric intake for the average citizen in Myanmar and Bangladesh, and it accounts for nearly two-thirds in Viet Nam. Even in relatively wealthier countries such as Thailand and Indonesia, it still accounts for nearly 50 percent of caloric intake (FAO, 2006). Rice eaters comprise the bulk of the world's poor: according to the *Human Development Report* (UNDP, 2003), approximately 70 percent of the world's 1.3 billion poor people live in Asia, where rice is the staple food.

Second, rice is grown predominately by small holders who have been adept at adopting new technologies when market signals were favourable. In many countries, rice farming is the modal occupation, and rice farmers are the single largest identifiable voting group.

Third, international rice markets have been historically thin and unstable, causing all Asian countries to buffer their own farmers and consumers from fluctuating world prices (and, therefore, making the fluctuations worse in an even thinner market). This buffering requires that governments actively control the flow of rice across their borders, and, hence, a policy of stabilizing rice prices directly contradicts free trade. The case for such stabilization has been made in the published literature, but it has not become part of mainstream development thinking. It is worth restating the case briefly.

Following Timmer (1989), the benefits of stabilizing staple food prices can be divided into three categories: microeconomic benefits for consumers, microeconomic benefits for producers and macroeconomic benefits to the entire economy.

Benefits for poor consumers. Rice is a major share of expenditures for the poor in Asia. For example, rice accounts for nearly 40 percent of expenditures for the poorest three-fifths of the urban population in Bangladesh (Bangladesh Bureau of Statistics, 1998). Therefore, poor consumers (including some farmers who are net grain purchasers at certain times of year) benefit from stable domestic rice prices because their low incomes are protected from periods of abnormally high rice prices. In the absence of stabilization, sharp price increases can cause famine for those who are not wealthy enough to afford the higher prices, or, at a minimum, significant hardship. Even if rice consumption is not reduced in response to higher prices, income effects will cause reduced intake of other foods high in protein, vitamins, and minerals such as meats, dairy products and vegetables. Even temporary reductions in the intake of these foods can cause problems (e.g. stunting and anemia) that have permanent effects, especially for young children and pregnant women (Block *et al*., 2004). Therefore, rice price stabilization can serve as a key component of a social safety net program by preventing sharp price fluctuations, instead of merely reacting to price increases when they occur with the hasty implementation of food distribution programs.

In addition to the direct welfare implications of volatile prices, there might also be adverse consequences for labor productivity. This is analogous to the efficiency wage argument, which says that higher wages might result in higher productivity (and higher profits for employers) if the higher wages induce improved patterns of food consumption (Strauss and Thomas, 1998). Note, however, that the efficiency wage argument typically refers to steady-state conditions of chronic poverty, whereas the stabilization argument refers to periods of transitorily high food prices.

Benefits for producers. Farmers also benefit from stable rice prices because they are protected from periods of abnormally low prices. Because many farmers are poor, this is to some extent an issue of equity, as is the case with consumers. In addition, however, price stabilization can enhance efficiency in the farm sector. To understand the efficiency effects, one must view the farmer as an investor in an uncertain biophysical environment where risk markets are imperfect and cannot guarantee access to credit when needed (Timmer, 1989). Were credit markets more reliable, farmers would be more likely to increase productive investment, especially investment with long gestation periods.

One response of many governments is to remedy this lack of credit by intervening directly to supply more. This often takes the form of subsidized credit, loan targeting, or a variety of other measures. The problems with such strategies have been well recognized for some time (Von Pischke *et al.,* 1983). They include, among others, reduced savings mobilization as a result of negative real interest rates, increased rent seeking behaviour as a result of the fact that not everyone is able to gain access to the subsidized interest rates, and decreased efficiency of financial intermediation as a result of the numerous bureaucratic requirements of loan targeting.

Price stabilization attacks this problem from a different direction. Instead of increasing the supply of credit to rice farmers, price stabilization reduces their demand for credit by protecting them from periods of very low prices that could cause cash flow problems. This approach avoids the large costs and inefficiencies associated with subsidized credit programs, although it does not eliminate the desirability of a well-functioning rural financial system in the long run, especially one that is connected to urban financial systems.

Benefits for the macroeconomy. Aside from the microeconomic benefits discussed above, there are also likely to be significant macroeconomic benefits in terms of investment and growth, especially in poor countries where rice makes up an important share of economic output. For example, the value of rice production was 31.5 percent of total income for Viet Nam in 1992–1993 (Minot and Goletti, 1998). In Bangladesh, the value of domestic rice production in 1997 was 27 percent of GDP.

To understand these macroeconomic effects, consider what happens in a closed economy when the price of rice changes in response to either a good or a bad harvest. If the harvest is poor (good), expenditures on rice will increase (decrease) because demand for staple foods is price inelastic, and there will be less (more) money available for spending on other goods and services in the economy. These fluctuations in nominal income available for spending elsewhere in the economy (spillovers) will affect prices and quantities in all other sectors of the economy by shifting demand curves in these sectors. In an open economy context, changes in world prices under free trade will have the same effect as fluctuations in the domestic harvest in a closed economy.

These spillovers and their macroeconomic consequences will be large only if the price elasticity of demand is low (in absolute value) and the budget share of the commodity is large for most consumers, conditions that are jointly satisfied only for staple foods in low-income countries. Moreover, these spillovers will have effects on efficiency, investment, and growth only in the presence of market failures. A discussion of these market failures provides a microeconomic foundation for the macroeconomic consequences.

One common market failure is imperfect credit markets. In such situations, and if marginal utility is strictly convex so that the marginal disutility of losses in consumption is greater near subsistence than in times of abundance, there will be a precautionary motive for savings (Deaton, 1989). If precautionary savings are important, a reduction in uncertainty as a result of rice price stabilization might decrease the amount of savings. However, to perform their function, precautionary savings must be relatively liquid. In the absence of highly efficient systems of financial intermediation, these savings are not easily channeled to finance investment in other sectors of the economy. Therefore, even if rice price stabilization were to reduce savings by reducing uncertainty, the supply of savings that is available for productive investment might increase because savings could be held in less liquid form.

Another common market failure is partially irreversible investment due to firm-specific capital. McDonald and Siegel (1986) show that, in the presence of uncertainty, firms will value the option of 'waiting to invest' in a way similar to the way investors value a call option in the stock market. In the words of Pindyck (1988):

> … when investment is irreversible and future demand or cost conditions are uncertain, an investment expenditure involves the exercising, or 'killing,' of an option – the option to productively invest at any time in the future. One gives up the possibility of waiting for new information that might affect the desirability or timing of the expenditure; one cannot disinvest should market conditions change adversely. This lost option value must be included as part of the cost of the investment.

Dixit and Pindyck (1994) show that, in the case of industry-wide uncertainty, the option value to waiting for individual firms disappears, but that increased uncertainty still depresses investment by raising the threshold price that justifies investment above the Marshallian long-run average cost. All these results hold even if firms are risk neutral. Therefore, spillovers from rice price instability into the rest of the economy can affect investment in many other sectors when there are sunk costs to investing.

Finally, the signals provided by market prices in all sectors of the economy will be weakened by spillovers caused by transitory price instability under conditions of imperfect information. This was first shown by Lucas (1972, 1973) in his analysis of the signal extraction problems created by highly variable inflation. Price changes in non-rice sectors of the economy can be either 'permanent' (i.e. resulting from shifts in technology and preferences) or temporary (e.g. resulting from spillovers from the rice sector). If all price changes for non-rice commodities were a result of shifts in the fundamental technology and preferences underlying the economy, these price changes would represent useful information. Where rice is a large share of the economy, however, price changes for non-rice commodities will often be caused by fluctuating rice expenditures as a result of temporary weather shocks. Economic agents are aware of these influences, but because changes in rice expenditures will affect demand in other sectors with long and variable lags that are difficult to model or predict, a signal extraction problem arises. There will be confusion about whether observed price signals represent shifts in technology and preferences that should influence long-term decisions or whether they are simply the result of transitory forces whose influence will disappear shortly. The consequence of this reduced information flow is that investment funds will not be directed to the sectors of the economy where future returns at the margin are greatest. The quality of investment, as measured by the real rate of return, will decline, with a negative effect on economic growth. This is consistent with the results in Dawe (1996), who finds that instability in export earnings has a large negative effect on the efficiency of investment.

The macroeconomic benefits described in this section can be quantitatively significant. Timmer (2002) determines that rice price stabilization added 0.5–1.0 percentage point of growth in GDP per year to the Indonesian economy in the 1970s when rice was still a large share of the economy and the world rice market was particularly unstable. Timmer's estimates are consistent with the work of Rodrik (1999), who stresses the importance of macroeconomic stability for investment and growth. The major argument in Dawe (2001) is that food (rice) price stability is a key ingredient of macro stability in Asia. Therefore, food price stabilization, as a policy measure, can bring about and sustain stable conditions for private investment and growth. Although they invoke wage and price rigidities that are not discussed here, Newbery and Stiglitz (1981, p. 441) also conclude from their analysis that: "there are some significant macroeconomic benefits that might be derived from price stabilization".

It is important to recognize that the benefits from stabilizing rice prices accrue to the citizens and economy of the country where prices are stable. There may be modest positive international spillovers from more rapid economic growth and greater trade activity, but most of the benefits are domestic. However, when trade policy is used to stabilize domestic prices of rice, many of the costs are incurred by the international rice market in the form of greater price volatility. This is obviously an attractive deal for domestic policy-makers. Still, the instability in the international rice market does feed back to these domestic policy-makers, usually by encouraging them to seek greater degrees of rice self-sufficiency in order to avoid interacting with the world market at all.

3. ROLE OF RICE RESERVE STOCKS IN PRICE STABILIZATION: INDONESIA'S SEARCH FOR FOOD SECURITY IN HISTORICAL AND REGIONAL PERSPECTIVE[2]

Food security as a political concept requires an operational definition. In most Asian countries this has taken the form of domestic price stability relative to world prices, thus requiring state control over trade flows in rice. In order to minimize the need to resort to trade at all, and to avoid the uncertainties in the international price of rice, self-sufficiency has also become a popular objective, the more so as countries become rich enough to afford the protection implied by measures needed to implement policies that achieve greater degrees of self-sufficiency. Although the political rationale for agricultural protection, even for the basic food grain, exceeds the economic logic, the sharp instability in world rice markets has supplied policy-makers with ample excuses to invest in rice production at levels that exceed narrow economic measures of comparative advantage. Such measures, however, do not capture the full benefits of higher farm incomes nor the greater ease in stabilizing a domestic rice economy that comes from reduced exposure to the world markets, especially for a large country.

Further, fear of food shortages in urban areas evokes a universal and visceral reaction. Governments are held accountable for provisioning cities at reasonable costs, and citizens have repeatedly demonstrated their capacity to bring down governments that fail in this obligation.[3] It is acute food shortages – not the average level of food prices – that induce

[2] This section draws extensively on Timmer (1995b).

[3] See Kaplan (1984) for a fascinating historical account of the relationship between urban masses and their rulers with respect to provisioning of basic foodstuffs.

anti-government panics, however. Food shortages are simply the mirror image of sharp price rises. Price policies that successfully avoid such episodes clearly contribute substantially to levels of overall social welfare. This level of social welfare is reflected in a more stable political economy, with its attendant positive impact on investors' expectations.

The pervasive, indeed universal, tendency of Asian governments to stabilize their domestic rice prices relative to unstable world market prices for rice suggests that the benefits may be very large, well worth considerable analytical and empirical efforts to understand and measure. The relatively rapid economic growth in many of these Asian countries argues that the impact of efficiency losses and budgetary costs on growth cannot be too large, at least if the price-stabilization program is well designed and implemented.

Most countries in the developing world explicitly favour strategies of food self-sufficiency as the most appropriate approach to achieving food security. This autarkic tendency has deep historical roots and remarkable political tenacity in the face of economists' arguments about forgone gains from trade (Lindert, 1991).

Indonesia provides a particularly vivid case study of this debate. The role of trade versus domestic production as the basis for food security has been analyzed and discussed in a surprisingly open and articulate manner since the beginning of the Suharto government in 1967. The proximate definition of food security has always revolved around price stability, especially for the price of rice, the country's primary food staple. Partly because of the economic and political chaos of the mid-1960s, and partly because of operational considerations faced in implementing any approach to food security, Indonesia has emphasized price stabilization as the foundation of its strategic design for food security. But this emphasis has not been myopic, focusing only on the static and partial equilibrium consequences of changes in rice prices. Instead, an effort has been made, even well before computable general equilibrium models became a standard tool of policy analysis, to consider dynamic and economy-wide ramifications of price policy, the distributional consequences for farmers and consumers, and the role of other commodities in the rice stabilization program.

From the late 1960s until the early 1980s, imports of rice were used routinely by BULOG, the Indonesian Food Logistics Agency, as the balance wheel between supply and demand in its defence of a floor price and ceiling price for rice. But the long-sought goal of rice self-sufficiency was achieved in the mid-1980s, and the balancing role of trade was superseded by the problems of managing domestic buffer stocks as the sole mechanism for balancing seasonal and annual differences between production and consumption. Because of the high costs of storing rice in the tropics and the finite size of stocks, wider margins between the floor price and ceiling price became a *de facto* balance wheel as well, but also called in question the implicit assumption that food security and price stability were synonymous.

Price stabilization has remained an important policy objective during surpluses and deficits, but the financial costs, feasible levels of prices, and general policy thrust with respect to the agricultural sector are sharply different in the two settings. A policy approach that favours greater flexibility in the agricultural economy, and greater price fluctuations to encourage farmers and consumers to be more flexible, would seem to be an appropriate response to such widely divergent environments. But carried very far, such flexibility is not compatible with continued emphasis on price stabilization. Consequently, the policy debate since the mid-1990s over food security and price stability has required a broad perspective, one that encompasses the contribution of agriculture to the development process and analysis of the price policies appropriate to stimulating that contribution.

3.1 Food security and self-sufficiency in rice

Self-sufficiency in rice and other foodstuffs such as sugar and soybeans has been a consistent objective of Indonesian agricultural policy since the beginning of the New Order regime in 1967. Both historical and production cost data based on farm surveys confirm that self-sufficiency in rice is less costly on average than rice imports from the world market. Because of fluctuations due to weather, diseases, and pests, however, rice production in Indonesia is unstable and in any particular year can be above or below the normal level of rice consumption. In order to stabilize the rice economy from production instability as well as from sharp fluctuations in world prices for rice, BULOG operates a floor and ceiling price policy using domestic buffer stocks as the balance wheel to smooth out year-to-year fluctuations in production and consumption. The goal is to keep rice consumption on a smooth trend despite unstable rice production. The primary vehicle for stabilizing rice consumption is the stabilization of rice prices, which has been BULOG's most important task.

For the ten years of the fourth and fifth five-year development plans (REPELITA IV and V), 1983–84 to 1993–1994, Indonesia was almost exactly self-sufficient in rice on average, and per capita availability (consumption) increased smoothly in all years but two. In none of the individual years, however, was domestic production exactly equal to consumption. In some years, for example 1984, 1989, and 1992, production was larger than consumption, and BULOG stocks increased. In other years, for example 1985 and 1993, production also exceeded consumption but, with BULOG warehouses full, exports were used to handle the surplus. In 1986, 1987, 1990, and 1991, consumption was slightly larger than production, and BULOG stocks were drawn down. In 1988, 1992 (and 1994) production was again less than the desired consumption level and, with low BULOG stocks, external supplies were called upon to provide stability to Indonesia's rice markets.

Despite all of this activity on BULOG's account, the overall picture is one of stable growth in per capita rice consumption, relative stability in Indonesia's rice market, and perhaps most importantly, the achievement for the first time of self-sufficiency in rice for two consecutive five-year plan periods. It must be stressed, however, that increasing rice production was only part of the story of self-sufficiency and rising rice consumption. The role of prices and price stability was also important in allowing consumers to maintain a smooth trend in rice consumption even though production varied considerably from year to year.

The second element of government involvement in reaching self-sufficiency is through the level of rice prices maintained in the domestic economy. Other things equal, a higher level of rice prices will increase rice production, decrease rice consumption and make self-sufficiency easier to achieve. It has often been said that Indonesia can always be self-sufficient in rice at some price; the issue is whether consumers can maintain satisfactory levels of rice consumption as well. But domestic rice prices do not exist in a vacuum. In particular, their level relative to the trend of prices in the world market and relative to the costs of inputs to farmers (especially fertilizer prices) strongly influences the efficiency with which consumers and producers allocate the scare economic resources of the society.

The third element of government policy with respect to self-sufficiency is price stabilization and the level of BULOG stocks considered appropriate for that purpose. With infinite stocks, prices can be kept completely stable, but both economic theory and experience dictate that a finite stock level cannot defend price stability under all circumstances.[4] Accordingly, an

[4] See Williams and Wright (1991) for a sophisticated analysis of the limits to price stabilization with finite stocks.

important trade-off exists. Larger buffer stocks permit a longer period of stable prices, but at costs that rise exponentially with the size of the buffer stock. Smaller stocks require that prices fluctuate more, but with substantial cost savings. The only escape from this apparent dilemma is to add a degree of freedom to the system by permitting supplies to move into or out of the country as an additional balance wheel, once stocks are drawn down or warehouses filled up.

Thus, three elements of government policy interact to create the environment for self-sufficiency in rice: (1) public investments in rice production to maintain it on the trend of rice consumption; (2) the establishment of a domestic level of rice (and fertilizer) prices that reflects their long-run opportunity costs in world markets; and (3) stabilization of domestic rice prices through market interventions using buffer stocks as a balance wheel. Each of these elements has powerful efficiency effects individually, as well as direct impact on the state budget, and these effects make each component a separate, important policy issue. But the interconnections among the three elements make it impossible to set policy for one without having a substantial impact on the others. Consistency among all three elements is essential in the long run if substantial resources are not to be wasted. Achieving this consistency is clearly the most difficult aspect of designing a policy to assure food security at the macro level.

3.2 Operational issues in analyzing price-stabilization policies

All countries in Asia intervene in their rice markets. The primary analytical methodology used by economists to understand the impact of intervention, the border price paradigm, says they should not (Timmer, 1986; Jones, 1995). This must be one of the widest gaps between theory and reality in all of economics. As Sicular (1989) notes in her conclusions to a major volume on food pricing in Asia, much of the intervention is intended to stabilize prices:

> One important concern revealed by observed food price policy in these six countries [Indonesia, Thailand, Korea, Philippines, Nepal, and China] has been a concern for stability. Stability has both political and economic facets. Political stability can require paying sufficient attention to the welfare of key political groups when setting food policy, sometimes at the expense of efficiency and equity. Economic stability has many aspects, one of which is simply price stability. Indeed, price variability is frequently of greater concern to policy actors than price levels...

Price stability is, of course, intimately tied to food security, that is, providing stable and adequate supplies of staple foodstuffs. In pursuit of food security, countries make choices about how heavily to rely on food imports and the degree to which domestic prices should be linked to international prices. In the presence of international price variability, policy-makers need to think carefully about how to interact with international markets. On the one hand, narrow-minded pursuit of food self-sufficiency can incur substantial costs in terms of gains from trade. On the other hand, opening the economy can destabilize prices internally, at times with negative economic and political consequences. Some countries try to resolve these problems by importing food while concurrently protecting domestic prices from the influence of international prices. Without careful planning, such an approach can create instability in the budgets of those agencies that maintain the buffer between domestic and international prices. Fearing the vagaries of international markets, countries such as Indonesia and Korea have shown reluctance to rely too heavily on imports of staple grains and have taken measures to delink domestic from international prices [Sicular (1989), pp. 291–2].

The gap between theory and practice exists because of failures at both ends. The analytical methodology that sees efficiency losses in every deviation from border prices has serious problems in purely theoretical terms. Relaxing the assumptions that make the framework simple and elegant, and therefore useful as a conceptual device, comes at a high cost in practical applicability. If analysts insist on realistic assumptions to reflect the pervasive market failures, nonequilibrium outcomes, and lack of information in the economies of developing countries, their methodologies are made progressively more complex, situation-specific, and dependent on the very knowledge that is lacking.

In rice-based Asian economies, rice price policy can affect economic growth, income distribution, and political stability – three important factors in any policy-maker's objective function. Economic growth is affected by the level and stability of price incentives to farmers, which stimulate growth in output and rural incomes. Low and stable consumer prices keep real wages low, thus stimulating investment, industrial output and exports. With purchases of rice still a large share of household budgets in many Asian countries and rice production the single most important farm activity, the impact of rice prices on real incomes by sector and income class is enormous. Most countries have no other policy instrument with a fraction of the potential of rice prices to alter the society's income distribution. Because of the economic significance of rice, maintaining reasonable stability in rice prices contributes directly to stabilizing expectations of investors as well as to political stability. Nothing is more unsettling politically than rapid shifts in real income and wealth among large sectors of the population. Governments can eliminate at least one important cause of such instability by stabilizing rice prices.

However, continuous market interventions and price controls have an impact on the development of a private marketing sector. Investments in physical and human capacity in this sector are not forthcoming if margins are squeezed, policy implementation is erratic, or the middleman is held responsible for policy failures. The loss is the absence of competitive traders in search of marketing opportunities for new commodities or greater volumes. Farmers everywhere need this dynamic search process; it provides them with information about what to produce and how profitable it will be. Government traders seldom reach farmers at all, much less with this type of information. Growth and diversification in agriculture is stimulated by transmitting information about changing demand patterns to farmers willing to experiment. Only a competitive, dynamic private trading sector has demonstrated much capacity to establish this link.

No price stabilization program that significantly retards the development of such a private trading sector can be successful in the long run. This is a particularly difficult lesson to learn for a parastatal marketing agency such as BULOG which has heavily invested in building its management capacity to handle many of these operational tasks itself. Just as it learns how to be more efficient and thus able to handle larger volumes successfully, the private sector should be playing a progressively larger role in day-to-day marketing activities. But how can government interventions into the level and stability of prices in domestic rice markets be designed to stimulate the development of a competitive private marketing sector rather than retard it?

Given the highly imperfect information and nearly non-existent risk markets in developing countries, especially in rural areas, mechanisms that stabilize expectations and speed learning by doing on the part of investors are likely to stimulate investments. However, in these environments, positive expectations on the part of a private trading sector are fragile; they take a long time to build and can be destroyed overnight with one foolish intervention. Trading is risky enough without having to figure out what the government will do. *Perhaps the best that price policy analysts can do to encourage an efficient private sector is to create a stable policy environment, set price margins wide enough for significant participation by the private sector, and eliminate legal and bureaucratic barriers to entry by* *private traders.* Simple as these tasks seem, they often conflict directly with the short-run or long-run interests of policy-makers in food price stabilization and of food logistics agencies in implementing it.

The conflict occurs because stabilizing grain prices has two distinct but related components: seasonal price stabilization between postharvest lows and preharvest highs; and year-to-year stability relative to world prices. The high costs of seasonal price stabilization often catch policy-makers by surprise. Squeezing the price margin to less than the lows and highs that would be dictated by the full costs of storage incurred by the private sector, including the profit and risk premium, is an expensive undertaking. The benefits, however, in terms of increased confidence on the part of farmers to invest more heavily in productive inputs, and on the part of consumers who do not need to engage in destabilizing hoarding behaviour, often justify the costs of implementing floor and ceiling price policies. Poor consumers also gain directly by not being faced regularly with extremely high prices against which they have few resources to buffer their food intake.

Stabilizing domestic prices in relation to world prices is most easily accomplished through a national buffer stock operated in conjunction with trade policy. Coordination is achieved by placing monopoly control over imports and exports in the hands of the same agency that manages the logistical operations involved in running the buffer stock. In principle, this role for the agency permits international trade to be the balance wheel that maintains a stable equilibrium between domestic demand and supplies available to the market from domestic production and net trade (and stock changes). Such direct quantitative controls conflict with WTO rules and desires of trading partners such as the United States and Australia, but they are standard in rice trade in Asia. Of the major countries in Asia, only Thailand and Bangladesh do not restrict international trade in rice to a state-controlled monopoly, and even Thailand intervenes in formation of domestic rice prices, especially at the farm level.

Two distinct forms of financial resources must be committed on behalf of the public food logistics agency. Assuming the agency is implementing a floor and ceiling price policy through a combination of domestic procurement, market injections from short-run buffer stocks, and international trade, it needs a line of credit to purchase domestic grain during the harvest and to store it until need for market injection, as well as a continuing budget allocation to cover operational losses incurred because of the squeeze on the price margin. A third form of financing, the subsidy required to cover losses on international trading (or profits), depends on prices in world markets relative to domestic prices and on the direction of trade. This relationship can change dramatically from year to year. South Korea nearly always profits when it imports rice from world markets; Indonesia did in 1983, but its imports required subsidies in 1980 and 1981. In 1985 and 1986 Indonesia had to subsidize rice exports. In 1989, Indonesia could have exported small quantities of rice at a profit, but chose to build up domestic buffer stocks under the banner of self-sufficiency. In 1993 BULOG exported at a loss, while in 1994 it imported at a small profit. Sizeable imports in 1995 pushed up the world price and BULOG imports required a small subsidy.

With proper financial controls and accounting procedures, central banks and ministers of finance should expect their food logistics agencies to repay, with full interest, the credit used for domestic procurement and seasonal stockholding when the stocks are sold in the market. Continuing losses incurred on behalf of policy-dictated objectives for price stabilization should be visible as direct subsidies in the routine budget. Such an open financing mechanism for food-price stabilization has the twin advantage of clearly identifying the regular subsidies incurred by society to stabilize its staple food prices and highlighting the fact that some of the instability is transferred to the outstanding debts owed by the food logistics agency. When crops are good and purchases are high, credit needs rise sharply. This credit is not repaid until the stocks are needed to contain domestic price rises. Repayment can take quite a while if the private sector (including farmers) also holds stocks from the good harvest and provides supplies to domestic markets for longer than normal. The added interest costs on the 'excessive' public stocks must then be added to the agency's routine subsidy, or the stocks must be exported (probably at a loss). The main point, however, is that demand for credit by the food agency becomes unstable as grain prices become stable. Since the outstanding credit held by a food logistics agency is often a substantial share of total credits in the formal banking system – 20 to 30 percent is common – the macroeconomic consequences of this financial instability can be quite dramatic (especially if the country is operating under strict credit ceilings imposed by an IMF standby agreement, as in Indonesia in the late 1960s and Bangladesh in the early 1980s).

Changes in the real scarcity of food require that adjustments be made somewhere in the economy. The important questions for the analysis of stabilization schemes for food prices are which adjustments do the least damage to the growth prospects for the economy, and to the desired distribution of income.[5] These questions require a general-equilibrium analysis with dynamic investment functions linked to the impact on expectations of instability in food prices, in credit markets, and in budgetary behaviour of the government.

The operational significance of the two basic principles – grain price stabilization both costs public resources and destabilizes either the government budget or the credit market – is quite profound. Planning of stabilization activities can be based on expected values under normal circumstances, and budgets can be drawn up under these assumptions. *But actual operations must be conducted as reality unfolds*, and reality is likely to hold surprises with respect to the size of the harvest, level of consumer demand, expectations of the private sector and its participation in storage and transportation, functioning of domestic credit markets, world market prices (in US dollars), and the country's exchange rate.[6] For the logistics agency to cope with these surprises, it must be able to arrange for substantial credit lines on very short notice, often no more than a week or two. Many government agencies have difficulty allocating resources so quickly unless they understand in advance the need and can trust the logistics agency to spend the money, with adequate financial controls, for the intended purposes.

Communication across agencies is especially important in building the understanding of the resource requirements for successful implementation of food-price stabilization schemes for extended periods of time. Clearly, a full understanding of these requirements might lead to a decision that stabilization is too expensive. A common mistake, however, is to decide that stabilization is worthwhile on the basis of *gross* underestimates of the costs, with subsequent under-financing of the logistics agency. Speculative attacks on the agency cause it to fail, thus exacerbating price instability and significantly jeopardizing credibility in all government activities because price-stabilization schemes are usually among the most visible of government interventions.[7]

Such government failures are a major justification for the free-market approach to agricultural pricing, but they are not inevitable. Relevant policy analysis that is effectively

[5] If poor consumers have systematically higher-cost access to credit, or are less able to predict price movements, they will be differentially prone to large changes in their rice consumption.

[6] Pinckney's (1988) analysis of the Kenyan experience with these issues presents several operational guidelines for coping with the deviation between planned and actual intervention levels.

[7] See Salant (1983) for an analysis of the conditions leading to successful speculative attacks on public food agencies, and their impact on price stability, and Rodrik (1989) for an analysis of the effects of government policy changes on their credibility with investors.

communicated to policy-makers can be an important input to more successful policies. However, the gaps in present approaches to improving policy analysis are painfully obvious. Academic scholars and methodologists are drawn to narrower and narrower topics that are amenable to formal mathematical treatment, whereas practitioners become more and more disenchanted with the perceived irrelevance of the new techniques.[8] To some extent, the experience with Indonesia's stabilization policies is a counterexample, where practice and methodology have evolved together.

3.3 Indonesia's experience in stabilizing rice markets during the Bustanil Arifin era, 1968–1995

The history of BULOG offers a unique opportunity to build an understanding of how practice and methodology can interact productively, starting with how the mission of the agency was formulated in the first place. This dimension of institution building is little acknowledged in the wider applause for BULOG's success in the next phase, establishment of an implementing agency that was able to respond to its radically new mission and a rapidly changing rice economy. Agency leadership and staff-training efforts have received most of the attention, but the extent of BULOG's integration into macro policymaking and access to financial resources also played key roles. Between the mid-1980s and the late 1990s, BULOG was used to 'fine tune' agricultural price policy with respect to goals for production, consumption, and overall food security. The analytical and operational capacities needed for such sophisticated interventions into agricultural policy would have been unthinkable even a decade before.

Parallel to the organizational and institutional efforts to strengthen BULOG's implementation capacity was a series of analytical debates over the appropriate policies to be implemented. Although the basic mission laid out by Mears and Afiff in 1968 was not challenged, all of the key parameters in the stabilization model were subject to continuous review.[9] The size of the marketing margin to be permitted between BULOG's floor price and ceiling price, the size of buffer stocks needed to supply monthly distributions and market operations, the price of fertilizer relative to the floor price and relative to world prices (and consequently, the size of the fertilizer subsidy) are issues that have received extensive analytical treatment by economists inside and outside the government. As world rice prices fell in the mid-1980s and Indonesia developed rice surpluses, analytical attention turned to the impact of rice prices on production, on the health of the rural economy, and ultimately, to consideration of the dynamic dimensions of rice price stability on the Indonesian economy and society.[10]

Surviving the world food crisis, 1970–1974

Although the First Five-Year Development Plan (Repelita I) was drafted in 1968 and inaugurated April 1, 1969, it was a document for the seventies. It was formulated on a premise of stability which came to full fruition in the 1970–72 period, and it was build around self-sufficiency in rice. The production program (BIMAS) stressed getting profitable inputs, subsidized credit, and information out to the farmers and letting them decide whether and how much to participate.

To complement the production program, an effective floor price for paddy was to be implemented. With the lesson learned several times over that farmers do not like to repay

[8] The debate over the costs and benefits of price stabilization is a clear case in point. The dynamic and macroeconomic benefits posited in this paper are not mathematically tractable in a general model without very specific empirical parameters, which immediately cost the model its generality and credibility.

[9] The original policy memorandum was published in 1969. See Mears and Afiff.

[10] See Pearson, *et al.*, (1990); Timmer (1991, 1993, 1995b, c).

debts with paddy at below market prices, BULOG was instructed to prevent the price of paddy in the villages from falling below a pre-announced floor price by actively buying rice in the market. With such forceful actions taken on behalf of the farmer, the government felt it could likewise commit itself to a nation-wide ceiling price for rice.

By mid-1972 the new programs looked like major success stories. Rice production was exceeding the high targets set in Repelita I, BULOG was so successful it took over handling responsibilities for wheat flour and sugar, and BAPPENAS and Ministry of Finance were trying to find alternative sources of revenue to take the place of food aid counterpart funds, which seemed about to disappear.

Instead, the generally good weather from 1968 to 1971 ran dry (throughout most of Asia). In addition, BULOG moved too quickly to improve its buying standards in order to reduce storage losses, and ended up buying very little rice in 1972. In a repeat of 1969 and 1967, the dry season was poor, BULOG stocks ran out, and imports were suddenly hard to find. The government lost control of the rice situation and reverted to emergency imports as the solution. More than a million tonnes of very expensive rice poured into Indonesia from mid-1972 to mid-1973, before the world market for rice disappeared. A year earlier it had seemed that no imports at all might be needed. Urban rice prices went through the ceiling price in late 1972 and were more than double that level by mid-1973. There were considerable political tensions in 1973 and 1974 as the stability seen from 1970 to 1972 disappeared along with rice supplies.

The drive to self-sufficiency, 1975–1983

By the mid-1970s it was possible to see just how important stability of the rice economy was to the overall success of the development program, and its vulnerability to events in the world rice economy. Bustanil Arifin (now with the rank of General, but universally know as 'Pak Bus') had been appointed the new Chairman of BULOG during the crisis, being recalled from his position as Consul General in New York. Financial constraints were nearly eliminated as petroleum dollars flowed into the Ministry of Finance after OPEC succeeded in raising oil prices. The disappearance of rice supplies from world markets in 1973 clearly established the political vulnerability of relying on large imports of rice. Farmer welfare received substantially more attention in the late 1970s as the political goal of rice self-sufficiency was translated into operational terms. Since the civil service and military were no longer so dependent on rice rations to maintain their real incomes, the pressure was off BULOG always to keep monthly distributions as the top priority. It had the resources to meet these requirements without difficulty.

From 1975 to 1983 BULOG implemented the government's floor and ceiling price policy and delivered monthly rations to the Budget Groups without a hitch. The changed external constraints noted above account for part of this success, but internal developments also played a major role. With the enthusiastic support of Pak Bus, massive and expensive efforts at staff recruiting and training were designed and carried out by Sidik Moeljono, the head of the expert staff. Supporting the floor price received top priority as a way of stimulating domestic rice production, a crucial task because of the perceived unreliability of the world rice market. From 1974 to 1978, persistent problems with disease and pests associated with the new rice varieties kept upward pressure on rural prices, so maintaining the floor price was relatively easy at the prices actually set, which merely kept pace with inflation. As world rice markets returned to normal in the late 1970s and Indonesia's foreign exchange reserves remained ample, BULOG turned increasingly to imports to meet rising demand in urban markets. Imports from 1977 to 1980 averaged nearly 2 million metric tonnes per year, or about one-fifth of the total amount of rice traded internationally.

The combination of disease and pest problems, which led to the widening import gap, and deteriorating rural-urban terms of trade as a by-product of Dutch Disease (from large oil revenues), which caused severe problems of rural poverty, forced a re-evaluation in 1978 of development strategy and the role of rice in it. BULOG was not well equipped to take the lead in rethinking its mission in the context of broader objectives and constraints. The agency was not a key player in either of the two basic policy changes in 1978 that set the rural economy in a new direction: the surprise devaluation of the rupiah in November 1978, which was partially intended to provide 'exchange rate protection' to the rural economy; and the decision to keep fertilizer prices constant while continuing to increase the floor price for rice at about the rate of inflation.[11] *Nominal* urea prices were unchanged from 1976 to 1983, and they were increased only slightly in 1983. When IR-36, an IRRI rice variety resistant to the most troublesome pests and diseases, was introduced on a nationwide basis in 1978, the stage was set for a surge in rice production that would transform BULOG's role. By 1984, the country was self-sufficient in rice, domestic procurement replaced imports as BULOG's sources of supply shifted, and the agency's success in defending the floor price was widely cited as a key factor in the unprecedented increase in rice production.

Managing self-sufficiency year by year: 1984–1989

The switch in primary source of supply had a radical effect on the management of BULOG. Far more logistical capacity was required; local warehouses, mills and transportation facilities were needed as domestically produced rice had to be stored and transported to points of distribution – a more complicated task than ordering imports for delivery at the time and location desired. Financial operations became much more complex when the variance in domestic procurement increased and the average time rice stayed in storage (and storage losses) rose. BULOG's outstanding credits from the Central Bank became a significant proportion of total bank credit for the whole economy. The agency became a significant macroeconomic actor.

Comparative experience would suggest that this was a dangerous time for the agency. It needed huge sums of money on a flexible basis for fixed investments, seasonal inventory, and operational expenses. *None of this financing was provided in the Routine Budget of the Ministry of Finance.* Finding funding mechanisms was a major challenge. They had to be sufficiently stable to permit long-range planning, sufficiently flexible to accommodate large variations in procurement financing on short notice (before rural market prices fell below the floor), and yet not too distorting to the rest of the economy. Senior leaders in the agency and their advisors worked closely with senior members of the economic team (the EKUIN ministry and the 'Economic Cabinet') and their advisors to find pragmatic solutions. Several measures contributed to keeping BULOG's finances off the front burner of political concerns.[12] Although some individual components of the agency's finances were public knowledge and officials in the Ministry of Finance reviewed BULOG's costs each year in order to calculate the 'book price' for sales to the Budget Groups, no one outside BULOG understood all the components of the financing mechanisms. It is probably true that no one inside BULOG knew how the individual components related to each other or how dependent they were on the external dynamics of Indonesia's rice economy.

Those dynamics changed radically as Indonesia approached and then surpassed self-sufficiency in rice. Substantial surpluses emerged in 1985, BULOG's warehouses were still

[11] See Timmer (1984) and Warr (1984).

[12] These measures included interest rate subsidies on an open line of credit at the Central Bank, annual increases in book profits from revalued rice inventories as nominal rice prices rose each year, 'cost-based' pricing for rice delivered to the Budget Groups, and profits from trading additional commodities put under BULOG's responsibility.

full from the record 1984 procurement, and support of the floor price was unsuccessful. Rice prices fell 20 to 30 percent below the floor price in many areas. Once again, BULOG was unprepared for an unexpected new mission, managing surplus stocks. A major external study undertaken in August, 1985, revealed several fundamental problems with the design of rice policy and BULOG's structure to implement it. The structural problems related mostly to financing mechanisms; the report concluded that without significant changes, BULOG would be bankrupt before the end of the decade.

To correct the logistical imbalances that BULOG faced, the report urged the use of price policy to fine tune BULOG's stock position relative to trends in domestic production and consumption. However, implementing this recommendation required yet another ratcheting upward in the agency's capacities to analyze and design policies that affected the rice economy. The new pricing model was used to reduce incentives gradually to rice farmers. Rice production slowed its rapid expansion and rested at a plateau from 1986 to 1988 that left procurement sharply below the levels of the previous five years. BULOG's surplus stocks were exported and used for distributions to the Budget Groups; by late 1987 the agency was unable to inject enough rice into retail markets to maintain price stability.

The shortages in 1987 caught everyone by surprise. The attention of most policy-makers and analysts was still focused on surpluses and government initiatives to stimulate diversification out of rice just as an Asia-wide drought, plus reduced stocks in the United States due to export subsidies, flipped the thin international market back to shortage. With a relatively short delay, Indonesian rice prices followed world prices up, ending 1988 at rough parity. However, because Indonesia had maintained its domestic rice prices well above those in world markets during the worst of the surplus in 1985 and 1986, domestic price increases were relatively smaller than those in the world market. Once again it seemed as though there was a longer run vision behind the stabilization program, although the abruptness of the domestic price increase was quite unsettling to many consumers and policy-makers.

BULOG activities were badly disrupted during the episode. Because of the strict policy of self-sufficiency being enforced by the President, imports were not available to replenish the stocks that had been used in a vain effort to control price increases in late 1987 and early 1988. The Government's floor price had been announced before prices ran out of control and by the procurement season in February, 1988, BULOG's permitted buying price was well below the structure of rural rice prices. Even with special task forces, premiums paid through the KUDs, and direct appeals to rice traders, BULOG was unable to replenish its stocks from domestic sources. Prices rose sharply from May to July and then stabilized at levels that were maintained (in real terms) until the surpluses in 1993.

Managing self-sufficiency on trend, 1990–1995

BULOG was able to 'recall' rice shipped abroad in 1986 as well as obtain permission for small quantities of rice under PL 480. The roughly 400 000 tonnes of external supplies that arrived late in 1988 and 1989 were never called 'imports' in public, but they did ease the agency through a difficult period before the excellent harvest in 1989 arrived. Excellent rains late in 1988 and very substantial price incentives for farmers, by some measures the highest since the late 1960s, produced a bumper crop. BULOG was able to procure over 2.5 million tonnes of rice, thus replenishing its buffer stock and returning the overall rice economy to an equilibrium not seen since the early 1980s.

The considerable turmoil in Indonesia's rice markets in the late 1980s did have one positive result. After several years of lobbying by senior policy-makers, the President accepted the concept of "self-sufficiency on trend" rather than year by year (World Bank, 1994). The added flexibility permitted BULOG to import substantial quantities of rice in 1991 and 1992, and to export in 1993. Because of the flexibility, BULOG was able to reduce the average level of stocks that it carried from one crop-year to the next from over 2.1 million tonnes during Repelita IV to less than 1.4 million tonnes during Repelita V. Full storage costs (including the value of quality losses when rice is stored for extended periods in the tropics) are roughly USD 100 per tonne per year, so BULOG's costs were reduced by about USD 3.5 million during Repelita V because of the new policy of self-sufficiency on trend.

More importantly, the new policy actually permitted BULOG to be more effective at stabilizing domestic prices. During the five years of Repelita IV, the average coefficient of variation of monthly retail rice prices in Jakarta and Surabaya was greater than 20 percent. During the five years of Repelita V, despite the greater volume of imports and significantly lower average stock levels, the coefficient of variation of retail rice prices in Jakarta and Surabaya averaged less than 10 percent. Thus flexibility in rice trade contributed significantly to a more efficient and a more effective BULOG.

By the middle of the 1990s, several crucial questions faced policy-makers with respect to the rice economy. Would Indonesia retain full self-sufficiency on trend in rice regardless of the consequences for domestic rice prices? Alternatively, would imports be used to lower the costs of price stabilization and to keep domestic prices on the trend in world prices? What impact would substantial price movements, up or down, have on the rural economy?

Unfortunately, the Asian financial crisis in 1997–98 meant these questions were never really answered. The crisis brought down the whole Suharto regime and BULOG's terms of reference and legal status were sharply altered in 1998 as part of an IMF standby agreement. It has taken nearly a decade for the agency to re-establish its dominant role in Indonesia's rice market, and it again has responsibility for stabilizing rice prices. The country largely avoided the world food crisis in 2007–08, partly by having high domestic rice prices before the crisis hit (Timmer, 2008, 2009).[13]

4. COUNTRY EXPERIENCES: 2000–2009, CHINA, INDIA, INDONESIA, THAILAND, PHILIPPINES

There are three kinds of food grain stocks in most economies: those held by official government agencies on behalf of public distribution and national food security; those held by the large-scale private trading sector – millers and processors, wholesalers and retailers; and those held by small scale participants, but who may be very numerous – farmers and consumers. The share of total grain stocks held by each of these three levels in the food system varies by country and commodity. In Asia, for rice, most countries have at least modest public reserves, a large share is held by the formal trading sector, and a highly variable share is held by farmers and consumers. Only for publicly held stocks are reliable data available on their size, and the world's largest stockholder of rice, China, keeps even these data as state secrets. It is fair to say that relatively little is known about the true size of rice stocks in the world, and how they change over time (Timmer, 2009).

Whatever their size, there are three separate approaches to managing rice stocks: technical, economic, and political. Good technical management of rice stocks requires an engineering approach that minimizes physical losses and quality deterioration. Good

[13] A more complete review of BULOG's experience after the Asian financial crisis until the mid-2000s is in Arifin (2008).

economic management requires a financial approach using the supply of storage model that explains inventory behaviour as a function of price expectations and the full costs of storage. The political approach to managing rice stocks seeks to guarantee food security for the society involved.

The basic idea was to achieve the political objective, subject to constraints imposed by good technical and management techniques. This approach is different than how the economics profession would normally approach the issue, which would be to maximize financial (economic) returns, subject to constraints imposed by good technical management and from political considerations.

After the sharp spike in rice prices in 2007–08, considerable concern arose that the political objective of food security – equated in Asia with stable rice prices – could not be achieved with economic instruments – the use of financial derivatives for managers on the supply side, and of safety nets for poor consumers (Galtier, 2009). Instead, direct political actions have been proposed to change market outcomes in the form of prices and distribution of incomes. These actions can be 'market-friendly,' in the form of public investments to raise agricultural productivity and transparent stabilization policies that rely primarily on the private sector to manage the food supply chain. But to meet the political objective of stabilizing rice prices, a market-friendly strategy will need to understand the behaviour of the three kinds of stockholders in the rice economy.

Fortunately, a good deal is known about the behaviour of these three different kinds of stockholders. National stockholding agencies usually have a formal mission to stabilize domestic rice prices, large-scale private traders and processors behave in fairly predictable ways according to the theory of supply of storage (Williams and Wright, 1991), and small-scale participants tend to act on the basis of the seasonality of production and short-run expectations about movements in rice prices (Timmer, 2009).

Unfortunately, most private stockholding behaviour tends to destabilize market prices, not stabilize them, *when there are expectations of shortages and rising prices*. Only publicly held stocks can counter this natural tendency and that is why food security has such a clear public good dimension. The focus here will be on publicly held stocks used to stabilize domestic prices. One dimension of such stability is that it also stabilizes the expectations of private stockholders. Of course, if public management of grain reserves is erratic, poorly funded, or captured by special interests, private expectations will be destabilized, making market price instability even worse. There is a special obligation on public managers of grain reserves to be transparent and effective in their price stabilization efforts.

What has been the historical record of the large Asian countries with respect to holding rice reserve stocks? Table 1 provides a simple glimpse at the data available to answer this question. These data on end-of-marketing-year rice stocks are reported on a monthly basis by the Foreign Agricultural Service of the USDA, usually on the basis of reports from resident agricultural counselors based in the US embassy in the respective country. The stock levels appear to be a mix of public and private stocks. Certainly BULOG does not expect to have over 7 million metric tonnes of rice on its own account by mid-2010. Still, these stock data are what most analysts have available to form judgments about the adequacy of world grain stocks, and they are used here.

Two things are obvious from data on stocks. First, Chinese rice stocks dominate the world total, even after their sharp drawdown by the mid-2000s (see Table 1). In 1999/00, Chinese stocks were 67.1 percent of the world total and they were still 52.1 percent in the October estimate for 2009–10. Second, there is no apparent relationship between levels

Table 1. Rice stocks, milled basis, end of marketing year, in 000 metric tonnes

Year	China	India	Indonesia	Thailand	Philippines	World
1999/00	98 500	17 716	6 022	1 711	2 002	146 905
2000/01	94 100	25 051	4 605	1 899	2 797	149 461
2001/02	82 167	24 480	4 836	2 401	3 407	136 923
2002/03	63 311	11 000	4 344	3 302	3 807	106 522
2003/04	43 915	10 800	4 018	1 706	4 047	85 394
2004/05	38 931	8 500	3 448	2 312	4 572	78 141
2005/06	36 783	10 520	3 207	3 594	5 293	75 992
2006/07	35 915	11 430	4 607	2 510	4 868	75 105
2007/08	37 640	13 000	5 607	2 207	4 420	80 380
2008/09	42 200	17 000	7 060	3 120	4 120	90 710
2009/10						
June est	44 445	19 500	6 807	4 223	3 002	94 993
Oct. est	44 750	10 000	7 560	3 520	3 230	85 900

Source: USDA, Foreign Agricultural Service, World Agricultural Supply and Demand Estimates (WASDE), various issues.

or changes in rice stocks and changes in world rice prices (see Table 2). The sharp run-up in rice prices late in 2007 and early in 2008 occurred while rice stocks were rising. The long decline in rice prices that ended in the early 2000s was accompanied by a significant drawdown in stocks. Any stock-price relationship must be subtle and more complicated than is apparent from these data.

Apart from China, individual country stories are also interesting. India's stocks have varied quite substantially over the decade. After the 2009 drought and late flooding, stocks are expected to be just half what they would have been without these natural catastrophes. Still, perhaps vindicating the Indian government's decision to build up stocks during the good harvest in 2008/09 rather than re-enter the export market, India's rice stocks will 'only' fall to a level comparable to those in the mid-2000s, when the domestic rice situation was quite manageable.

Stocks in the Philippines are also expected to be quite low relative to levels since 2001–02, and these estimates were made before the impact of the October typhoons was fully assessed. With India clearly remaining out of the export market (indeed, probably returning to the import market), and the Philippines in need of additional imports, the stage seems set for another run-up in rice prices. But Thailand, Indonesia and China are holding large stocks relative to recent years, and even with the bad production results in India and the drawdown in stocks there, global rice reserves remain larger than in any year since 2003–04, except for the large recovery in 2008–09. In late 2009, rice prices have only started to rise significantly.

Any price weakness stems largely from the very large supplies available out of Viet Nam and the large stocks held in Thailand as it attempts to support domestic farm prices for rice. An effort by Thailand to move its surplus stocks into the world market will hold down rice prices, at least temporarily. The longer run price trends will depend crucially on what happens to production and consumption in the largest producers, China, India and Indonesia, and to exportable supplies in Thailand and Viet Nam.

Table 2. Ending rice stocks as a percent of consumption during marketing year, and nominal rice prices

Year	China	India	Indonesia	Thailand	Philippines	World	Nominal Rice Price, USD, Viet Nam 5s
1999/00	73.6	21.4	17.0	18.4	23.8	36.9	USD 202
2000/01	70.0	33.0	12.8	20.3	32.0	37.8	165
2001/02	61.1	28.0	13.3	24.6	37.7	33.3	185
2002/03	46.7	13.8	11.9	34.9	39.9	26.1	184
2003/04	33.2	12.6	11.2	18.0	39.5	20.7	212
2004/05	29.9	10.5	9.6	24.4	44.0	19.2	244
2005/06	28.7	12.4	9.0	37.7	49.4	18.3	259
2006/07	28.2	13.2	12.8	25.7	40.6	17.8	292
2007/08	29.5	14.4	15.4	23.0	32.7	18.8	620
2008/09	32.6	18.3	19.0	30.3	30.2	20.8	456
2009/10							
June est	33.7	21.0	18.2	40.6	22.3	21.4	
Oct est	33.8	11.2	20.2	36.7	23.1	19.6	383

Source: USDA, Foreign Agricultural Service, World Agricultural Supply and Demand Estimates (WASDE), various issues.

Of the individual countries analyzed in Tables 1 and 2, the three largest – China, India and Indonesia – used a combination of trade and buffer stock policies to stabilize their domestic rice prices during the 2007–08 world food crisis. Such stabilization requires some capacity to isolate the domestic rice market from world markets and can only be implemented through government actions (although private traders can handle most of the actual logistics).[14] Such isolation runs directly against the spirit and, for many countries, the letter of WTO agreements. But it is a very widespread practice. Demeke, Pangrazio, and Maetz (2009) count 36 countries that used some form of border intervention to stabilize their domestic food prices during the 2007–08 crisis.

Such policies can have a huge impact. India, China, and Indonesia stabilized their domestic rice prices during the 2007–08 food crisis by using export bans (or at least very tight controls) and local reserve stocks, thus protecting well over 2 billion consumers from sharply higher prices. The policies pursued by these three countries demonstrate the importance of understanding local politics in policy formation. Although the end results were similar – food prices remained stable throughout the crisis – the actual policies pursued in each country were quite different (Slayton, 2009a, b; Dawe, forthcoming, a).[15]

From the perspective of the rest of the world, 'local' in Indonesia is big; 'local' in India and China is really big. As Dawe (forthcoming, b) emphasizes, there is a case to be made

[14] Isolation from the world market does not, of course, guarantee more stable prices. Indeed, for most countries, open borders to world markets lead to greater price stability, as local shortages and surpluses can be accommodated through trade.

[15] The 'pass through' of price increases in world markets to the domestic economies of China, India and Indonesia from early 2007 to early 2008 were 4 percent, 8 percent, and -3 percent, respectively. In each case, however, domestic rice prices were already higher than world prices, before the crisis hit.

simply in terms of *aggregate global welfare* that stabilizing domestic rice prices in these large countries using domestic reserve stocks and border interventions might be both an effective and an efficient way to cope with food crises, even after considering the spillover effects on increased price volatility in the residual world market. Countries able to stabilize their domestic rice prices accounted for over 300 million metric tonnes of rice consumption in 2007–08, out of a total of 428 mmt, or more than 70 percent of world rice consumption. Dawe emphasizes that unstable supply and demand must be accommodated *somewhere*, and passing the adjustment to the world market may be both equitable and efficient in a second-best world where fast-acting and well-targeted safety nets are not available.

5. THE FUTURE OF PUBLIC RICE RESERVES[16]

Efficient paths to providing food security that are politically feasible have been hard to find. Any such path will involve greater diversification of agricultural production and consumption, including a greater role for international trade, continued commercialization and market orientation, and a balance between the roles of the public and private sectors. At the core will be the welfare of farm households as they struggle with these issues. Mechanisms to enhance asset accumulation, including land consolidation and larger farm enterprises, will be needed for at least some of these households to remain competitive as agricultural producers. Others will exit agriculture. More effective rural credit systems will help this process, but institutional changes in land tenure are also likely to be needed, even if these are mostly in the form of long-term rental arrangements.

5.1 Role of government

The new emphasis in development economics on governance as a key factor affecting the rate and distribution of economic growth brings the opportunity to link powerful political forces, such as the deep desire on the part of both urban and rural populations for food security, to the growth process itself. The obvious link is through policy analysis, where the analysis systematically utilizes 'neoclassical political economy', to use Srinivasan's (1985) nomenclature. Understanding the role of markets and the state, and their mutual interaction, will be key (Timmer, 1991b).

Within a framework where economic decision-makers are free to make choices based on their own knowledge and conditions, the role of government remains critical. In particular, government investments that allow markets to function efficiently are essential to fostering a dynamic rural economy, especially in agriculture. Unfortunately, the provision (or attempted provision) of food security through food price stabilization has conflicted with this goal in many countries (especially in Latin America and Africa) as a result of excessive government intervention in the marketing chain. In Asia, India has also intervened strongly in domestic marketing.

However, several Asian countries have been able to avoid this mistake. Indonesia, for example, successfully stabilized domestic rice prices around the mean of world prices for nearly 3 decades through a combination of domestic procurement to defend a floor price and an import monopoly that shielded the domestic market from large price fluctuations on the world rice market. During this time, domestic procurement averaged only approximately 5 percent of total production (or 7 percent of marketed surplus, using an estimate of marketed surplus as a share of production of 70 percent; Ellis *et al.*, 1991). Price stabilization with such limited procurement was possible for two reasons. First, control

[16] This section draws on Timmer and Dawe (2007).

over international trade shielded the domestic economy from an unstable world market. Second, only small changes in the market quantities traded are necessary to have a large effect on market prices because demand for staple foods such as rice is price-inelastic. In years when domestic production was plentiful, imports were reduced and domestic stocks accumulated, and conversely in years of production shortfalls (Timmer, 1996).

Other Asian countries have managed rice price stabilization with similarly limited interventions into private marketing systems. Like Indonesia, the Philippines has successfully stabilized domestic rice prices (although at high cost; see Tolentino *et al.*, 2001; Dawe, 2003; and Dawe, *et al.*, 2006), and its procurement rate as a percentage of domestic production is similar to that in Indonesia. Such a strategy of intervention at the margins of the private marketing system arguably accelerates the formation of efficient private markets in the early stages of development by reducing risk for and encouraging entry of prospective traders, thereby enhancing competition and the integration of markets.

Bangladesh operates a variable rice tariff, with the level of the tariff varying on an ad hoc basis depending on the size of the harvest. When domestic production suffered substantial shortfalls as a result of the 'flood of the century' in 1998, import tariffs were eliminated and large private sector imports were allowed to flow into the country from India, thus stabilizing domestic prices (Dorosh, 2001; 2008). In other years, however, when domestic supplies are more plentiful, tariffs are increased to restrict the inflow of imports. Government held stocks are relatively low, typically approximately 2.5 percent of annual production (lower than in Indonesia and the Philippines). Although more ad hoc than the systems in Indonesia and the Philippines, the Bangladesh system serves to stabilize prices, and it does so at relatively low cost.

Exporters such as Thailand and Viet Nam (during the past 15 years) have stabilized domestic rice prices with essentially zero government procurement from farmers, instead relying on a variable export tax (Thailand; Siamwalla, 1975) or a system of variable export quotas (Viet Nam) that depended on the size of the domestic harvest: if supplies were plentiful, the quota was relaxed, but if supplies were low, the quota was reduced.

The government role also spans a wide range of other activities, from macroeconomic policy at the national level to providing immunizations to poor children in remote areas. The key areas where government must provide support to the rural economy are growth-oriented economic policies and macroeconomic stability, the generation of new technologies, facilities for the creation of human capital, and the provision of infrastructure to lower transactions costs. Large gains in agricultural productivity come from such public investments, which create new wealth for all members of society to share. All are essential components of a dynamic rural economy, and many of them require financial resources. Quite obviously, there is an opportunity cost to the funds used for rice price stabilization.

Despite the relatively low costs of rice price stabilization in Asia (compared to price stabilization in other parts of the developing world), there is still ample scope for further lowering the costs of stabilizing food prices. A particularly promising method for achieving these cost reductions is the use of a sliding scale of import tariffs (or export taxes), provided the maximum tariff is below the ceiling binding negotiated under the WTO or other free trade agreements. The idea of a sliding scale is not new: the nineteenth century Corn Laws in Great Britain used a sliding scale of tariffs to stabilize grain prices (Timmer, 2002).

Variable tariffs/taxes are most often used when the commodity in question is an exportable (e.g. rice in Thailand and palm oil in Indonesia), but less commonly when the commodity is an importable. This preference might be partly for reasons of security: when a commodity must be imported, most people think there is less food security than when a commodity is exported. From the mid-1980s until 2007, the world rice market appeared to be substantially deeper and more stable than it was from the mid-1960s to the early 1980s (Dawe, 2002). If the world rice market were 'normal,' there should be less fear of using international trade to stabilize domestic food supplies. Relying more on the world market would allow government stocks and procurement to be reduced, therefore generating cost savings that could be used for other important public goods. These cost savings could be especially significant in India (Cummings, Gulati, and Rashid, 2009), the Philippines (Pagulayan, 1998; Sicat, 2003) and Indonesia (World Bank, 2006).

The 2007–08 world food crisis called this strategy into question, but the search continues for more efficient instruments to stabilize domestic rice prices than large reserves stocks and expensive investments in rice self-sufficiency. A system of variable tariffs would be more efficient in the use of government resources, and it could also address the concerns that all Asian countries voice over price instability for the staple food. The constant cry of opposition to freer trade in rice among many policy-makers in the region consistently raises the specter of unstable prices. Having an efficient answer to the problem of fluctuating prices, instead of merely insisting that government should get out of the way and allow unlimited instability, could help overcome this opposition and pave the way for a more liberal trading environment that saves scarce resources and provides for more sensible price policy.

5.2 The political economy of stabilizing rice prices

For the large countries of Asia, investments since the 1960s to raise the productivity of domestic rice producers brought greater stability to the rice economy at the macro level, mostly because reliance on the world market had been destabilizing in relation to domestic production. Expanded rice production and greater purchasing power in rural areas, stimulated by the profitable rice economy, improved the level and stability of food intake of rural households. The dynamic rural economy helped to reduce poverty quickly by inducing higher real wages. The combination of government investments in rural areas, stable prices at incentive levels, and higher wages helped to reduce the substantial degree of urban bias found in most development strategies (Lipton, 1977; 1993). Growth in agricultural productivity has been seen also to stimulate more rapid economic growth in the rest of the economy.[17]

From this perspective, it is a sign of great progress that policy-makers throughout Asia have come to worry more about keeping rice prices high rather than keeping them low. Historically, in those societies in which poverty has remained untouched or even deepened, the agricultural sector has been seriously undervalued by both the public and the private sectors. In addition to an urban bias in most domestic policies, the root cause of this undervaluation was a set of market failures. Commodity prices, by not valuing reduced hunger or progress against poverty, failed to send signals with appropriate incentives to decision-makers. These inappropriate signals tend to cause several problems.

First, low values for agricultural commodities in the marketplace are reflected in low political commitments (Bates, 1981). However, political commitments to rural growth

[17] An entire body of literature exists that analyzes the role of agriculture in economic growth (Johnston and Mellor, 1961; Timmer, 1988a, 1992, 1995a, 2002, 2005a; Eicher and Staatz, 1998). Specific linkages that have been identified in this literature work through the capital and labor markets, as analyzed by Lewis (1955); through product markets, as specified by Johnston and Mellor (1961); and through a variety of non-market connections that involve market failures and endogenous growth mechanisms (Timmer, 1995a, 2002, 2005a, b). Literature that links agriculture to pro-poor growth includes Huppi and Ravallion (1991), Ravallion and Datt (1996), Timmer (1995c, 1997, 2004, 2005a), Ravallion and Chen (2004), and World Bank (2004).

are needed to generate a more balanced economy (Lipton, 1977; Timmer, 1993). The developing world has already seen a notable reduction in the macroeconomic biases against agriculture, such as overvalued currencies, repression of financial systems and exploitive terms of trade (Westphal and Robinson, 2002; Anderson and Martin, 2009). Further progress might be expected as democracy spreads and empowers the rural population in poor countries (although agricultural policies in most democracies make economists cringe, a point discussed shortly).

The second problem with low valuation of agricultural commodities is that rural labor is also undervalued. This weakens the link between urban and rural labor markets, which is often manifested in the form of seasonal migration and remittances. There is no hope of reducing rural poverty unless real wages for rural workers rise. Rising wages have a demand and a supply dimension, and migration can affect both in ways that support higher living standards in both parts of the economy. Migration of workers from rural to urban areas raises other issues, of course, but those issues depend fundamentally on whether this migration is driven by the push of rural poverty or the pull of urban jobs (Larson and Mundlak, 1997). Whatever the cause, the implications for food security are clear: a greater share of food demand will originate from urban markets. Whether these urban markets are supplied by domestic farmers or international trade is one of the key food security debates under way in most Asian countries.

So far, the typical response has been for both of these problems to be addressed by trade and subsidy policies that increasingly protect farmers from foreign competition, especially rice farmers. How does urban bias turn so quickly to agricultural protection? The question has fascinated political scientists and economists for some time. Building on Krueger's (1974) and Olson's (1965) theories of rent-seeking and collective action, Anderson and Hayami (1986) attempt to explain the rapid rise of agricultural protection in Asia in terms of the changing role of agriculture in the structural transformation and the costs of free-riding in political coalitions. A broader effort by Lindert (1991) follows the same approach, which is now formalized as 'positive political economy'. Actors in both economic and political spheres make rational (personal) choices with respect to policies, using political action, lobbying, and even bribery as mechanisms of influence.

These 'rational choice' models of agricultural protection, although illuminating, are not entirely satisfactory. An alternative model that builds on Asian societies' deep desire for food security, manifested as stable rice prices, does a much better job of explaining changes in the nominal degree of protection of rice farmers in Asia (Timmer, 1988b, 1993). When world rice prices decline, but domestic prices are stabilized, the inevitable outcome is protection, although 'stabilization' describes the intention of policy-makers better than 'protection'. It is this deep-seated desire for food security that explains the rapid flip from urban bias to high protection. Newly well-off urban workers no longer need cheap rice to survive, but they still must buy all of their rice in local markets. They want to be certain it is available. For societies deeply distrustful of the world market as a source of reliable supplies, it is a very short step to protecting their own rice farmers as the surest vehicle to ensure the availability of rice.

6. CONCLUDING OBSERVATIONS

These characteristics of rice-based food systems forge a strong link between politics and economics, a link that policy-makers, elected or not, see as a public mandate to deliver food security. Without understanding this link, it is impossible to understand Asia's record of economic growth, driven historically by dynamic rural economies, and the subsequent, seemingly inevitable, rise of agricultural protection. Although some of the forces driving this protection are similar to those in Europe and the USA, the speed, level, and early onset are unique to Asia. In this sense, the rice-based economies are 'different' (Timmer, 2009).

The way forward is to make rice less 'different' to consumers, farmers and in world markets, by making it more of an economic commodity and less of a political commodity. Much progress has actually been made in this direction – in 1980 rice was about 7 percent of economic activity in Asia and this had dropped to 3 percent by 2007. Unfortunately, that progress has not been clearly recognized or incorporated into new, politically viable strategies for food security in Asia.

Still, the ingredients of such a strategy are clear: sharply higher investments in agricultural productivity broadly and in rice productivity specifically; greater investment in rural human capital, to improve labour productivity and mobility; more efficient rural financial markets, to facilitate farm consolidation and even rural exit; and coordinated international efforts to encourage larger reserve stocks for rice, in combination with agreements to open the world rice market to freer trade to deepen and stabilize price formation. This is a big agenda, to be sure, but implementing it, even gradually, will ensure a more prosperous and equitable future for Asia's farmers and greater food security for its consumers.

REFERENCES

Anderson, J. R. & Roumasset, J. A. 1996. Food insecurity and stochastic aspects of poverty. *Asian Journal of Agricultural Economics*, 2(1): 53–66.

Anderson, K. & Hayami, Y. 1986. *The Political Economy of Agricultural Protection*. Sydney, Allen and Unwin.

Anderson, K. & Martin, W., eds. 2009. *Distortions to Agricultural Incentives in Asia*. Washington, DC, World Bank.

Arifin, B. 2008. From Remarkable Success Stories to Troubling Present: The Case of BULOG in Indonesia. *In* S. Rashid, A. Gulati & R. Cummings, Jr, eds. *From Parastatals to Private Trade: Lessons from Asian Agriculture*, pp. 137–165. Baltimore, MD, Johns Hopkins University Press for the International Food Policy Research Institute (IFPRI).

Bates, R. 1981. *Markets and States in Tropical Africa*. Berkeley, CA, University of California Press.

Bangladesh Bureau of Statistics 1998. *Household Expenditure Survey 1995–96*. Dhaka, Bureau of Statistics.

Behrman, J.R. 1984. The analytics of international commodity agreements. *In*: C.K. Eicher and J.M. Staatz, eds. *Agricultural Development in the Third World,* pp. 241–52. Baltimore, MD, Johns Hopkins University Press.

Block, S.A., Kiess, L., Webb, P., Kosen, S., Moench-Pfanner, R., Bloem, M. W. & Timmer, C. P. 2004. Macro shocks and micro outcomes: Child nutrition during Indonesia's crisis. *Economics and Human Biology*, 2(1): 21–44.

Cummings, R. Jr., Gulati, A. & Rashid, S. 2009. *Grain Price Stabilization Experiences in Asia: What We Have Learned?* Paper prepared for Workshop on Institutions and Policies to Manage Global Market Risks and Price Spikes in Basic Food Commodities, FAO, Rome, October 26–27.

Dawe, D. 1996. A new look at the effects of export instability on investment and growth. *World Development,* 24(12): 1905–14.

Dawe, D. 2000. The contribution of rice research to poverty alleviation. In: *Redesigning Rice Photosynthesis to Increase Yield* (eds Sheehy J. E., Mitchell P. L. and Hardy B.), pp.3–12. Makati City (Philippines) and Amsterdam (The Netherlands), International Rice Research Institute and Elsevier Science.

Dawe, D. 2001. How far down the path to free trade? The importance of rice price stabilization in developing Asia. *Food Policy*, 26(2): 163–75.

Dawe, D. 2002. The changing structure of the world rice market, 1950–2000. *Food Policy*, 27(4): pp. 355–70.

Dawe, D. 2003. Equity effects of rice trade liberalization in the Philippines. *In*: Mew T. W., Brar D., Peng S., Dawe D. and Hardy B. (eds.) *Rice Science: Innovations and Impact for Livelihood,* pp. 1007–1022. Beijing, International Rice Research Institute, Chinese Academy of Engineering and Chinese Academy of Agricultural Sciences.

Dawe, D., Piedad, C., Moya, F. & Casiwan, C.B., eds. 2006. *Why does the Philippines import rice? Meeting the challenge of trade liberalization.* Los Banos, the Philippines, International Rice Research Institute (IRRI).

Dawe, D., ed. Forthcoming, a. *Rice Crisis: Markets, Policies and Food Security*. London, Earthscan Press with Food and Agricultural Organization of the United Nations (FAO).

______________. Forthcoming, b. Conclusion: Can the next rice crisis be prevented?, *In* Dawe, David, ed., Forthcoming, a. *Rice Crisis: Markets, Policies and Food Security.* London, Earthscan Press with Food and Agricultural Organization of the United Nations (FAO).

Deaton, A. 1989. *Saving in developing countries: Theory and review.* Discussion Paper No. 144, Research Program in Development Studies, Woodrow Wilson School, Princeton University.

Demeke, M., Pancrazio, G. & Maetz M. 2009. *Country responses to the food security crisis: Nature and preliminary implications of the policies pursued.* (Available at: http://www.fao.org/fileadmin/user_upload/ISFP/pdf_for_site_Country_Response_to_the_Food_Security.pdf)

Dixit, A. K. & Pindyck, R. S. 1994. *Investment under Uncertainty*. Princeton, NJ, Princeton University Press.

Dorosh, P. A. 2001. Trade liberalization and national food security: Rice trade between Bangladesh and India. *World Development*, 29(4): 673–89.

______________. 2009. Price stabilization, international trade and national cereal stocks; World price shocks and policy response in South Asia. *Food Security*, 1: 137–49.

Dreze, J. & Sen, A. 1989. *Hunger and Public Action*. Oxford, Clarendon Press.

Eicher, C. K. & Staatz, J.M., eds.1998. *International Agricultural Development*. Baltimore, MD, Johns Hopkins University Press.

Ellis, F., Magrath, P. & Trotter, B. 1991. *Indonesia rice marketing study 1989–91*. Badan Urusan Logistik, Jakarta, Indonesia.

FAO. 2006. FAOStat on-line electronic database. (Available at: http://www.fao.org/waicent/portal/statistics_en.asp)

Fogel, R.W. 1991. The conquest of high mortality and hunger in Europe and America: Timing and mechanisms. *In*: Higonnet, P. Landes D. S. & Rosovsky, H., eds. *Favourites of Fortune: Technology, Growth, and Economic Development since the Industrial Revolution*, pp. 35–71. Cambridge, MA, Harvard University Press.

Galtier, F. 2009. *How to manage food price instability in developing countries*. Summary of the study concerning instruments devoted to food price instability management, funded by the Agence Francaise de Developpement (AFD) and the French Ministry of Foreign and European Affairs (MAEE). CIRAD and UMR MOISA, France.

Huppi, M. & Ravallion, M. 1991. The sectoral structure of poverty in Indonesia during an adjustment period: Evidence for Indonesia in the mid-1980s. *World Development*, 19(12): 1653–78.

Johnston, B.F. & Mellor, J. W. 1961. The role of agriculture in economic development. *American Economic Review*, 51(4): 566–93.

Jones, C. 1995. Rice Price Stabilisation in Indonesia: An Economic Assessment of the Changes in Risk Bearing. *Bulletin of Indonesian Economic Studies* (Canberra), 31(1), April, 109–28.

Kaplan, S.L. 1984. *Provisioning Paris: Merchants and Millers in the Grain and Flour Trade during the Eighteenth Century.* Ithaca, NY, Cornell University Press.

Krueger, A.O. 1974. The political economy of the rent-seeking society. *American Economic Review*, 64(3): 291–303.

Kuznets, S. 1966. *Modern Economic Growth*. New Haven, CT, Yale University Press.

Larson, D. & Mundlak, Y. 1997. On the Intersectoral Migration of Agricultural Labor. *Economic Development and Cultural Change*, 45(2): 295–319.

Lewis, W. A. 1955. *The Theory of Economic Growth*. London, Allen and Unwin.

Lindert, P. 1991. Agricultural protection in historical perspective. *In* C.P. Timmer, ed. *Agriculture and the State,* pp. 29–83. Ithaca, NY, Cornell University Press.

Lipton, M. 1977. *Why Poor People Stay Poor: Urban Bias in World Development*. Cambridge, MA, Harvard University Press.

Lipton, M. 1993. Urban bias: Of consequences, classes and causality. *In*: A. Varshney, ed. *Beyond Urban Bias*, pp. 229–58. London, Frank Cass.

Lucas, R.E. 1972. Expectations and the Neutrality of Money. *Journal of Economic Theory*, 4: 103–124.

Lucas, R.E. 1973. Some international evidence on output-inflation tradeoffs. *American Economic Review*, 63(3): 326–34.

McDonald, R. & Siegel, D. 1986. The value of waiting to invest. *Quarterly Journal of Economics*, 101(4): 707–27.

Mears, L.A. & Afiff, S. 1969. An Operational Rice Price Policy for Indonesia. *Ekonomi dan Keuangan Indonesia*. Jakarta, Vol. XVII: 3–31.

Minot, N. & Goletti, F. 1998. Rice export liberalization and welfare in Vietnam. *American Journal of Agricultural Economics*, 80(4): 738–49.

Newbery, D.M.G. & Stiglitz, J.E. 1979. The theory of commodity price stabilization rules: Welfare impacts and supply responses. *Economic Journal*, 89(356): 799–817.

Newbery, D.M.G. & Stiglitz, J.E. 1981. *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*. New York, Oxford University Press.

Olson, M. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA, Harvard University Press.

Pagulayan, A.C., Jr. 1998. Philippines. In *Agricultural Price Policy in Asia and the Pacific*. Tokyo, Japan Asian Productivity Organization.

Pearson, S.R., Falcon, W.P., Heytens, P., Monke, E. & Naylor, R. 1990. *Rice Policy in Indonesia*. Ithaca, Cornell University Press.

Pinckney, T.C. 1988. *Storage, Trade, and Price Policy Under Production Instability: Maize in Kenya.* IFPRI Research Report No. 71. Washington, DC, International Food Policy Research Institute.

Pindyck, R.S. 1988. Irreversible investment, capacity choice, and the value of the firm. *American Economic Review*, 78(5): 969–84.

Ravallion, M. & Chen, S. 2004. *China's (uneven) progress against poverty.* World Bank Policy Research Working Paper 3408. Washington, DC, World Bank.

Ravallion, M. & Datt, G. 1996. How important to India's poor is the sectoral composition of economic growth? *World Bank Economic Review*, 10(1): 1–25.

Rodrik, D. 1989. *The Credibility of Structural Adjustment Policies to Investors*. Cambridge, MA, Kennedy School of Government. Processed.

Rodrik, D. 1999. The New Global Economy and the Developing Countries: Making Openness Work. Washington, DC, Overseas Development Council.

Salant, S. 1983. The vulnerability of price stabilization programs to speculative attack. *Journal of Political Economy*, 91(1): 1–38.

Sharma, R. & Morrison, J. 2009. *Trade Policy for Agricultural Development and Food Security: Reflections from Asia.* Paper for the Asia-Pacific Trade Economists' Conference on Trade-Led Growth in Times of Crisis, Bangkok, Thailand, November 2–3.

Siamwalla, A. 1975. A history of rice policies in Thailand. *Food Research Institute Studies*, 14: 233–49.

Sicat, G. 2003. *Philippine Economic and Development Issues*. Pasig City, Manila, Philippines, Anvil Publishing.

Sicular, T., ed. 1989. *Food Price Policy in Asia*. Ithaca, NY, Cornell University Press.

Slayton, T. 2009a. *Arson Forensics: What Set the World Rice Market on Fire in 2008?* Presented at the FAO Workshop on Rice Policies in Asia held in Chiang Mai, Thailand, from February 9–12.

_____________. 2009b. Rice Crisis Forensics: How Asian Governments Carelessly Set the World Rice Market on Fire. Working Paper No. 163, Centre for Global Development, Washington, DC.

Srinivasan, T. N. 1985. Neoclassical political economy: The state and economic development. *Asian Development Review*, 3(2): 38–58.

Strauss, J. & Thomas, D. 1998. Health, nutrition, and economic development. *Journal of Economic Literature*, 36(2): 766–817.

Timmer, C.P. 1984. Energy and Structural Change in the Asia-Pacific Region: The Agricultural Sector. *In* R.M. Autista and S. Naya, eds. *Energy and Structural Change in the Asia-Pacific Region: Papers and Proceedings of the Thirteenth Pacific Trade and Development Conference.* Manila: Philippines Institute for Development Studies and the Asian Development Bank.

_____________. 1986. Getting Prices Right: The Scope and Limits of Agricultural Price Policy. Ithaca, NY, Cornell University Press.

_____________. 1988a. The Agricultural transformation. *In* H. Chenery. & T.N. Srinivasan, eds. *Handbook of Development Economics, Volume 1,* pp. 275–331. North-Holland, Amsterdam.

_____________. 1988b. Review of *The Political Economy of Agricultural Protection: East Asia in International Perspective*, K. Anderson & Y. Hayami. *Asian-Pacific Economic Literature*, Vol 2: 66–9.

_____________. 1989. Food price policy: The rationale for government intervention. *Food Policy*, 14(1): 17–42.

_____________. 1991a. Food Price Stabilization: Rationale, Design, and Implementation. *In* D.H. Perkins & M. Roemer, eds. *Reforming Economic Systems,* pp. 219–48 and pp. 456–59. Cambridge, Harvard Institute for International Development. Distributed by Harvard University Press.

_____________ ed. 1991b. *Agriculture and the State: Growth, Employment, and Poverty in Developing Countries*. Ithaca, NY, Cornell University Press.

______________. 1992. Agriculture and economic development revisited. *Agricultural Systems*, 40(1-3): 21–28.

______________. 1993. Rural Bias in the East and Southeast Asian Rice Economy: Indonesia in Comparative Perspective. *Journal of Development Studies*, 29(4): 149–76.

______________. 1995a. Getting agriculture moving: Do markets send the right signals? *Food Policy*, 20(5): 455–72.

______________. 1995b. Food Security and Rice Price Stabilization: An Essay in Honor of Bustanil Arifin. *In* Ministry of Cooperatives and Small-Scale Enterprises (Indonesia), *Beras, Koperasi dan Politik Orde Baru* [*Rice, Cooperatives and New Order Politics*]. Jakarta (October), pp. 326–51.

______________. 1995c. The Political Economy of Rapid Growth: Indonesia's New Development Model. *In* R.A. Goldberg, ed., *Research in Domestic and International Agribusiness Management*, vol. 11, pp. 117–34. Greenwich, CT, JAI Press.

______________. 1996. Does BULOG stabilize rice prices in Indonesia? Should it try? *Bulletin of Indonesian Economic Studies*, 32: 45–74.

______________. 1997. How well do the poor connect to economic growth? CAER Discussion Paper No. 17. Cambridge, MA, Harvard Institute for International Development.

______________. 2000. The macro dimensions of food security: Economic growth, equitable distribution, and food price stability. *Food Policy*, 25, pp. 283–95.

______________. 2002. Agriculture and economic growth. *In* Gardner B. and Rausser G., eds. *Handbook of Agricultural Economics*, Volume IIA, pp. 1487–546. North-Holland, Amsterdam.

______________. 2003. Food security and rice price policy in Indonesia: The economics and politics of the food price dilemma. In Mew T. W., Brar D. S., Peng S., Dawe D. and Hardy B, eds. *Rice Science: Innovations and Impact for Livelihood,* pp. 777–88. Beijing, International Rice Research Institute, Chinese Academy of Engineering, and Chinese Academy of Agricultural Sciences.

______________. 2004. The road to pro-poor growth: Indonesia's experience in regional perspective. *Bulletin of Indonesian Economic Studies*, 40:177–207.

______________. 2005a. *Agriculture and pro-poor growth: An Asian perspective.* Working Paper No. 63, Centre for Global Development, Washington, DC.

______________. 2005b. Food security and economic growth: an Asian perspective. *Asian-Pacific Economic Literature*, 19: 1–17 (H. W. Arndt Memorial Lecture).

______________. 2006. Indonesia and pro-poor growth. *In* Besley, T. & Cord, L. eds. *Country Experiences with Pro-Poor Growth*. London, Palgrave Macmillan.

______________. 2008. The Causes of High Food Prices. Chapter 2-3 In *Asian Development Outlook Update*. (September) Asian Development Bank, Manila, the Philippines, pp. 72–93.

_____________. 2009. Rice Price Formation in the Short Run and the Long Run: The Role of Market Structure in Explaining Volatility. Centre for Global Development Working Paper 172, May, 2009, pp. 1–46.

Timmer, C.P & Dawe, D. 2007. Managing Food Price Instability in Asia: A Macro Food Security Perspective. *Asian Economic Journal,* 21(1): 1–18.

Tolentino, V.B.J., Noveno, E., dela Pena, B., Villapando, I. & Rayco, B. 2001. *101 facts about rice in the Philippines.* Manila, the Philippines, Department of Agriculture and Asian Development Bank.

UNDP. 2003. *Human Development Report*. New York, UNDP.

Von Pischke, J.D., Adams, D.W. & Donald, G. 1983. *Rural Financial Markets in Developing Countries*. Baltimore, MD, Johns Hopkins University Press.

Westphal, L. & Robinson, S. 2002. *The State of Industrial Competitiveness in Developing Countries*. New York, United Nations Development Program.

Warr, P.G. 1984. Exchange rate protection in Indonesia. *Bulletin of Indonesian Economic Studies*. (Canberra), 20(2), August.

Williams, J.C. & Wright, B.D. 1991. *Storage and Commodity Markets*. Cambridge, Cambridge University Press.

World Bank. 1993. The East Asian Miracle: Economic Growth and Public Policy. New York, Oxford University Press.

_____________. 1994. *Indonesian Economic Report*. Washington, DC.

_____________. 2004. *Directions in Development: Agriculture and Poverty Reduction*. Washington, DC, Agriculture and Rural Development Department, World Bank.

_____________. 2006. *Making the New Indonesia Work for the Poor*. Jakarta and Washington, DC, World Bank.

Food price spikes and strategic interactions between the public and private sectors: Market failures or governance failures?

T.S. Jayne and David Tschirley[1]

[1] Jayne and Tschirley are Professors, Department of Agricultural, Food, and Resource Economics, Michigan State University. This paper is based on a presentation prepared for the FAO meeting on Institutions and Policies to Manage Global Market Risks and Price Spikes in Basic Food Commodities, Rome, 26–27 October 2009. The authors are grateful to USAID/Kenya, and to the Africa Bureau and Economic Growth and Trade Bureau of USAID for their support of this study through awards to the Food Security III Cooperative Agreement.

1. INTRODUCTION

When food prices shoot over import parity, this often leads to social and political unrest and even the toppling of governments. If markets behaved efficiently and in the absence of trade barriers, food prices should not exceed the price in world markets plus the cost of importing it to domestic markets (i.e. import parity). However, food prices routinely soar above import parity in several countries of East and Southern Africa, causing widespread hunger and asset depletion among the poor.

Policy-makers have two good reasons for seeking to understand why domestic food prices sometimes exceed import parity: first, to develop strategies to protect the welfare of the urban and rural poor in response to national food production shortfalls, and second, to promote political and social stability. This study is motivated by the need to avoid such food crises, to understand why they occur with such regularity in the region, and to consider policy options for avoiding them in the future.

At the heart of this issue are the interactions between governments and traders in food markets. Traditional development economics typically analyses the performance of food markets as the impact of shifting demand and supply functions. This approach can be usefully complemented by an investigation of the strategic interactions between public and private marketing actors and how their behaviour responds to one another. We conclude that a better understanding of these strategic interactions is necessary to put in place appropriate strategies for ensuring that domestic food prices do not exceed import parity and thus reduce the potential for extreme upside price shocks.

The following section explores the political economy interactions between the state and private sector in grain markets. We then lay out a theory that explains how government reliance on discretionary trade policy instruments leads to strategic interactions that can precipitate food crises. We then examine the details of two specific cases from the recent 2008/09 year in which domestic food prices greatly exceeded import parity prices for extended periods: (1) the case of Kenya from late 2008 into August 2009; and (2) the case of Malawi from late 2008 to April 2009. The concluding section summarizes the main findings, considers the potential effectiveness of alterative policy responses under consideration to ensure against upside food price risk.

2. POLITICAL ECONOMY OF FOOD MARKETS IN THE REGION

Despite the conventional perception that food markets have been 'liberalized', many African governments in East and Southern Africa continue to intervene heavily in food markets. The stated purpose of most government operations in markets is to stabilize food prices and supplies. Governments pursue price stabilization objectives through two main routes: (1) marketing board operations, and (2) discretionary trade policy instruments, such as export bans and variable import tariff rates. A defining feature of the marketing environment in the 'liberalization period' in most of East and Southern Africa has been tremendous unpredictability and frequent change of direction in governments' role in the market. In this environment, the performance of food markets is greatly affected by the way the private sector and the government interact.

2.1 Marketing board operations

Marketing board operations have generally been more modest in recent years than during the pre-control period. However, they continue to be major actors in their countries' maize markets. Using data provided by the national marketing boards between 1995 and 2004, the boards' annual purchases have fluctuated from an estimated 15–57 percent of the domestic marketed maize output in Kenya, 3–32 percent in Malawi, and 12–70 percent in Zambia (Jayne, Nijhoff, and Zulu, 2006). These figures understate the boards' full impact on markets because they do not count their often sizeable maize imports and subsequent release onto domestic markets. Because the boards are typically the largest single player in the market and often behave unpredictably, their operations can create major risks and trading losses for other actors in the market. In countries such as Malawi, Zambia, Zimbabwe, and Kenya, the marketing boards' involvement appears to have risen in recent years, as budget support from governments has shifted somewhat over the past decade from 'conditionality' agreements to minimally tied, or untied, budget support.[2]

2.2 Discretionary use of trade policy instruments

In addition to direct involvement in crop purchasing and sale at controlled prices, governments influence markets and marketing participants' behaviour through discretionary trade policy instruments such as export bans, changes in import tariff rates, and control over importation through licenses. In many countries, traders seeking to import grain must apply for import licenses. If licenses are not issued, opportunities for the market to hold domestic prices in line with import parity are lost.

Similar problems arise due to uncertainty about when and whether governments will alter their import duties in response to a short crop. Traders that mobilize imports early face financial losses if the duty is later waived and competing firms (or the government parastatal) can import more cheaply. When governments create uncertainty over when and whether an import tariff will be waived during a poor crop season, the result is commonly a temporary under-provision of imports, which can then result in shortages where local prices exceed import parity levels for periods of time (Nijhoff *et al.*, 2003). When the import tariff is finally waived, imports are compressed into a truncated period, which may cause transport bottlenecks and exacerbate the market's ability to quickly overcome local scarcity especially if import requirements are large relative to domestic transport capacity.

2.3 Motivations for use of discretionary policy tools

Why have successive governments in the region tended not to pursue the market reform and liberalization agenda recommended by international development agencies? There are two possible explanations. The first is that government objectives are varied, inherently political, and vulnerable to influence and capture by elites. As argued by Lopez (2003), the allocation of public expenditures tends to be biased in favour of private goods, such as input subsidies, that can be captured by politically influential groups and against the provision of public goods that would improve the overall performance of markets and thus have broad-based benefits for the poor. The political landscape in much of Africa can also be described as being dominated by neo-patrimonial relationships, in which government commodity distribution is an important tool by which leaders maintain loyalty and patronage among rural leaders and their constituents (van de Walle, 2001; Pletcher, 2000).

[2] Conditionality agreements typically identified specific policy reforms or actions that governments would commit themselves to doing in exchange for receiving loans from international lenders. Untied loans are financial injections directly to the Ministry of Finance with less stringent strings attached as to how the funds are to be spent.

The second class of explanations has to do with genuine government concern for the welfare of smallholders as well as urban dwellers. White maize is the strategic political crop in this region of Africa. Maize became the cornerstone of an implicit and sometimes explicit 'social contract' that the post-independence governments made with the African majority to redress the neglect of smallholder agriculture during the colonial period (Jayne and Jones, 1997). The controlled marketing systems inherited by the new African governments at independence were viewed as an ideal vehicle to implement this objective. The benefits of market controls designed to produce rents for European farmers during the colonial period instilled the belief that the same system could also promote the welfare of millions of smallholders if it was simply expanded (Jenkins, 1997). The social contract incorporated the understanding that governments were responsible for ensuring cheap food for the urban population.

While the social contract approach achieved varying levels of success in promoting smallholder incomes and raising consumer welfare, a common result in all cases was an unsustainable drain on the treasury. The cost of supporting smallholder production - through input subsidies, credit programs with low repayment rates, commodity pricing policies that subsidised transport costs for smallholders in remote areas, and the export of surpluses at a loss - contributed to fiscal deficits and, in some cases, macroeconomic instability. Under increasing budget pressure, international lenders gained leverage over domestic agricultural policy starting in the 1980s, which culminated in structural adjustment programs. While structural adjustment is commonly understood to be a decision that international lenders imposed on African governments, a more accurate characterization of the process is that this adjustment was unavoidable due to the mounting fiscal crises that the social contract policies were imposing on governments (Jayne and Jones, 1997). Continuation of the status quo policies was not an option in countries such as Malawi, Tanzania, Zambia, Zimbabwe, and Kenya, and in some of these countries, the controlled marketing systems had already broken down even prior to policy liberalization as parallel markets swiftly became the preferred channel for most farmers and consumers. Moreover, the erratic performance of the state-led systems, reflected by frequent shortages of basic commodities and late or partial payments to farmers, created support for reform among some domestic constituencies.

The rise of multi-party electoral processes in the early 1990s has, however, made it difficult for governments in these countries to withdraw from 'social contract' policies. Elections can be won or lost through policy tools to reward some farmers with higher prices and reward consumers with lower prices, and this is hardly unique to developing countries (Bates, 1981; Bates and Krueger, 1993; Bratton and Mattes, 2003; Sahley *et al.,* 2005). Because they provide obvious demonstrations of support for millions of small farmers and consumers, a retreat from the social contract policies exposes leaders to attack from opposition candidates (Sahley *et al.* 2005). For this reason, it remains difficult for leaders to publicly embrace grain market and trade liberalization, even as they accepted structural adjustment loans under conditionality agreements from international donors to reform their internal and external markets. And starting in the late 1990s, the transition of the World Bank and other development partners from structural adjustment loans with ex-*ante* conditionality to direct budget support with ex-post conditionality made it easier for states to reinstate some elements of the social contract policies.

By the early 2000s, grain marketing boards have once again become the dominant players in the market in Kenya, Malawi, Zambia, and Zimbabwe (Jayne *et al*. 2002). Each of these countries have a highly unpredictable and discretionary approach to grain trade policy, commonly imposing sudden and unanticipated export and import bans, changes in import tariff rates, or issuing government tenders for the importation of subsidised grain. Problems frequently arise due to uncertainty about when and whether governments will alter import duties or import intentions in response to a short crop (e.g. Zambia in 2000–01, 2001–02; 2005–06; Malawi in 2001–02). Traders otherwise willing to mobilise imports early are likely to incur financial losses if the government later waives the duty and allows competing firms (or the government parastatal) to import more cheaply. When governments create uncertainty over import intentions or tariff rates during a poor crop season, the result is commonly a temporary under-provision of imports, which can produce a situation of acute food shortages and price spikes far above the cost of import (Nijhoff *et al.,* 2003; Mwanaumo *et al.,* 2005; Tschirley and Jayne, forthcoming). Analysts not familiar with the details of these situations often erroneously interpret them as evidence that markets fail and that the private sector is weak, leading to a rationale for continued direct government involvement in marketing. These illustrations highlight the importance of strategic interaction, in determining food security and improving market performance.

3. CONCEPTUAL FRAMEWORK

Our conceptual framework is based on five premises; we explain each of these in more detail below and draw on two concepts in the political science and sociology literature – the *credible commitment problem* and the *wicked problem* – to develop implications. Our premises are: i) government and traders interact in the same political and economic space but with differing objective functions; ii) the two are dependent on each other in that the behaviour of each affects the outcome of the other; iii) trust between government and traders is difficult to develop because of differing objectives, values, and world views; iv) information about the other's behaviour is imperfect, and the effects of some behaviours are seen only with a time lag; and v) as a result, each must base their own behaviour in part on expectations about the behaviour of the other.

Government's objective is to remain in power. In the electoral democracies that have prevailed in Southern Africa for the past 15 years, this requires gaining sufficient votes to win the next election. Given the importance of food staples in the budgets of these countries' (mostly poor) consumers', ensuring adequate supplies of staple foods throughout the country at prices accessible to the poor, and gaining political credit for this outcome, makes an important contribution to government's ultimate political objective.

Traders' main objective is to maximize profits over some time horizon. Traders' profits are clearly affected by government policies and practices. For example, sudden imposition of trade restrictions, or direct government importation of food and targeted sales to selected buyers at subsidized rates, can dramatically affect a trader's bottom line for good or bad, depending on their market position in relation to the government action: a trader sitting on large stocks of maize when an export ban is imposed could lose large sums of money, while another without stocks but with a contract to supply maize to an institutional buyer could earn much higher profits than in the absence of the export ban. Likewise, any ability that traders might have to engage in non-competitive behaviour can negatively influence the achievement of government's instrumental objective of broad and affordable access to food.

Government and traders cannot be certain what the other will do, so each must base their behaviour in part on expectations regarding the likely behaviour of the other. This dynamic creates a '*credible commitment problem*', in which the inability of parties to make credible commitments to each other precludes a course of action that would resolve a conflict (North, 1993; Schaffer 1989; Greif, Milgrom, and Weingast, 1994; Acemoglu, 2003). For example, government may state a commitment to importing a certain quantity of grain within a specified time period; but even in the absence of mistrust, the complexity of decision making means that traders cannot be certain that government will actually do this. Nor can traders be certain of who will be allowed to buy the grain from government if and when it does import, or at what price. These unknowns are major sources of risk and potential financial loss for traders. For its part, government cannot be sure that traders will import sufficient food during a crisis to assure broad access at politically acceptable prices. In fact, because demand for food staples is price-inelastic, governments know that trader profits will be increased in the short-run by restricting supply, and so are sensitive to the possibility that traders may collude to do this.

The typical solution to commitment problems involves *third party guarantees* (Acemoglu, 2003). In economies with well developed institutions, the judicial system frequently plays this role: parties to a contract don't need to fully trust each other (though this helps) as long as they believe that the courts will efficiently and effectively enforce the contract in the case of default by one party. In our commitment problem, a competitive market could provide a third party guarantee, by imposing sufficient discipline on individual traders that their profit seeking actions result in government also achieving its goal. In the terminology of the social trust literature (Falcone and Castelfranchi, 2001), government could delegate the task of maintaining adequate supplies and accessible prices to traders as a collective, i.e. to the market.

Several factors stand in the way of such a choice. First, markets may not be fully integrated and competitive and so may not provide this discipline. This may be especially true of markets for large-scale food imports, which require substantial financial and physical (e.g. transport, storage) capital, though evidence presented below suggests that integration in the region is improving. Informal markets may be more competitive, but are by definition smaller in scale, have more limited geographical scope, and thus may not by themselves be able to respond adequately to a large national shortfall. Second, high transport costs in African markets mean that, even if markets are competitive, final costs to consumers during national production shortfalls can be high (Poulton *et al.*, 2006, p. 346; Tostau and Brorsen, 2005). Finally, government officials – and the public whose votes they need – may have little appreciation for how competitive markets can convert individual profit seeking into socially beneficial outcomes. This understanding is further hindered by the differing beliefs, values, and world views that broadly characterize the government and trading sectors in the region;[3] as noted by Poulton *et al*. (2006; p. 346), civil society also frequently "feels vulnerable to 'speculators' and may be particularly wary where prominent traders come from minority ethnic groups". The trade problem, especially during a food crisis, thus takes on elements of a "*wicked problem*", in which "core beliefs are at stake, competing sides defend their belief systems and attack" those of others, and the problem "(resists) resolution by appeal to the facts" (McBeth *et al.*, 2007; see also Conklin, 2006).

The result of this dynamic is that government often prefers to take an active and direct role in assuring adequate food supplies. Yet no government in the region is capable of handling this challenge on its own. It thus enlists the private sector, but attempts to control its behaviour through some mix of import/export permits, awarding access to subsidized government imports only to particular firms, direct public distribution, and use of the political 'bully pulpit'[4] regarding the amount of food that the private sector should import.

[3] The public and trading sectors are of course not completely separate. Individuals in government sometimes collaborate with the trading (and maize milling) sectors, frequently in secret and for purposes of personal enrichment. We have also acknowledged the validity of patronage as a (partial) explanation for the dynamic we are investigating. We maintain, however, that this collaboration is most often merely strategic, and does little to bridge the gulf in world view between the two parties.

[4] This refers to the use of the persuasive powers and moral authority of the office of the president/prime minister to cajole and otherwise verbally push actors to behave in a fashion believed to be in the public interest.

With no third party solution to the commitment problem, and with trust undermined by the wicked problem, the parties behave in ways that undermine the interests of both. Key among these is *in*action by the private sector: because many firms are motivated more by fear of loss than by desire for gain (Kahneman, Knetsch and Thaler, 1991), uncertainty regarding government behaviour may lead to private sector not importing even when current or anticipated domestic prices suggest that they should. As a result, consumers are harmed by skyrocketing food prices, governments lose political standing, the private sector foregoes current profits, and both miss an opportunity to build a competitive commercial trading network that could serve everyone's interests during future production shortfalls.

The following sections provide two concrete illustrations of how public and private sector interactions caused maize prices to greatly exceed import parity prices: (1) the case of Kenya from late 2008 into August 2009; and (2) the case of Malawi from late 2008 to April 2009.

4. KENYA: JANUARY TO AUGUST 2009

In early 2008, Kenya's main season harvest in late 2008 was estimated to be below average due to high fertilizer and fuel prices as well as post-election violence in early 2008. Erratic main season rains further reinforced the early warning conclusions that maize shortages would arise by early 2009 unless steps were taken to import maize. Early warning estimates of import requirements were in the range of 1 million tonnes. Imports from Tanzania and Uganda were believed to be able to satisfy some of Kenya's residual maize requirements, but Tanzania has an export ban in place. Kenya, on the other hand, maintained a 50 percent import duty on maize through the port of Mombasa throughout 2008. The duty made private importation uneconomic and created a situation in which the Kenyan government would need to arrange maize importation from the world market to avert shortages. However, as of December 2008, the government had imported only 135,000 tonnes from South Africa. Private informal imports Tanzania and Uganda were estimated at 120 000 tonnes through 2008 despite official trade bans (RATIN, 2009).

Kenya's maize import tariff rate has always been a topic of speculation by grain traders given sudden changes and occasional zero-rating by the government (Figure 1). Millers,

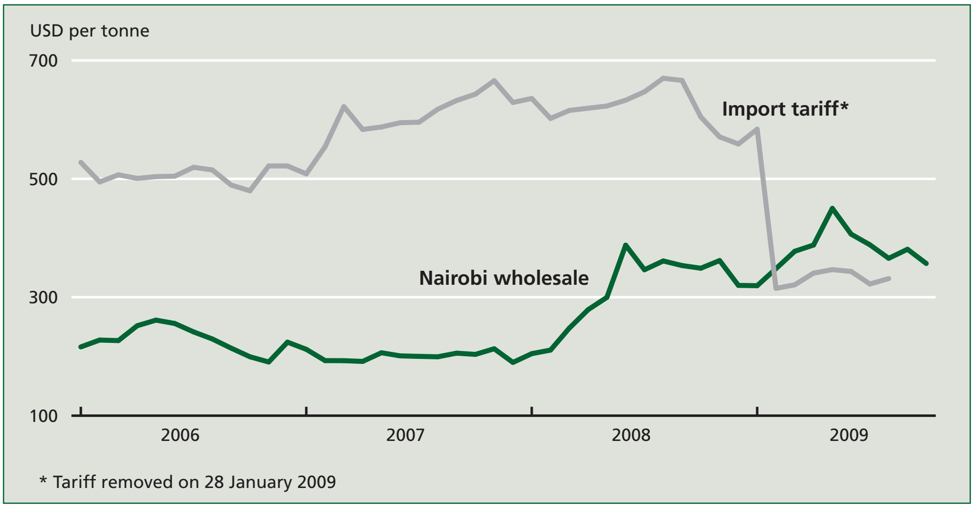
Figure 1. Maize import tariff rate through Mombasa Port, Kenya, 1994–2009

Source: Ministry of Trade and Industry.

traders, and local analysts had been arguing for a duty waiver since it became clear in mid-2008 that massive imports would be required. This would have allowed sufficient grain to be imported well in advance of the depletion of domestic supplies and thereby avoid congestion at the port and undue strain on available upland transport capacity.

In response to the poor harvest and restrictions on importation, prices have risen sharply in 2008. Figure 2 presents Nairobi wholesale maize price trends denominated in U.S. dollars. Note that 2007 price levels were relatively average despite the rise in world food prices that had already begun. High world prices in 2007 and early 2008 no doubt pushed Kenyan maize prices in the range of USD 300 to USD 350 by mid-2008 when the market moved toward an import parity price surface in anticipation of the need for imports. But because of delays in government importation and government's decision to maintain the 50 percent tariff on imports through Mombasa throughout 2008, maize prices stayed at very high levels in late 2008 despite the tumbling of world prices starting in October 2008. Maize prices usually decline by November or December in Kenya as the main season harvest hits the market. The fact that prices continue to stay over USD 300 per tonne at this time could have been an indicator of a food crisis to come.

Figure 2. Nairobi local and import parity prices, January 2006–August 2009



Source: Ministry of Agriculture Market Information Bureau for Nairobi wholesale prices; Kenya Bureau of Statistics for exchange rates; SAFEX and Tegemeo Institute for import parity prices.

In January 2009, Kenya's food crisis took a new turn as allegations of corruption over the issuing of import licenses, reported diversion of maize imports to Sudan, and a lack of transparency over the sale of subsidized NCPB grain have led to the sacking of most of the NCPB Board of Directors and 17 senior managers. On January 16, 2009, President Mwai Kibaki declared a state of emergency and launched an international appeal for USD 463 million to feed roughly 6 million people who were estimated to be food insecure. In January, the World Food Programme has pledged to feed 3.2 million people following the government's declaration of a food crisis in the country.

The import duty on maize was finally lifted on January 28, 2009, allowing importers to buy maize from the international market and bring it into the country duty free. Millers and traders immediately placed import orders from South Africa. Within three weeks, supplies starting landing at Mombasa Port. The Grain Bulk Handling facility at the port was able to offload grain at a capacity of roughly 220 000 tonnes per month. However, inland transport capacity now became the main constraint. The Kenyan Railways system linking Mombasa to the main population centres in central and western Kenya had stopped operating and private transport capacity was insufficient to handle the massive grain imports that were concentrated into weeks immediately after the import duty was lifted. Grain traders interviewed during this period indicated that the maximum transport capacity from Mombasa is 150 000 tonnes per month, which would have been sufficient to transport to upland population centres if imports had been mobilized by mid- to late-2008 earlier, but which were not possible to stave off shortages by the time the import tariff was actually lifted in late January 2009. Consequently, rationing of maize was experienced in late 2008 and domestic prices continued to climb upward of USD 350 per tonne, even as the cost of importing maize to Nairobi had fallen to the USD 300–320 per tonne range. Because grain did not arrive at the port early enough to transport sufficient volumes upcountry (given transport capacity constraints) to meet demand requirements, maize market prices continued to climb during the first half of 2009 well over import parity. This state of affairs could have been avoided if the import tariff was lifted much earlier, especially since national shortfalls were predicted by the early warning systems and by local policy institutes as early as May 2008.

The compression of maize imports into a two-month period (late February–April 2009) also generated additional marketing costs that were ultimately borne by Kenyan consumers. Because inland road transportation was insufficient to handle the volumes imported (estimated at 0.7 million tonnes), traders were forced to store their grain in facilities outside the Mombasa port waiting for available transport to arrive. Upland transport capacity was further constrained by the fact that fertilizer importation for the main growing season typically occurs in February–March as well.

By September 2009, domestic maize prices were again falling in line with import parity as imports continued to relieve the deficit and production from some areas of the country began to hit the market.

5. MALAWI: NOVEMBER 2008 TO APRIL 2009

Malawi has recently received critical acclaim for its success in transforming the country from a food-aid dependent importer to a food secure exporter (New York Times 2007).[5] In 2005/06, the government re-introduced a large-scale fertilizer subsidy program (see Dorward *et al*. 2008 for a detailed assessment). Erratic rainfall in 2005/06 impeded the impact of this program in 2006. In the 2006/07 crop year, the combination of favourable weather and the distribution of improved maize seed and fertilizer through the subsidy program produced what was considered to be a record maize harvest in 2007. The government issued an official maize production estimate of 3.4 million tonnes. Domestic consumption requirements were believed to be in the range of 2.1 million tonnes, indicating a surplus of well over a million tonnes.

In response to the reported surplus for the 2007/08 marketing season, the government issued tenders to private traders to supply 450 000 tonnes for export to other countries

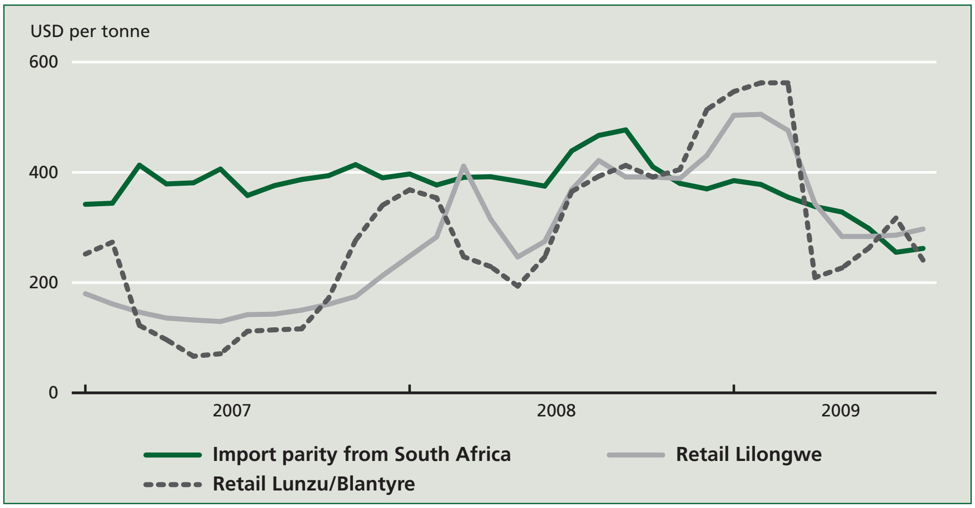
[5] President Bingu Wa Mutharika was recently awarded a United Nations (UN) Global Creative Leadership Award and also received the first Food, Agriculture and Natural Resources Policy Network (FANRPAN) food security policy leadership award for reviving the country's fertilizer subsidy programme. He also was honored at the 2008 African Green Revolution Conference in August 2008 for the country's success in promoting food security.

in the region. However, the private sector reported difficulties in sourcing this quantity of maize, and by late 2007 Malawi had only exported 283 000 tonnes. The government then suspended further exports due to a rapid escalation in domestic market prices. Within several months after the harvest, maize prices reached near record highs, exceeded only in the major crisis year of 2001/02 and the drought year of 2005/06 (Figure 3). By late 2007/early 2008, maize prices in Malawian markets were USD 100 to USD 150 per tonne higher than in other regional markets. The 2007/08 season was also characterized by reports of localized maize shortages, rationing of maize by the Agricultural Development and Marketing Corporation in Malawi (ADMARC) and net maize imports of over 50 000 tonnes from neighbouring countries, primarily Mozambique and Tanzania (Reuters 2008; FEWSNET 2008a). These outcomes are difficult to reconcile with the official estimates of a record maize harvest of 3.4 million tonnes in 2007.

In May 2008 the Government of Malawi reported that the country had produced another major maize surplus, estimated at 500 000 tonnes. In an effort to provide a floor price for this surplus and to accumulate food security stocks, the government instructed ADMARC to purchase more maize this year than in previous years. To achieve this, ADMARC announced commodity buying prices early in the season and also started buying earlier than usual. ADMARC also opened more seasonal markets and temporary buying points.

ADMARC began procuring maize at 20 000 kwacha (USD 140) per tonne at the start of the 2008 harvest, but quickly raised its price to 25 000, then 30 000, and then 40 000 (USD 280) per tonne to outbid private traders. However, market prices rose dramatically in response to the scramble for maize (Figure 3). By early August, ADMARC and the National Food Security Reserve Agency (NFRA) had procured only 60 000 tonnes combined, which by most accounts was considered to be too little to meet the demand for grain at ADMARC depots through the upcoming lean season before the 2009 harvest in May. By early August 2008, only 2–3 months after the reportedly good harvest, maize prices had reached historic highs (Figure 3). Many in Malawi felt that these price rises were orchestrated by private traders. On August 19, the Government of Malawi announced a ban on private maize trade, then in September instructed traders to operate within the official floor and ceiling

Figure 3. Retail maize prices, Blantyre vs. import parity from South Africa, 2000–2009



Source: Ministry of Agriculture monthly price bulletins for retail maize prices; SAFEX and hauliers transport rates for import parity prices.

price of 45 000 kwacha (USD 316) per tonne and 52 000 kwacha (USD 366) per tonne. However, market prices were far above this level and many traders simply stopped buying grain. The Government then arranged a contract with one large trader to supply maize to ADMARC at prices well above the ceiling price.

There is increasing speculation that the official government maize production forecasts may have been overestimated (e.g. Dorward *et al.*, 2008). Reduced confidence in official crop forecasts creates difficulties in determining whether formal imports are required. Evidence suggesting that the 2007 and 2008 Ministry of Agriculture maize production estimates may have been overestimated is based on three points:

(1) *Estimates of substantial informal maize imports from neighbouring countries:* While national maize production estimates for the 2007 and 2008 harvests were both far above national consumption requirements, imports from Mozambique and Tanzania have been streaming into the country almost continuously since January 2004 when the Famine Early Warning Systems Network (FEWSNET) began monitoring informal cross border trade in the region. According to FEWSNET, Malawi has been a net importer of maize in virtually every month, importing 59 000 tonnes of maize in the 2007/08 season through informal cross-border trade flows. In the first 6 months of the 2008/09 season alone, Malawi has imported over 55 000 tonnes of maize (FEWS Net 2008a). In 2007, the Government of Malawi did export roughly 300 000 tonnes of maize to Zimbabwe, but with the apparent consequence of causing rapid price escalation to unprecedentedly high levels in late 2007 and early 2008 as shown in Figure 3.

(2) *Maize prices in Malawian markets have, for most of the 2007/08 and 2008/09 marketing years, exceeded those in nearby regional markets in Mozambique, Tanzania, and Zambia.* At certain times, such as late 2008, Malawian prices have been at least USD 50 per tonne higher than market prices observed on the other sides of the border. In early 2008, after the government exported maize to Zimbabwe, Malawian prices surged over USD 400 per tonne, exceeding those in the neighbouring Zambian and Mozambique markets by USD 100 per tonne. By contrast, Malawi maize prices over the 2000–2007 period have averaged only USD 147 per tonne in Lilongwe and USD 164 per tonne in Lunzu/Blantyre, and it is difficult to explain how official estimates of a record maize harvest could coincide with price levels over twice as high as long-term average prices.

(3) Rationing of maize by ADMARC: reports in Malawi's newspapers and focus group discussions with farmers in Central and Southern Malawi in 2008 (Reuters, 2008; Jayne *et. al*, 2009) reveal frequent stock-outs and rationing of maize sales by ADMARC in both 2007 and 2008. The combination of maize shortages at ADMARC depots, continuous net imports of maize from neighbouring countries, and price levels in Malawi that are higher than those of regional neighbours all suggest that official maize production estimates in recent years have been somewhat overestimated.

The likelihood of food deficits in the 2008/09 season was manifesting in the form of rapidly rising food prices in late 2008. NGOs and World Food Programme (WFP) have indicated that they were unable to source maize in Malawi for school feeding and relief operations because they are forced to tender at prices below 52 kwacha per kg, a level at which both large traders and ADMARC were refusing to sell. Relief organizations could not request financial support for relief food purchases without a formal recognition of a food problem, which is politically difficult given that the President of Malawi has received international acclaim for his success in turning Malawi into a surplus food producer. Consequently, social entitlement programs were undermined by the continued price regulations, while relief food operations were at least temporarily impeded. In early October, 2008, the Malawi

Vulnerability Assessment Committee released a report estimating that 1.5 million people were vulnerable to food insecurity, as many rural households had run out of maize and were forced to purchase their residual food requirements at prices that were extremely high. According to interviews with traders in late 2008 and mid 2009, applications for import licenses were rejected on the grounds that Malawi had sufficient maize supplies, even as prices especially in the southern parts of the country continued to soar over USD 450 per tonne, well above the cost of importation from South Africa.

6. IMPLICATIONS FOR STRATEGIES TO MANAGE FOOD PRICE SPIKES IN BASIC FOOD COMMODITIES

In much of East and Southern Africa, food markets continue to be plagued by a high degree of uncertainty and ad hoc government entry into and retreat from markets, despite official policy pronouncements which are largely inconsistent with actual state behaviour. These inconsistencies give rise to problems of credible commitment regarding governments' policy statements, and hence create risks and costs for private traders. The high degree of policy uncertainty and control over trade impedes private investment to develop access to markets and services for smallholder farmers.

Many countries in East and Southern Africa have continued highly discretionary market and trade interventions of various types, and hence an empirical assessment of these countries' food market performance since the 1990s reflects not the impacts of unfettered market forces but rather the mixed policy environment of legalized private trade within the context of continued strong government operations in food markets. There is widespread agreement that this food marketing policy environment, however it is characterized, has not effectively supported agricultural productivity growth for the millions of small farmers in the region.

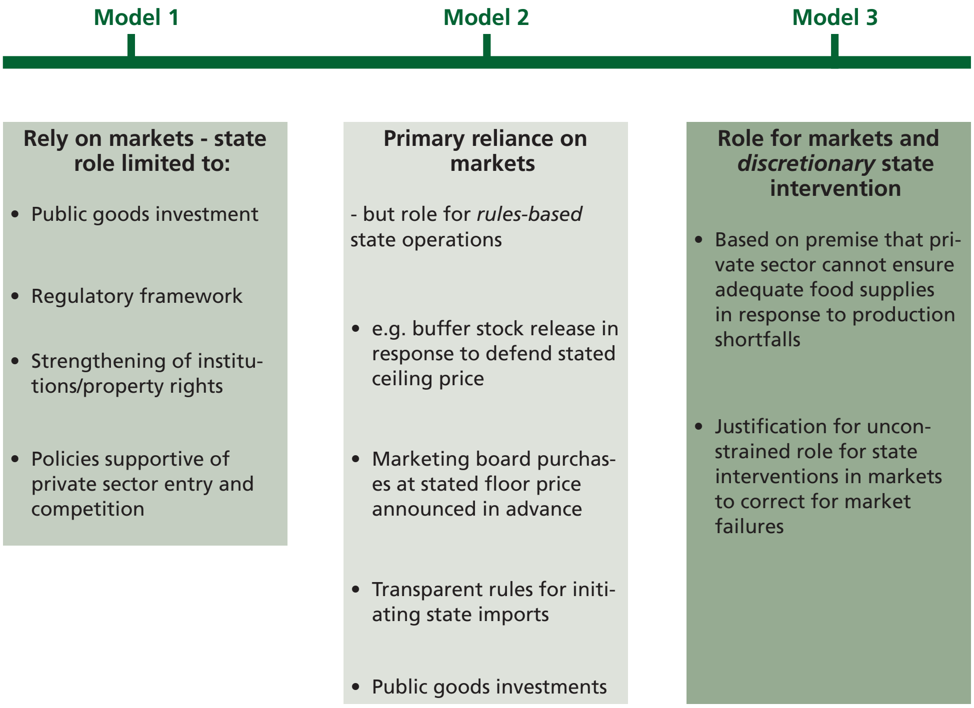
Local banks also tend to withdraw from lending to the sector and allocate most of their investment capital to relatively safe and high-interest government bonds. In these ways, there is still a great deal of sectoral reform to be gained in Africa, not necessarily to liberalize private trade but to unencumber it from the risks and high costs posed by unpredictable government actions in food markets.

Three competing models have dominated policy discussions in Africa over the past decade regarding the appropriate role of the state in staple food markets (Figure 4):

Model 1: State role confined to provision of public goods to strengthen markets: This approach relies on the private sector to carry out the main direct marketing functions – purchase/assembly from farmers, wholesaling, storage, transport, milling, and retailing. The role of the state is confined to provision of public goods: market rules and regulations, physical infrastructure, regulatory oversight of finance, market information, investment in new technology, organizing farmers into groups for means of reducing costs and risks of accessing finance, inputs, and marketing. This position is close to the 'Washington Consensus', which is now generally out of favour.

Model 2: Rules-based state interventions to stabilize market activity: This approach also relies on markets to carry out most of the direct food marketing functions, but the role of the state is expanded to include direct marketing operations, especially in the

Figure 4. Competing visions of staple food market development



arrangement of imports, the management of food buffer stocks, and release of stocks onto markets when prices exceed a publicized ceiling price. The rationale for state operations is based on the premise that markets fail in some respects and direct rules-based state operations are necessary maintain food prices within reasonable bounds. The defining feature of Model 2 is that there is precommitment: the rules governing state operations are determined in advance, publicized, and followed in a non-discretionary manner. This approach appears to be favoured by many technical analysts.

Model 3: Discretionary state intervention to provide state with maximum flexibility to achieve state policy objectives: The defining feature of this model compared to Model 2 is that state operations are not confined to pre-committed rules that would constrain the state's ability to intervene only when these intervention criteria are met. Most governments in eastern and southern Africa are essentially following Model 3 and have done so from the start of the liberalization process. In practice, Model 3 has provided a highly unpredictable and discretionary approach to grain trade policy, commonly imposing export and import bans, variable import tariffs, issuing government tenders for the importation of subsidized grain, and selling their grain stocks to domestic buyers at prices that are unannounced in advance and often far below the costs of procuring it.

Therefore, in spite of the widespread perception that African governments have comprehensively adopted food market liberalization programmes, in reality the agricultural performance of many countries since the 1990s reflects not the impacts of unfettered market forces but rather the mixed policy environment of legalized private trade within the context of extensive and highly discretionary government operations in food markets. Markets may be officially liberalized, but their behaviour and performance are profoundly affected by discretionary interventions by the state.

There are very few examples of Model 1 for staple foods to examine in Africa or perhaps anywhere for that matter. The rationale for Model 2 is that well executed parastatal price stabilization operations can in theory put an upper bound on food prices and also protect against downside price risk by defending floor and ceiling prices through stock accumulation and release onto markets. Successful implementation of Model 2 requires that the marketing boards possess a great deal of technical and management skill.

The weaknesses of Model 2 are that (1) given the long history of ad hoc state intervention in food markets, it is not clear whether Model 2 could be regarded as a credible policy; and (2) given constraints on available government funds for agriculture, spending on expensive government operations in food markets reduces the amount that can be spent on public investments that could potentially earn a higher social return.

Despite being the most common approach for the role of government in food markets, Model 3 is clearly vulnerable to lack of trust, cooperation and coordination between the private and public sectors. A discretionary approach to government operations creates great risks for private sector and tends to impede the private sector from performing functions that it would otherwise do more confidently under Models 1 and 2. The poor performance that results from this high degree of uncertainty and lack of coordination is often attributed to market failure, but a strong case can be made that the more central and underlying causes are chronic under-investment in public goods and a lack of credible commitment in the policy environment, leading to low levels of trust and coordination among public and private sector actors in the staple food systems.

Although price stabilization could in theory have important benefits for producers and poor consumers, along the lines of Model 2, these benefits do not appear to have been successfully achieved because they have been pursued more along the lines of Model 3, i.e. unpredictable and untimely changes in import tariff rates, ad hoc restrictions on private importation, etc. In fact, price instability appears to be greatest in the countries where governments continue to rely heavily on marketing boards and discretionary trade policies to stabilize prices and supplies (Chapoto and Jayne, 2009). Maize price instability in countries like Malawi and Zambia are extremely high despite the persistence of these government operations. By contrast, the operations of Kenya's maize parastatal have reduced price instability (Jayne, Myers, and Nyoro, 2008). While it is difficult to estimate the counterfactual – i.e. the level and instability of food prices that would have prevailed over the past 15 years in the absence of these government operations – there are strong indications that at least some aspects of government interventions in food markets have exacerbated rather than reduced price instability for both producers and consumers.

Concrete guidance

1. When early warning estimates predict a need for large import quantities, remove tariffs soon enough to allow traders to imports over a sufficiently long time period to avoid transport capacity constraints and domestic stockouts.

2. Expand transport capacity e.g. rehabilitate Kenya rail system. If this were done prior to 2009, maize imports could have arrived in greater volumes much faster in early 2009 and pushed food prices down faster.

3. Review the rationale for denying import licenses when applied for by traders.

4. Consider the costs and benefits from the standpoint of governments of transitioning from discretionary trade and marketing policy (Model 3) to adherence to more systematic rules-based policies (Model 2). As concluded earlier, nurturing credible

commitment in with regard to trade policy is likely to promote market predictability and therefore lead to greater supplies and price stability in food markets during times of domestic production shortfalls.

5. Consider whether current proposals for international stockholding would be effective in the presence of domestic transport capacity constraints. International physical or financial reserves would not be able to relieve localized food production shortfalls unless local transport capacity is adequate to absorb sufficient imports within a concentrated period or unless import licenses are provided or the state carries out or contracts for the importation from the international stock source.

REFERENCES

Acemoglu, D. 2003. Why not a political Coase theorem? Social conflict, commitment, and politics. *Journal of Comparative Economics*, 31(4): 620–652.

Bates, R. 1981. *Markets and States in Tropical Africa: The Political Basis of Agricultural Policies*. Berkeley, University of California Press.

Bates, R. & Krueger, A. (eds). 1993. *Political and Economic Interactions in Economic Policy Reform: Evidence from Eight Countries.* Oxford: Basil Blackwell.

Bratton, M. & Mattes, R. 2003. Support for economic reform? Popular attitudes in Southern Africa. *World Development*, 31(2): 303–323.

Chapoto, A. & Jayne, T.S. 2009. *Open or closed maize border policy: A comparison of maize price instability in East and Southern Africa*. International Development Working Paper, number forthcoming, Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing.

Conklin, J. 2006. Wicked problems & social complexity. Chapter 1 of *Dialogue Mapping: Building Shared Understanding of Wicked Problems*, Wiley.

Dorward, A., Chirwa, E., Kelly, V & Jayne, T.S. 2008. *Evaluation of the 2006/07 Agricultural Input Supply Programme, Malawi*. Final report, School of Oriental and African Studies (SOAS), Wadonda Consult, Michigan State University, and Overseas Development Institute (ODI), undertaken for the Ministry of Agriculture and Food Security, Govt. Malawi. March, 2008 (available at http://www.aec.msu.edu/agecon/fs2/inputs/documents/AISPFinalReport31March.pdf)

Falcone, R. & Castelfranchi, C. 2002. Social trust: a cognitive approach. *In* Castelfranchi and Tan, eds*, Trust and Deception in Virtual Societies*. Springer.

FEWS Net. 2008a. *Informal Cross Border Food Trade in Southern Africa*. Washington, DC, Famine Early Warning Systems Network.

FEWS Net. 2008b. *Report on the Joint Field Trip on Post–harvest Food Security and Maize Marketing Monitoring*. 16 – 25 June 2008. Washington, D.C.: FEWS Net, WFP, Government of Malawi, and FAO. (available at http://www.fews.net/docs/Publications/Joint%20Trip%20report-%20Post-Harvest%20Food%20Security%20and%20Maize%20Marketing%20Monitoring%20JuneI%202008.pdf)

Greif, A., Milgrom, P. & Weingast, B.R. 2004. Coordination, commitment, and enforcement: The case of the merchant guild. *The Journal of Political Economy*, 102(4): 745–776.

Jayne, T.S. & Jones, S. 1997. Food Marketing and Pricing Policy in Eastern and Southern Africa: A Survey. *World Development,* 25(9): 1505–1527.

Jayne, T.S., Govereh, J., Mwanaumo, A., Nyoro, J., & Chapoto, A. 2002. False promise or false premise: The experience of food and input market reform in Eastern and Southern Africa. *World Development,* 30(11): 1967–1986.

Jayne, T.S., Zulu, B. & Nijhoff, J.J. 2006. Stabilizing food markets in Eastern and Southern Africa. *Food Policy,* 31(4): 328–341.

Jayne, T.S., Myers, R.J. & Nyoro, J. 2008. The effects of government maize marketing policies on maize prices in Kenya. *Agricultural Economics*, 38(3): 313–325.

Jenkins, C. 1997. The politics of economic policy-making in Zimbabwe. *Journal of Modern African Studies*, 35: 575–602.

Kherallah, M., Delgado, C., Gabre-Madhin, E., Minot, N. & Johnson, M. 2002. *Reforming Agricultural Markets in Africa.* Baltimore, Johns Hopkins University Press.

Lopez, R. 2003. Under-investing in public goods: evidence, causes, and consequences for agricultural development, equity, and the environment. *Agricultural Economics,* 32(1): 211–224.

McBeth, M., Shanahan, E., Arnell, R. & Hathaway, P. 2007. The intersection of narrative policy analysis and policy change theory. *Policy Studies Journal,* 325(1): 87–108.

Mwanaumo, A., Jayne, T.S., Zulu, B., Shawa, J., Mbozi, G., Haggblade, S. & Nyembe, M. 2005. Zambia's 2005 Maize Import and Marketing Experiences: Lessons and Implications. *Policy Synthesis #11, Food Security Research Project, Lusaka*.

Nijhoff, J.J., Tschirley, D., Jayne, T., Tembo, G., Arlindo, P., Mwiinga, B., Shaffer, J., Weber, M., Donovan, C. & Boughton, D. 2003. Coordination for Long-term Food Security by Government, Private Sector and Donors: Issues and Challenges. *Policy Synthesis* 65, Michigan State University.

North, D. 1994. Institutions and credible commitment. *Economic History*, WPA 9412002.

North, D. 1987. Institutions, transaction costs, and economic growth. *Economic Inquiry*, 25(5): 419–428.

Pletcher, J. 2000. The Politics of liberalizing Zambia's maize markets. *World Development*, 28(1): 129–142.

Poulton, C., Kydd, J., Wiggins, S. & Dorward, A. 2006. State intervention for food price stabilization in Africa: Can it work? *Food Policy,* 31(4): 342–356.

RATIN. 2008. East Africa Food and Trade Bulletin. September 2008, No. 50. Nairobi: Regional Agricultural Trade Intelligence Network and Eastern Africa Grain Council.

Sahley, C., Groelsema, B., Marchione, T. & Nelson, D. 2005. *The Governance Dimensions of Food Security in Malawi*. USAID Bureau of Democracy, Conflict, and Humanitarian Assistance, Washington, D.C.

Schaffer, M. 1989. The credible-commitment problem in the centre-enterprise relationship. *Journal of Comparative Economics*, 13(3): 359–382.

Tostau, E. & Brorsen, W. 2005. Spatial price efficiency in Mozambique's post-reform maize markets. *Agricultural Economics,* 33(2): 205–214.

Tschirley, D. & Jayne, T.S. 2010. Exploring the logic of Southern Africa's food crises, *World Development,* 38(1): forthcoming.

van de Walle, N. 2001. *African Economies and the Politics of Permanent Crisis, 1979–1999*. Cambridge, Cambridge University Press.

Hedging cereal import price risks and institutions to assure import supplies

Alexander Sarris[1]

[1] Paper presented at the International Agricultural Trade Research Consortium (IATRC) meeting held in Fort Myers, Florida on December 13–15, 2009. A. Sarris is Director, Trade and Markets Division, Food and Agriculture Organization (FAO) of the United Nations. I would like to thank Ms Marianna Paschali for research assistance. The views expressed here are those of the author and do not represent official views of FAO or its member countries. Contact Alexander.sarris@fao.org.

1. INTRODUCTION

The sudden and unpredictable increases in many internationally traded food commodity prices in late 2007 and early 2008 caught all market participants, as well as governments, by surprise and led to many short term policy reactions that may have exacerbated the negative impacts of the price rises. On the basis that such interventions were in many cases deemed inappropriate, many governments, think tanks, and individual analysts have called for improved international mechanisms to prevent and/or manage sudden food price rises. Similar calls for improved disciplines of markets were made during almost all previous market price bursts, but were largely abandoned after the spikes passed, mainly because they were deemed difficult to implement. However, the fact that the recent downturn in prices coincided with a global financial crisis, which in itself has contributed to increasing levels of poverty and food insecurity, appears to have galvanized attention on the issues facing global agricultural markets. The purpose of this paper is to discuss issues relevant to managing food staple import risks, and to assess possible new international institutional mechanisms designed to instill more confidence, predictability and assurance in global markets of basic food commodities, with the ultimate purpose to render less likely future food price spikes.

The financial crisis that started to unravel in 2008 coincided with sharp commodity price declines and food commodities followed this general trend. Price volatility has therefore been considerable. For instance, in February 2008, international wheat, maize and rice price indices stood higher than the same prices in November 2007, only three months earlier, by 48.8, 28.3, and 23.5 percent respectively. In November 2008, the same indices stood at -31.9, -3.2, and 52.3 percent higher respectively, compared with November 2007. In other words, within one year these food commodity prices had increased very sharply and subsequently declined (except rice) equally sharply. Clearly such volatility in world prices creates much uncertainly for all market participants, and makes both short- and long-term planning very difficult. Analyses of food commodity market prices indicate that, albeit not unusual from a historical perspective, volatility is likely to continue and possibly increase in the future due to new factors, external to the food economy (Sarris, 2009a, 2009b). Food market instability can also lead to various undesirable short and long term impacts, especially for vulnerable households, as several studies have documented (e.g. Ivanic and Martin, 2008, and several other studies in the same special issue of *Agricultural Economics*).

Staple food commodity price volatility, and in particular sudden and unpredictable price spikes, creates considerable food security concerns, especially among those individuals or countries who are staple food dependent and net buyers. These concerns range from possible inability to afford increased costs of basic food consumption requirements, to concerns about adequate supplies, irrespective of price. Such concerns can lead to reactions that may worsen subsequent instability. For instance excessive concerns about adequate supplies of staple food in exporting countries' domestic markets may induce governments to take measures to curtail or ban exports, thus inducing further shortages in world markets and higher international prices. This may induce permanent shifts in production and/or consumption of staples in net importing countries, with the result that subsequent global supplies may increase and import demands may decline permanently altering the fundamentals of a market.

The recent food market spike occurred in the midst of another important longer-term development. Over the last two decades there has been a shift of developing countries from the position of net agricultural exporters – up to the early 1990's – to that of net agricultural importers (Bruinsma, 2003). Projections to 2030 indicate a deepening of this trend, which is due to the projected decline in the exports of traditional agricultural 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. According to the latest FAO figures (FAO, 2009a) in 2008–09 global imports of all cereals were 280.2 million tonnes, 215.2 million tonnes of which were imports of developing countries. Within developing countries, those classified as Least Developed Countries (LDCs) have witnessed a rapid worsening of their agricultural trade balance in the last fifteen years. Since 1990, the food import bills of LDCs have not only increased in size, but also in importance, as they constituted more than 50 percent of the total merchandise exports in all years. In contrast, the food import bills of other developing countries (ODCs) have been stable or declined as shares of their merchandise exports (FAO, 2004).

This trend has been particularly pronounced for Africa. Table 1 indicates that during the period 1970–2004, the share of agricultural imports in total imports of goods and services has declined, but the share of imports in total merchandise imports has increased, with the exception of North Africa. More significantly, the share of agricultural imports in total exports of goods and services, an index that can indicate the ability of the country to finance food imports, while declining from 1970 to 1980 and 1990, has increased considerably from 1990 to 2002–04. This suggests that agricultural (mostly food) imports have necessitated a growing share of the export revenues of African countries.

Table 1. Developments in African agricultural import dependence 1970–2004

	Share of agricultural imports in total imports of goods and services			
	1969–71	1979–81	1989–91	2002–04
North Africa	20.4	4.8	3.5	3.4
Sub-Saharan Africa: LDC	38.4	22.2	19.6	15.1
Sub-Saharan Africa: Other	33.5	20.9	21.4	15.9
Africa	33.3	18.5	17.3	13.2
	Share of agricultural imports in total merchandise imports			
	1969–71	1979–81	1989–91	2002–04
North Africa	23.9	24.2	23.0	17.5
Sub-Saharan Africa: LDC	21.5	22.2	25.9	27.3
Sub-Saharan Africa: Other	17.4	14.8	14.2	18.1
Africa	20.6	20.3	22.4	23.7
	Share of food imports in total exports of goods and services			
	1969–71	1979–81	1989–91	2002–04
North Africa	14.4	18.3	13.2	9.9
Sub-Saharan Africa: LDC	37.6	28.2	30.2	34.9
Sub-Saharan Africa: Other	14.1	8.7	6.8	11.1
Africa	24.1	18.8	17.9	20.9

Source: Author’s calculations from FAO data.

Among Asian developing countries, by contrast, over the same time period the share of agricultural imports in total imports of goods and services has declined from 33.0 to 7.8 percent, and the share of total food imports in total exports of goods and services has declined from 15.5 to 7.1 percent. Hence Asian developing countries' food imports have not increased beyond their capacity to import them. In Latin America and the Caribbean (LAC) agricultural imports are on average less than 20 percent of total merchandise imports. The above suggests that the issue of growing food imports with inability to pay is mostly an African LDC country problem.

The medium-term food outlook, based on projections of net imports of the FAO COSIMO model that pertain to developing countries and LDCs, indicates that based on current estimates, developing countries will increase their net food imports by 2016 in all products except vegetable oils. Similarly LDCs are projected to become an increasing food deficit region in all products. Clearly this suggests that as LDCs become more dependent on international markets, they will become more exposed to international market instability.

The conclusion of this descriptive exposition is that many developing countries and especially LDC countries in Africa have become more food import dependent, without becoming more productive in their own agricultural food producing sectors, or without expanding other export sectors to be able to counteract that import dependency. This implies that they may have become more exposed to international market instability and hence more vulnerable.

Turning to analysis of food import bills a study by Gürkan, *et al.*, (2003) has indicated that between the mid-1980s and 1990s, the LDCs were under economic stress due to the need to import the food they required to maintain national food security. The food they imported reached, on average, about 12 percent of their apparent consumption by the end of the millennium. While this is not necessarily a negative outcome, as it may be due to domestic production restructuring following comparative advantages, the study showed that throughout that period, the growth in these countries' commercial food import bills consistently outstripped the growth of their GDP, as well as total merchandise exports. The study also revealed that LDCs 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 brought about a significant increase in the vulnerability of the LDCs.

A more recent analysis by Ng and Aksoy (2008) supports the above observations. It reveals that of 184 countries analysed with data for 2004–05, 123 were net food importers, of which 20 were developed countries, 62 middle income countries and 41 low income countries. From 2000 to 2004–05 more low income countries have become net food importers. The analysis revealed that the 20 middle income oil exporting countries are the largest food importers, and that their net food imports have increased significantly. This is the group that is most concerned about reliability of supplies, rather than cost of imports. Several small island states (which are generally middle income countries) and low income countries (LICs mostly in Africa) were revealed to be most vulnerable to food price spikes. Analysis of recent data indicates that among the non-grain exporting oil exporters, the average share of cereal imports to total domestic supply is 56 percent. Among small island developing states (SIDS) the same average is 68 percent.

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 LDCs and low income food deficit countries (LIFDCs)[2]. The major problem of LIFDCs is not only price or quantity variations *per se*, but rather major unforeseen and undesirable departures from expectations, that can come about because of unanticipated food import needs due to unforeseen adverse domestic production developments, as well as adverse price moves. In other words, unpredictability is the major issue. This is also the gist of the argument of Dehn (2000), who argued that the negative impacts on growth of commodity dependent economies come from unanticipated or unpredictable shocks, rather than from ex-post commodity instability.

Apart from the problem of the unpredictability of food import bills for LIFDCs, another problem that surfaced during the recent food price spike was the one of reliability of import supplies. Several net food importing developing countries (NFIDCs) that could afford the cost of higher food import bills, such as some of the middle income oil exporting countries, and small island states mentioned above, faced problems of not only unreliable import supplies but also the likelihood of unavailability of sufficient food import quantities to cover their domestic food consumption needs. This raises a different problem for these countries, namely the one of assurance of import supplies. Several of these countries, e.g. those surrounding the Arab Peninsula and the Persian Gulf, have unfavourable domestic production conditions and rely on imports for a substantial share of their domestic consumption. Unavailability of supplies creates large food security concerns for these countries.

The issue of food import risk for LIFDCs has been discussed extensively for some time, especially after the commodity crisis of the early 1970s. Several proposals for international food insurance schemes were put forward in that period (for an early review see Konandreas, *et al.,* 1978). The issue of financing of food imports by LIFDCs featured prominently in the discussions leading to the World Trade Organzation (WTO) Uruguay Round Agreement on Agriculture (URAA), 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' (article 16.1 of the URAA). 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 programs, in order to address such financing difficulties."

The rest of the paper proceeds as follows. In the next section we provide a review of the risks and food import access problems faced by various countries including LIFDCs and NFIDCs, and issues pertinent to policies to deal with them. Subsequently, in section 3, we present a short review of some institutional issues in food importing. In sections 4 and 5 we show how food import price risk can be hedged with futures and options and provide empirical evidence based on data of the past 25 years for several countries.

In section 6 we discuss an international institutional mechanism, in the form of a clearing house, to assure availability of food import quantities by NFIDCs but also possibly LIFDCs and other food importing countries. Section 7 concludes.

[2] LIFDCs are a FAO classification. The latest list of May 2009 includes 77 countries. The list of LDCs is one used by the United Nations (UN) and as of May 2009 includes 50 countries. All but 4 LDCs are also included in the LIFDC list. The list of Net Food Importing Developing Countries (NFIDCs) is a World Trade Organization (WTO) group, which as of May 2009 includes all 50 LDCs and another 25 higher income developing countries, for a total of 75 countries. Of the 25 extra countries in this list only 8 are in the FAO list of LIFDCs, the others being higher income countries. The Low Income Countries (LICs) is a World Bank classification of 53 countries that overlaps significantly with the UN list of LDCs.

2. RISKS FACED BY FOOD IMPORTERS AND POLICIES TO DEAL WITH THEM

Policies for the effective management of price booms differ depending on whether the shock affecting the country is transitory or permanent. Factors to consider are the following: (i) Does the price shock have its origins in factors external to the country, such as world markets, or in domestic production supply imbalances in the markets concerned? (ii) How transitory are the factors that have led to the price shock? (iii) What is the level of uncertainty concerning the factors that may influence the future course of prices? The answers to these questions are not easy, and there may be legitimate differences of opinion among analysts concerning such assessments.

Another issue concerns the possible impacts of the price shock on the country's economy and its citizens. The impact of increasing prices on the wider economy is determined by a number of structural characteristics. Typically, low income food importing countries that are dependent on foreign aid and are characterized by high levels of foreign debt are the most vulnerable to positive food price shocks. Food price increases will directly affect consumption, increasing the incidence of poverty, as well as government expenditure and borrowing, thus worsening debt sustainability. The deterioration of the terms of trade may result in destabilizing the economy, thus hindering economic growth. In the long run, given that countries implement appropriate policies to stimulate agricultural production, supply response to high prices may partly offset this negative impact.

The potential adverse effects of high commodity prices are not restricted to low income food importing countries. Economic insight suggests that exporting countries may experience long-run negative consequences at the macroeconomic level. For these countries, the most frequently cited negative consequence is that of exchange rate appreciation causing a contraction in the non-commodity sector of a commodity exporting economy. Unless the institutional environment in a country assists investment opportunities, high prices may have no permanent impact on the sector.

Similarly at the micro level, inhabitants of a country will be affected differently by high food prices. While generally urban households that are net staple food buyers will lose, as they have to pay more to keep adequate diets, many rural households, especially those that are substantial producers of staple foods will benefit. Households react differently to price booms depending on whether they are urban or rural as well as on their initial endowment and production structure, their consumption patterns, the constraints they face in terms of investment, and the policies that are in force. While poor urban households constitute the most vulnerable population group, poor households in the rural areas may also be negatively affected depending on how they adjust to increasing prices, in terms of changes in production, consumption and savings. On the one hand, if household consumption and activities are not conditioned by credit constraints, income windfalls can be invested, resulting in consumption and welfare increases in line with income from the investment. On the other hand, if the household faces credit and liquidity constraints, as most poor rural households in developing countries do, price boom windfalls can be consumed right away. Thus, price increases may benefit a number of net producing households, leave other households unaffected in the long run, or significantly worsen the welfare of some net consuming and inadequate food producing households. Moreover, price booms are often associated with increased price and general market volatility that may affect income and investment decisions. Finally, the extent of infrastructure development, the availability of credit markets and extension services and the policy environment are crucial factors in the management of price booms by households. For example, well functioning credit markets will allow producers to invest amounts higher than their household savings permit, whilst targeted extension services can assist households in making appropriate investment choices.

Any adopted policy measure should not try to protect or benefit one vulnerable group by damaging the benefits to another poor constituency. In this context, it is important to ascertain the extent to which price signals are transmitted to the domestic markets, the identification of vulnerable population groups that can be targeted for support, as well as the agricultural sector's ability to respond to increasing prices. The macroeconomic environment is also important in formulating policy options. Important indicators consist of the composition of the current account of the balance of payments, the terms of trade, the movements of exchange rates, the country's foreign borrowing requirements and the fundamental characteristics of the domestic labour market.

An additional issue that is imperative before a country adopts specific policy measures is to ascertain and be clear about the objective of the policy. Too often policy measures are adopted with a very narrow objective, and may end up affecting negatively other areas of equally important domestic concern. Also if the objective is known and generally agreed upon, then any policy measure can be judged against others that may offer similar benefits, but with smaller side effects or negative secondary consequences. Finally, is there are more than one policy objectives, it may well be that a combination of measures is necessary to simultaneously achieve all of them.

The reactions to the recent price boom, suggest that policy responses to the food price surge have been prompt, with governments in many developing countries initiating a number of short-run measures, such as reductions in import tariffs and export restrictions, in order to harness the increase in food prices and to protect consumers and vulnerable population groups. Other countries have resorted to food inventory management in order to stabilize domestic prices. A range of interventions have also been implemented to mitigate the adverse impacts on vulnerable households, such as targeted subsidized food sales (Rapsomanikis, 2009).

Demeke, *et al.*, (2009) revised the policies adopted in response to the recent food price spike and indicate that the responses of developing countries to the food security crisis appear to have been in contrast to the policy orientation most of them had pursued over the last decades as a result of the implementation of the Washington consensus supported by the Bretton Woods Institutions. This period had been characterized by an increased reliance on the market – both domestic and international – on the grounds that this reliance would increase the allocation of resources by taking world prices as a reference for measuring economic efficiency. The availability of cheap food on the international market was one of the factors that contributed to reduced investment and support to agriculture by developing countries (and their development partners), which is generally put forward as one of the reasons for the recent crisis. This increased reliance on markets was also concomitant to a progressive withdrawal of the state from the food and agriculture sector, on the ground that the private sector was more efficient from an economic point of view.

The crisis has shown some drawbacks of this approach. Countries depending on the world market have seen their food import bills surge, while their purchasing capacity decreased, particularly in the case of those countries that also had to face higher energy import prices. This situation was further aggravated when some important exporting countries, under intense domestic political pressure, applied export taxes or bans in order to protect their consumers and isolate their prices from world prices.

As a result, several countries changed their approach through measures ranging from policies to isolate domestic prices from world prices; moving from food security based strategies to food self-sufficiency based strategies; trying to acquire land abroad for securing food and fodder procurement; engaging in regional trade agreements or and; interfering with the private markets through price controls, anti-hoarding laws, government intervention in output and input markets, etc.

Before one discusses any mechanism to manage food import risks it is important to ascertain the types of risks that are relevant to food importers. Food imports take place under a variety of institutional arrangements in developing countries. A study by FAO (2003) contains an extensive discussion of the current state of food import trade by developing countries. It notes that while in some LIFDCs state institutions still play a very important role in the exports and imports of some basic foods, food imports have been mostly privatised in recent years, although with some exceptions, and in some countries, state agencies operate alongside with private importers.

A public sector food importer, namely a manager of a food importing or a relevant food regulatory agency faces the problem of determining the requirements that the country will have to satisfy the various domestic policy objectives. Such objectives may include domestic price stability, satisfaction of minimum amount of supplies, demands to keep prices at high levels to satisfy farmers, or low to satisfy consumers and many other targets relevant to various aspects of domestic welfare. For instance, if the government of the country needs to keep domestic consumer prices of a staple food stable at some level P_c then an estimate of domestic requirements in a year t could be given by a simple formula such as

$$R_t = D(p_{ct}) - Q_t \qquad (1)$$

Where R denotes the yearly requirements, $D(.)$ the total domestic demand of the commodity (which will, of course, depend on other variables than just price), and Q denotes the domestic production. Private stockholding behaviour would be part of the demand estimates in (1).

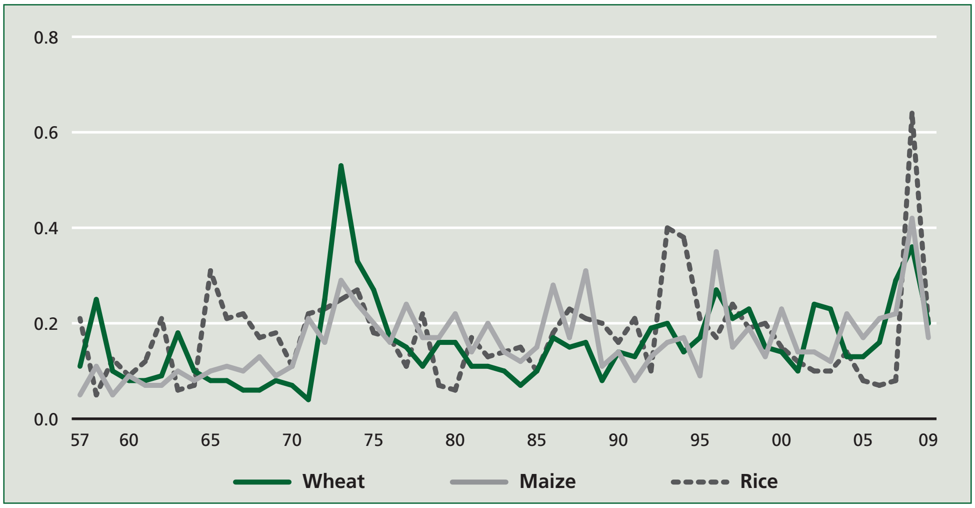
The problem of the manager of the food agency is four-fold. First there needs to be a good estimate of the requirements. This is not easy for several reasons. First estimates of domestic production are not always easy, and more so the earlier one needs to know them. While richer countries have developed over time sophisticated systems of production monitoring, this is not the case for developing countries, especially those that are large and obtain supplies from a large geographical area. Another problem in assessing requirements concerns the estimates of domestic demand, which are also subject to considerable uncertainties. These uncertainties involve variables that enter the demand of the staple, such as disposable incomes, prices of substitute staples, behaviour of private stocks, and many other factors. Clearly these errors are larger the longer in advance one tries to make an estimate of domestic requirements, and the less publicly available information exists about the variables that determine demand.

The second problem of the public sector food agency manager, once the domestic requirements have been estimated, is to decide how to fulfil 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 non-fulfilment of the estimated requirements which may cost domestic social problems and food insecurity. The third problem of such an agent is how to minimize the overall cost of fulfilling these requirements, given uncertainties in international prices and international freight rates, and to manage the risks of unanticipated cost overruns. For instance, if the agency imports more than is needed, as estimated by ex-post assessment of the domestic market situation, then the excess imports will have to be stored or re-exported and these entail costs. Last, but not least, and related to the overall cost of fulfilling the requirements, the agent must finance the transaction, either through its own resources, or through a variety of financing mechanisms.

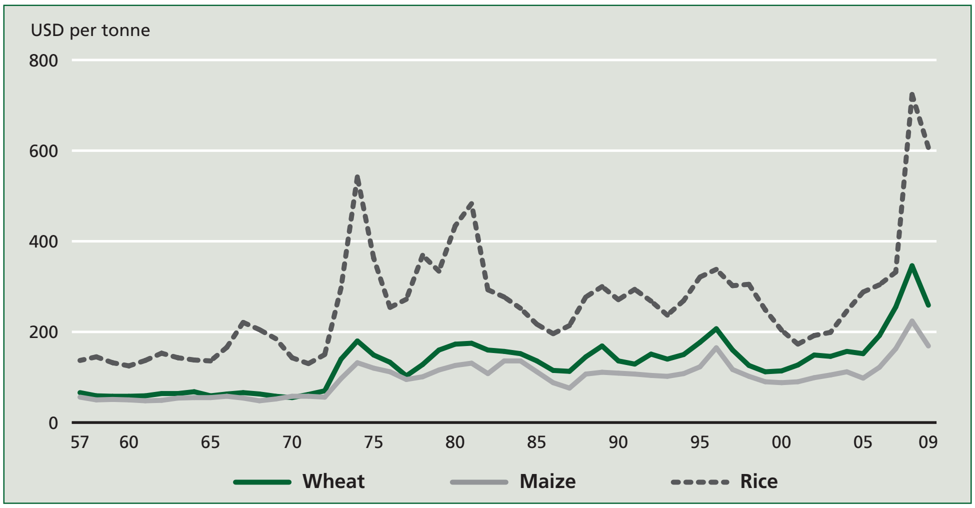
In many countries the State has withdrawn from domestic food markets, and it is private agents who make decisions on imports. The problem however of private agents is not much different or easier than that of public agents. A private importer must assess with a significant time lead, the domestic production 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. Clearly the private importer faces risks similar to those of

Figure 1. Historic volatility and nominal international prices for the major cereal commodities 1957–2009

Nominal annualized historical volatility: Cereal commodities, 1957-2009*



Nominal prices: Cereal commodities, 1957-2009*



* For 2009 only January - May average
Source: FAO Trade and Markets Division.

the public agent, as far as unpredictability of domestic production, international prices, and domestic demand are concerned, and in addition faces an added 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 crisis, surveys by FAO documented the adoption of many short term policies in response to high global staple food prices, which must have created considerable added risks for private sector agents. 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 trade finance.

The outcome risks (welfare or financial losses for instance) faced by the various food import agents depend considerably on the extent to which their operations and actions are shaped by uncertain and unpredictable events. Apart from the domestic uncertainties like production and demand unpredictability, the main external uncertainty facing food importers is international price variability and hence unpredictability. International prices for importable staple commodities are quite variable, as they respond to fast shifting global market fundamentals and information. In the context of the events of the last two years, it is interesting to examine the evolution of world market price volatility. Figure 1 plots the indices of annualized historic volatilities (estimated by normalized period to period changes of market prices) of nominal international prices of the basic food commodities (wheat, maize and rice) over the previous five decades. The figure also exhibits the nominal international prices on the basis of which the indices of volatility are determined. The reason for the juxtaposition of the two types of information is to examine visually the relationship between the level of commodity prices and the market volatility. It has been known since Samuelson's classic article (Samuelson, 1957) that in periods of price spikes, overall supplies are tight, and market volatility should be higher, hence the expectation that during periods of price spikes the index of market volatility should exhibit a rise as well.

A most notable characteristic of the plots in Figure 1 is that historic volatility (as an index of market instability) of most food commodities, while quite variable, appears not to have grown secularly in the past five decades. However, this is not the case for rice. During the recent boom of 2007–08, the volatilities of all three commodities appear to have increased markedly. These observations, while only visual, and need to be corroborated with appropriate econometric analysis, suggest that volatility tends indeed to increase during price spikes, just as theory predicts. This suggests that unpredictability increases during periods of prices spikes, and this makes problems of managing import risks more difficult. If the data is plotted in real terms the conclusions are the same, suggesting that volatility issues are little affected by whether one uses nominal or real prices.

The above discussion pertains to risks faced by food importers, whether public or private, in determining their appropriate trade strategies, whether these involve imports only or imports and stock management. However, once the level of imports needed is determined, there are two additional risks faced by import agents, apart from the price risk. The first is the financing risk, namely the possibility that import finance may not be obtainable from domestic of international sources. This is the risk identified as most crucial by the FAO (2003) study for agents in LIFDCs. The second risk is counterparty performance risk, namely the risk that counterparty in an import purchase contact will default and fail to deliver. This latter risk is one that came to the fore during the recent price spike, and is can be due to both commercial and non-commercial factors. Commercial factors may include the inability for the supplier to secure the staple grain at the amount and prices contracted because of sudden adverse movements in prices. Non-commercial factors include export bans, natural disasters or civil strife, in the sourcing country that may render it impossible to export an agreed upon amount of the staple.

There are four ways to manage the food import risks. The first involves **avoiding or reducing the risk** altogether. This can only be done if there is no need for imports. For a public agency this can be done only if a policy of food self sufficiency or near food self sufficiency for the relevant staple is pursued by the government, perhaps combined with a policy of domestic stock management to control domestic consumer prices. Lower import dependence leads to less vulnerability in terms of import price spikes, but a rearrangement of domestic production structure, which may not be efficient. Hence there exists a trade-off between avoiding the excessive reliance on variable and risky imports in order to assure more reliable staple food supplies, and avoiding skewing the domestic production pattern toward commodities which may not ensure adequate profitability to producers or comparative advantage to the country. For an early illustration of this idea applied to a developing food importing country (Egypt) country see Sarris (1985). For a private agent, avoiding import risk can be done if the agent decides not to import at all.

The second way to manage the food import risk is to attempt to **change the fundamentals of supply and demand**, by manipulating directly the markets that create those risks. For instance, if prices are unstable, then one way to deal with this problem is to try to stabilise them. This attitude to dealing with risks was in fashion in earlier periods, when it was thought that direct commodity control was the proper way to deal with commodity market risk. Domestic control of agricultural markets was the dominant paradigm for a long time in many countries, and is still practiced widely in several countries (including many developed ones). The experience of international commodity control was disappointing (Gilbert, 1996) and is justifiably not currently regarded as an option. Domestic price control of commodities through either trade policy or direct market intervention has also proven to be very expensive, either financially or from a growth perspective. The reason is that it invariably distorts long term market signals, and hence affects the allocation of resources, with likely adverse consequences for growth. It also turns out to be very costly as Deaton (1999) has very convincingly shown, and as developed country governments in the EU and the United States have found out.

The third way to manage food import price risks is to **transfer some of the risk to a third party for a fee**. This is the standard approach to insurance, where a well defined event and related risk is identified first, and then insurance is purchased against the eventuality of the risk materializing. Insurance depends considerably on the ability to identify the risks to which the agent is exposed (which involves not only the specific events, but also the probability distribution of their occurrence) and which are important for the agent, and the availability of insurers who are willing to provide the insurance for a reasonable and affordable premium. Usually insurance can be provided for events for which a probability distribution can be ascertained, and is readily observable, and for risks that can be pooled across a wide range of insured agents. Insurance can be much more easily provided (privately or publicly) for risks that are idiosyncratic and hence can be pooled together by an insurer, such as individual health risks, than for events that are 'covariate' namely affect a wide range of agents simultaneously. High global prices for instance create covariate risks, as they affect all food importers simultaneously. It is clear that food imports are affected by both idiosyncratic risks (namely those that are particular to a country at any one time, such as production shortfalls), as well as covariate, such as global price shocks that affect all importers simultaneously. Global covariate risks create systemic risk problems, and hence may need global solutions.

The fourth way to manage food import risks is to do **none of the above** and just cope with whatever the situation in every period may be. In other words 'bend with the wind'. Such a strategy requires the ability to adjust one's situation to cope with the unexpected event. For instance, if an agent has enough financial resources, and high prices just involve higher cost of imports, then the agent may just pay the higher prices. If the agent faces unavailability of enough import supplies then this will imply reduced domestic consumption with whatever consequences this may have. Clearly this may not be an acceptable option in many country situations.

The major competition in managing food import risks is between approaches two and three above. For a long time governments considered that the best way to reduce commodity price instability was to intervene in the markets and try to stabilize them. Instability was considered a problem that had to be dealt with by eliminating it or reducing it. While some countries have been successful at doing this (the EU through the Common Agricultural Policy, many Asian countries through parastatals, etc.) many others, especially those in Africa, in the course of controlling markets, had rather adverse impact on market functioning. Recently there are many more risk management tools and institutions available, and it is the technological development that must be considered when discussing policy options.

The above discussion assumed that there are no external insurance systems or safety nets or risk diversification instruments available to the entities (individuals of countries) that are exposed to commodity risks. This, however, is not the case for entities in developed countries. Farmers and agricultural product consumers (such as all agents in the marketing chain) in developed countries have a variety of market based instruments with the help of which they can manage the risks they face. For instance elevators that buy grains from farmers in the United States hedge their purchases from farmers in the futures or options markets. Similarly international buyers of coffee and cocoa manage their exposure to commodity risks in the international future and option markets. Producers and consumers in these countries have developed sophisticated market based risk management strategies to deal with commodity risks, and the development of a variety of financial instruments in the last two decades (futures, options, swaps, etc.) has enlarged the possibilities for risk management by these agents. The consequence is that producers and consumers of commodities in developed countries can trade for a price the risks they face in organized markets as well as in less organized over the counter (OTC) markets (for a review of such risk management possibilities and practices see Harwood *et al.*, 1999; Sarris, 1997; and Varangis, *et al.*, 2002).

While the modern markets for risk management instruments are open to all, entities within developing countries have not been very active in using them. The reasons involve a variety of institutional imperfections and financial constraints (for a review see Debatisse *et al.*, 1993). This implies that aid in the form of additional national or domestic targeted safety nets is likely to be not only useful, but also conducive to growth and poverty alleviation. This is the main justification for provision of safety nets at the micro or macro level.

Compensatory financing, such as what has been provided through STABEX, and what is now provided by the Cotonou agreement, and the IMF's Compensatory and Contingency Financing Facility (CCFF), have been the main macro instruments to deal with export earnings vulnerability of developing countries. While the underlying theoretical and empirical rationale for these instruments is solid, their implementation is likely to lead to results opposite to what is desirable. The reason is what is known in the insurance literature as moral hazard. This refers to behaviour, which is altered by the provision of the insurance, so as to make the recipient party adopt more risky strategies, and hence be more vulnerable. A good example is the changed structure of European and US farm producers because of the provision of extensive safety nets in the form of various price supports. The consequence of these programs, apart from the expanded production, has been both increases in the size of many farmers, but also considerable specialisation, something that has made them very vulnerable to downward price fluctuations, and has increased their opposition to reducing the level of the various developed country agricultural safety nets.

The same idea applied to compensatory financing implies that governments of countries recipient of compensatory finance might not make efforts at reducing the exposure to export earnings and import expenditure uncertainty facing them. In fact, they may even adopt export concentration, rather than export diversification strategies, if they know that any export earnings shortfall will be compensated.

The point of this discussion is that the only risks that should be insured via either compensatory financing or any other domestic or national safety net mechanism, without leading to moral hazard problems, are the unanticipated ones. Predictable variations should be dealt with differently, for instance through *ex ante* planning, and not ex-post. Compensating for predictable variations in incomes encourages governments or producers to avoid the necessary *ex ante* adjustments.

That unpredictability rather than instability is the main problem in agricultural production, is one of the oldest, but apparently forgotten or not appreciated, issues in agricultural economics. In fact one of the earliest classic works in agricultural economics considered exactly the issue of agricultural price unpredictability and the benefits of establishing forward prices for producers (Johnson, 1947). By establishing forward prices for agricultural producers, one basically eliminates one of the most troublesome and potentially damaging sources of income unpredictability, and makes producers able to plan better their activities.

Establishing predictability in agriculture has been one of the earliest institutional developments of the modern era in developed countries. In fact the modern US agricultural marketing system realised very early the benefits of a market based system of forward prices, and through the simple system of warehouse receipts, emerged one of the most sophisticated and useful marketing institutions in modern agriculture, namely the institution of futures markets. It is not perhaps coincidental that futures markets developed independently in several countries and long time ago. In more recent years, the development and globalization of financial markets has led to the proliferation of many other risk management commodity related instruments, notably options, and weather related insurance contracts. While in some developed countries the marketing system response to unpredictability has been the establishment of sophisticated forward markets, in most other countries, both developed and developing, the response of producers, and through their pressure of governments, has been the institution of fixed or minimum price marketing arrangements.

In principle such minimum fixed price schemes, can be viable, and logically justified, if there is a good mechanism of predicting future prices. The major problem, however, of most such schemes is not that they are in principle wrong, but that they have most often been transformed to price support or taxation instruments that have veered off their purpose of providing forward signals and minimum prices based on proper predictions. Examples abound in both the developed countries, (for instance the consequences of the expensive and inefficient EU based agricultural price supports are well documented), as well as developing ones (for instance the large implicit taxation involved in much of African export agriculture). The consequence for developing countries is that now, under pressure from donors, the older and inefficient marketing systems that provided some price predictability have been abolished, without any new system in their place.

It therefore appears that the major issue in post adjustment agriculture in most developing countries is how to establish some forward pricing or insurance system for agricultural producers and governments without distorting the markets. Once such forward mechanisms can be established then one can talk about systems of insurance or systems of compensation.

Concerning prices, the major issue, of course, in establishing predictability, is to have some mechanism of assessing future prices. There are basically two such ways. The first is based on market evaluations of the future, and as such it is institutionalised in the organized futures markets that exist for many commodities. The second is based on some kind of technical evaluation of prices, for instance based on a mechanical formula using moving averages of past realisations. Price forecasting is a very uncertain endeavour, however, and the relevant issues are beyond the scope of this paper.

In the sequel the perspective taken is that of an agent, public or private, who has an estimate of requirements of the staple product for his/her commercial or other needs, namely for profit or for food security purposes. Furthermore, it will be assumed that the agent has made a decision of the mix of imports and stock adjustment that will be utilized to satisfy these requirements. This decision, it must be underlined, is a highly nontrivial one for a public agent, and may involve considerable analytical sophistication. Examples of the very few available relevant empirical applications are Sarris (1992) for Ghana, Pinckney (1989) for Bangladesh, and Berlagge (1972) for Pakistan.

3. SOME INSTITUTIONAL ISSUES OF IMPORTING STAPLE FOODS AND RISKS INVOLVED

International staple food trade, even though if involves relatively low or no levels of transformation of the raw material, is a complicated business. The stages involved start with the collection of the staple from producers, warehousing and transporting to port, sea transport, port unloading and warehousing at destination, transporting and/or processing in the destination country, warehousing there, and finally selling to the final buyer. The full cycle takes normally 3–6 months, and many times longer, hence it involves considerable risks over the period from which the two parties (seller and buyer) enter into some kind of contractual agreement for a transaction and the final settlement of goods delivery and payment.

For an importer (public or private) who estimates that he will need to have a specific quantity of imports available at a given future time t, (for ease of exposition t is measured in months), and given that the time lag between contracting a transaction and delivery is some months, the process starts several months ahead, with a decision to contract for local delivery some months k in the future. A first decision that must be made by the importer is the number of months k ahead of the actual delivery of the anticipated needs at t. In most countries international grain importing is done through the use of spot tenders for a set of specified contract requirements (quantity, quality, etc.). These involve a short period (1–2 weeks) before the tender's closing date, and this is done so as to minimize the risk of the counterparty to the transaction to renege on an agreed contract awarded.

For an importer who has decided on a given level of imports, there are three major risks. The first is the risk of unanticipated movements in prices. The second is the counterparty risk of non-delivery of the agreed supplies. A major factor in contract defaults is adverse price movements that have not been hedged adequately by supplier, so price risk is a major factor in counterparty delivery risk. The third is the risk of adverse financial developments that are not adequately foreseen, such as credit related constraints or sudden changes in the country's or the financing bank's conditions.

The advantage of the spot tender is that the risk, whether it is price change or any other event that may impinge on the contract, is small, given the short period of time between the award of the tender and actual delivery. However, in periods of market upheaval as in the last two years, the risk of counterparty default increases considerably for spot tenders. This is because any trader who wins the tender, unless already assured of supplies, either through own supplies already in warehouse or through already committed purchases, may choose to renege on a contract, in the face of adverse price movements, if he has not covered adequately the price risk of the transaction. An alternative is to plan several months k in advance, with a forward contract. While such a contract will diminish the counterpart risk of not finding enough supplies, it will increase the price risk, which if not covered adequately, may be detrimental to the importer. Another alternative to a spot or forward contract is a longer term contract for regular deliveries. Such a contract allows considerable room for forward planning on both the importer and the supplier, sides but it can only be done when there is a clear knowledge of regular and recurrent needs for a particular product.

Another way for the importer to lessen the counterparty risk is to arrange for a third party to take part of the risk. This can usually be a bank which could provide an Over the Counter (OTC) delivery contract. While banks are not usually physical traders, they may be able to ensure better the performance of such contracts by contracting with suppliers in exporting countries and basically lessening the risks to the buyer.

The financing of imports and managing the risk of the financing provided is a very complicated business and involves a variety of agents. An excellent discussion of the various institutional arrangements can be found in FAO (2003). One may start by reviewing the principal payment methods for international trade, which range from open account-clean draft payment terms, namely payment upon shipment or arrival, to a variety of deferred payment terms, such as open account-extended payment, consignment, irrevocable letter of credit, cash in advance, and many others. All of these payment terms involve a variety of financing arrangements, such as seller's credit (deferred payment from buyer) which give rise to trade bills and traders' acceptances, issuance of letters of credit by local importer country banks, bank loans to importers, and others. Depending on the terms of financing, the cost and risks of these financing arrangements differ.

The major conclusion of the survey on financing of food imports done by FAO (2003) was that the major problem for developing country food imports is the existence of significant financial constraints that may prevent the local agents, public or private to import the full amounts that they deem appropriate for their operations.

4. HEDGING FOOD IMPORT PRICE RISK WITH FUTURES AND OPTIONS[3]

The problem that will be dealt with in this section is whether the use of organized futures and options markets can reduce the unpredictability of the food import bill, and at what cost.

Consider an agent who needs to plan imports of some basic food into a NFIDC or LIFDC. The present analysis focuses on wheat, which is one of the most widely traded cereals,

[3] The analysis and results in this section are exposed more fully in the paper by Sarris, Conforti and Prakash (2009).

characterised by well established cash, futures and options markets, and is imported by many NFIDCs. Most countries in this group do in fact import more than just wheat: maize, rice, other cereals, as well as other staples are also common import items.

The problem posed is the following. In the course of a year, the agent will need to import certain amounts of wheat for delivery to the country's border in a given month. It shall be assumed that the agent knows the amounts to be imported in every month, several months ahead. While this assumption may not be perfectly valid as, despite the overall advance production information, monthly requirements may not be exactly known many months in advance, the results stay valid under the objective analysed.

In order to expose simply the theory behind the hedging rules, assume initially that the agent knows that at time *1*, which is some months ahead of the present time, that 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_0 is the futures price of the commodity observed in a relevant organized commodity market at the current period (which is denoted by a subscript *0*) for the futures contract expiring at the, or nearest 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 at or 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 in the current period is denoted by r_0, whereas the profit from the option in period *1* is denoted by $\pi 1$. This profit will be equal to $f_1 - s$ 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 can be written as follows.

$$M = p_1 m_1 - (f_1 - f_0)x - (\pi_1 - r_0)z \qquad (2)$$

It shall be postulated that the agent wishes to minimize the conditional variance of (2), conditioned on information available at the time the agent makes the hedge. This is the objective utilized in several previous analyses of hedging rules, such as Lapan, *et al.*, (1991), and Sakong, *et al.*, (1993), and can also be derived from more general welfare objectives. This objective also turns out to be relevant even if the agent wishes to minimize only the variance of the positive deviations from the unanticipated import cost (see Sarris, *et al.*, 2009). In any case this objective is not meant to capture the full range of domestic food security objectives in any given country, but only the narrower objective of reducing unpredictability of imports.

The solution to the above problem is found under some 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 near futures price.

$$p_1 = \alpha + \beta f_1 + \theta_1 \qquad (3)$$

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

It is also assumed that the current (namely at time *0*) 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.

Given the above assumptions, the minimization of the conditional variance implies that the optimal solution is $x = \beta m_1$ and $z=0$. In other words, the result is 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 (Benninga, *et al.*, 1984; Rolfo, 1980).

One could hypothesize, even in the case in point in which import quantities are known *ex ante*, that the importer only has call options available as a hedging instrument, instead of futures, and explore the optimal hedging rule for this case. It can then be easily derived from the above equations, that in such a case the optimal hedge ratio with call options only is also equal to β, irrespective of the strike price.

All the above discussion pertains to the problem of hedging future import requirements. However, another possibility for the importer, is to buy at time t, namely k months ahead of the actual needs, 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, she/he will need to pay storage cost, and deal with the price uncertainty at the time of the sale. Futures prices reflect the market determined cost of storage of a commodity between the time the futures is bought and the later physical transaction time (times t and $t+k$ in our discussion), albeit this cost can be negative because of backwardation. Hence buying futures can be considered as an alternative to storing, albeit the market determined cost of storage in the Chicago market, may have little to do with the cost of storage (and any implicit backwardation) in the local market. 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 (in this case Chicago), 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, this is something about which we do not have any information, and do not pursue further here.

Turning to the empirical implementation, the situation simulated is one where monthly wheat imports can be hedged with futures and options in the Chicago market. Analysis of wheat import data by source for most countries reveals that the bulk of wheat imports is obtained from three sources, namely the US, Australia, and Argentina. Time series analysis of the monthly export unit values of Australia and Argentina as well as that of the monthly US Gulf price for hard winter ordinary no 2 wheat, indicate that they are highly correlated. Hence the US Gulf price is considered as an indicative price for all wheat imports. The next issue concerns the relationship between the Gulf prices and CBOT prices, as it is this that will dictate the hedge ratio, as well as the form of the function for price expectations. Time series analysis indicated that these prices are cointegrated, and that adjustment to short term shocks is quite fast. Hence the parameters obtained in the relevant time series estimations are used to specify the parameters of equation (3)[4].

Consider the problem of hedging the price risk for an amount of wheat equal to the hedge ratio times the known amount that will be imported some months ahead.

[4] It turns out that the hedge ratio β is very close to 1 (0.998) and the constant is quite small.

Futures and options daily data were obtained from the Chicago Board of Trade (CBOT) from 1985 to 2008, hence they include the high price episode of the last two years. It is assumed that all import transactions are done at Gulf prices. The simulations involve buying futures or call options k months in advance of the actual order, and selling them when the actual physical transaction for wheat imports is concluded.

The actions of the agent will aim at insuring the price risk of the physical purchases. It will be assumed that the cash orders for wheat 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 prices at which wheat imports will be valued and eventually paid, are prices of one month ahead of the actual physical arrivals at the border.

In order to implement the simulations, the agent must decide on the parameters of the rules to follow, namely: the day of the year and month at which the contract (futures or option) is bought; what contract to buy (namely for which month to buy a futures or option contract); how much quantity to buy of the contract; and for options, the decision must be made at what strike price to buy a call option.

The following rules (strategies) are simulated:

Rule 1. Hedging only with futures contracts
Under this set of rules, which are similar to those simulated by Faruqee *et al.,* (1997), it is assumed that the agent buys futures k months in advance of the date when he/she needs to contract the actual delivery. The contract date is assumed to be one month before the needed monthly physical delivery of import, as per the seasonal import needs, which, as indicated above, is assumed to be known. 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. For the simulations reported below, it has been assumed that the day when the transaction is made is the day closest to the middle of the month.

Concerning costs, it is first assumed that the cost of buying or selling futures is USD 0.15 per tonne, just as in Faruqee *et al.,* (1997). In addition it is assumed that each futures transaction requires the deposit of a 5 percent margin. There is an interest cost on this margin valued at the US monthly short term interest rate. This cost is calculated over the period of the hedge.

Rule 2. Hedging with options
All 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 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 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 this future price for which insurance is sought. Hence if α =0.1, the (out of the money) call option bought implies that if the future price observed at the time of ordering the grain import, is above the strike price – which as per the option specification is 1.1 times the current future 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, a transactions cost for buying the call option equal to 4.5 percent of the option price is assumed.

It is assumed that the objective of the hedging exercise is to reduce the conditional variance of the import bills. Given this assumption, 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. These changes can be expressed for a period $t+k$ as follows

$$M_{t+k} - E(M_{t+k,t}) = \{p_{t+k} - E(p_{t+k,t})\}m_{t+k} \quad (4)$$

One can then compute the variance (or standard deviation) of the changes in (4) over a given historical period. Note that implicit in (4) is the assumption, already discussed earlier, that the expected and actual imports at time $t+k$ are the same.

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

$$\{[p_{t+k} - E(p_{t+k,t})] - \beta(f_{t+k} - f_t - \tau_f f_t - m\arg c)\}m_{t+k} \quad (5)$$

where τ_f denotes the unit transactions cost of buying a futures contract and *margc* is the interest cost of the margin.

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

$$\{[p_{t+k} - E(p_{t+k,t})] - \beta(\pi_{t+k} - r_t - \tau_o r_t)\}m_{t+k} \quad (6)$$

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) τo denotes the unit transactions cost of buying a call option contract.

As per assumption (3) and the empirical estimates of (3) 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 the following expression is used for estimating the conditional expectation in equations (4)-(6):

$$E(p_{t+k,k}) = \alpha + \beta f_t^{t+k} \quad (7)$$

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 (see next section).

The simulation exercise compares the normalized standard deviations of the expressions in (4)-(6). The normalization is obtained by dividing the standard deviation of the differences in expressions in (4)-(6) 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 term is the same in the case of unhedged and hedged imports, so that whatever differences are 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 average monthly import values are approximate and indicative wheat import bills, built up on the assumption, discussed above, that the price paid by an importing country when importing from the US or any of the other main exporters is the Gulf price.

5. EMPIRICAL SIMULATION RESULTS OF HEDGING WHEAT IMPORTS WITH FUTURES AND OPTIONS

Table 2 presents the average unanticipated changes in the cash and future prices over the periods 1985–7 to 2005–12 the recent upheaval 2006–1 to 2008–12 and for the two periods combined, and the standard deviation of prediction errors.

Several observations are in order. First the ability of a simple linear formula like (7) to predict the subsequent actual cash price is quite good on average in 'normal' periods, even some months in advance. Notice that the average percent forecast errors during the period 1985 to 2005 for all values of were smaller than 1.2 percent. During the period of high prices, namely the period 2006–8, the ability of a simple formula like (7) to predict the eventual cash price of wheat deteriorated only slightly for k=2 and k=4, but more so for k=6. This performance is mirrored in the ability of the futures price for forecast the subsequent futures price. The forecast statistics for average unpredictability of the futures prices are quire similar to those of the cash market statistics.

Turning to the variability of *ex ante* predictions, the last two sets of rows in Table 2 exhibit the standard deviation of the percent forecast errors of the expected cash and the futures prices. It can be seen that these are considerable and increase with the length of time before the actual purchase, as would be expected. For instance for k=2, namely for two months advance, the average percent standard deviation for the cash and futures price of wheat

Table 2. Average unanticipated prediction errors of cash and futures prices, coefficients of variation of cash and futures prices, and standard deviations of percentage prediction errors of cash and futures prices for wheat on CBOT over 1985–2008

		1985–7 to 2005–12	2006–1 to 2008–12	1985–7 to 2008–12
Average Gulf price (USD/tonne)		143.3	257.6	157.6
	k=2	-1.1	1.5	-0.7
$(P_t-E_{t-k}(P_t))/P_t$ (percent)	k=4	-1.2	1.6	-0.9
	k=6	-1.0	4.2	-0.3
	k=2	-0.3	0.9	-0.2
$(F_t - F_{t-k,t})/P_t$ (percent)	k=4	-1.3	1.0	-1.0
	k=6	-1.9	3.5	-1.2
CV of Gulf price (percent)		18.9	30.3	33.7
CV of CBOT near futures price		17.1	32.2	31.8
	k=2	8.3	16.1	9.6
Stdev of $(P_t-E_{t-k}(P_t)/P_t)$ (percent)	k=4	10.9	22.6	13.0
	k=6	13.3	26.0	15.6
	k=2	8.0	16.2	9.4
Stdev $[F_t - (F_{t-k,t})/P_t]$ (percent)	k=4	10.4	22.6	12.6
	k=6	12.9	25.6	15.2

Source: Sarris, Conforti and Prakash (2009).

over the period 1985–2005 is around 8 percent. As the 95 percent confidence interval for predictions under normality is about two standard deviations, these numbers imply that even within 2 months before actual ordering, the price uncertainty is in the vicinity of 16 percent of the currently observed cash price. This is considerable and basically indicates the variability and unpredictability in these markets, even for short planning periods. For k=4 the same standard deviations increase to 10–11 percent. For k=6 the numbers jump to about 13 percent. Notice, however, that during the food price increase period of 2006–08, the unpredictability increased considerably, with the standard deviations of the prediction errors in both cash and futures markets increasing by 100 percent or more in some cases from the averages of the more normal twenty year period of 1985–2005.

Turning to the unpredictability of the import bills, out of the LIFDCs group, eleven countries were selected that have been wheat importers over the past 25 years, based on availability of monthly import data. The sample of importers accounted for 58 percent of total LIFDCs wheat imports in the period 1980–2008, and for 23 percent of world imports of this product.

Table 3 indicates the unanticipated normalized standard deviations of monthly wheat import bill changes (based on (4)) with and without hedging with futures. Table 4 repeats the exercise when hedging is done only with at the money options. The results cover as in the previous tables two periods, namely the period 1985–7 to 2005–12, namely before the grains price spike, the spike period 2006–1 to 2008–12, and the two periods combined.

The results in Table 3 indicate that for all the countries analyzed there seems to be substantial reductions in import bill unpredictability for all periods and for all values of k, when imports are hedged with futures. The only exception seems to be India for which the unpredictability with futures and for k=4 seems to have slightly increased. This seems an oddity and is not due to the behaviour of the cash or futures prices, as these affect all countries in the same fashion. The phenomenon may be due to the particular pattern of imports of India during the crisis period. In fact wheat imports of India during the last year of the crisis period, namely 2008, declined to about 10 percent of the average wheat imports of the previous two years. Furthermore, India seems to have exhibited in the past 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 during the rest of the year. It may be that the combination of the particular price pattern of wheat during the crisis, in combination with the particular import pattern of India during the crisis generates this result.

The reductions in unpredictability of import bills seem to be larger during the crisis period of 2006–08 compared with the earlier period for all countries and values of k, with the notable exceptions of China and India.

Table 4 indicates that if hedging was done with options only, the unpredictability of wheat import bills would have also decreased considerably for all countries and periods, again with the only exception being India for the crisis period and for k=4. The percent reductions in unpredictability are smaller with options (as expected from theory) in all cases. The reductions seem to be larger for the crisis period for all countries except China and India.

The simulated reductions in unpredictability are quite substantial. An important result is that reductions in unpredictability were quite significant during the recent crisis period and larger than in normal times. This suggests that during price spike 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, seem to be

Table 3. Unanticipated normalized standard deviations of monthly wheat import bill changes with and without hedging with futures and 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 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	-64.8	-54.9
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: Sarris, Conforti and Prakash (2009).

quite efficient, no agent can be expected to make profits in the long run from applying hedging rules of the types simulated here. Hence the motivating force for hedging can be predictability and improved planning, and not profitability, which would rather be the motivation of private speculators, but not of financial or import planners.

6. A PROPOSAL TO CREATE A DEDICATED FOOD IMPORT FINANCING FACILITY[5]

As identified in previous studies by FAO (2003), a major problem facing LDCs and NFIDCs is financing for both private and parastatal entities of food imports, especially during periods

[5] The discussion in this section draws partly on an earlier unpublished paper by FAO and UNCTAD (2005)

Table 4. Unanticipated normalized standard deviations of monthly wheat import bill changes with at the money options hedging only

	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 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	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	-45.0
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	053.1	-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: Sarris, Conforti and Prakash (2009).

of excess commercial imports. The financing constraint arises from the imposition, by both international private financial institutions and domestic banks that finance international food trade transactions, of credit (or exposure) limits for specific countries or clients within countries. These limits can easily be reached during periods of need for excess imports, thus constraining the capacity to procure finance for food imports and as a result, food import capacity. It is this constraint that the facility proposed here is designed to overcome.

The purpose of the food import financing facility (FIFF) is to provide financing to importing agents/traders of LDCs and NFIDCs to meet the cost of **excess food import bills. The FIFF will not replace existing financing means and structures; rather it is meant to complement established financing sources of food imports when needed**. This will help "to maintain usual levels of quantities of imports in the face of price shocks, or to make it possible to import necessary extra quantities in excess of usual commercial import requirements", as anticipated under the Marrakesh Decision. The financing will be provided to food importing agents. It will follow the already established financing systems through central and commercial banks, which usually finance commercial food imports using such instruments as letters of credit (LCs). The financing provided through the FIFF will not only increase the financing capacity of local banks, but will also induce the exporters' banks to accept the LCs of importing countries in hard currency amounts larger than their credit ceilings for these countries.

The FIFF is envisioned not to actively provide finance to a given country's agents continuously, but only if specific conditions arise. Such **trigger conditions** involve predicted food import financing needs in excess of some margin above trend levels of food import bills. The predictions will be based on the *price* and *volume* components of imports, whereby prices are world market prices for key food commodities imported by LDCs and NFDICs. The volume component involves indicators relating to reductions in domestic production due to a variety or objectively determined indicators (primarily weather), or reductions in food aid which may force the country to import more at commercial terms. A key decision in the set up of the facility is whether only external (mainly price) shocks are to be financed, or also some types of internal shocks (e.g. those due to natural disasters or adverse weather). The FIFF outlined below can function under either or both of these conditions.

Based on appropriate trigger conditions (to be elaborated below) and appropriate amounts (specific to each country), the FIFF will make available financial resources to the concerned banks (of the importing or exporting country), in the form of guarantees and not actual funds, albeit the latter could also be envisioned. The banks in turn will make the excess finance available to domestic food exporting or importing agents, over and above their normal financing needs or ceilings. A key aspect of the FIFF is that it will not finance the whole food import bill of a country, but only the excess part (to be discussed below). In this way 'co-responsibility' will be established, only real and likely unforeseen needs will be financed, and the cost of excess financing will be kept at a low level.

The basic feature of the proposed FIFF is to provide the required finance at a very short notice, and exactly when needed, once the rules of operation are agreed upon in advance. Thus, the delays common to past ex-post insurance or compensation schemes that rely on ex-post evaluation of 'damages' can be avoided. The proposed FIFF will operate in real time.

The FIFF could function in different ways. The most efficient way for the FIFF to operate is like a '**guarantee**' **fund**, which will enable commercial banks to extend new credit lines to food importers when required. Alternatively, the FIFF can act as a financing intermediary, borrowing in the international bank and capital markets for on-lending to food importers. In both cases, its financial strength would be based on guarantees provided to the FIFF by a number of countries or international financial institutions. The fund will charge a small premium to cover its operational and risk costs, and will also hedge its loans in the organized and over the counter (OTC) derivatives markets so as to minimize the risk of losses. The main advantage of the FIFF lies in its minimal costs. Through risk pooling for a large number of countries and food products, and owing to its risk management activities, the operational costs and the amount of the revolving fund needed for the FIFF will be relatively small.

The **basic structure** of the facility would consist of the following:

1. A core team of experts (seconded from various international institutions, or employed directly) will be dedicated to the FIFF and assume the task of estimating food import trends and current requirements, as well as determining the trigger conditions and the amounts of excess food import financing limits for each affected country.

2. The FIFF will benefit from guarantees by a number of countries, which will allow it to borrow for long term in international markets to make up its operating fund, or to provide loan guarantees to commercial banks.
3. When specific trigger conditions arise, the FIFF will interpose between importers and sellers (without interfering in normal commercial relationships). Through its actions, it will make available financing to banks financing food exports, or the central and/or commercial banks of importing countries, (according to pre-set procedures and criteria), who will then make additional loans available to exporters or domestic importers. These loans will be reimbursed to the FIFF within six months (or a longer period agreed upon) by the relevant banks.

The real functioning of the facility will be more complex, since it has to reduce FIFF costs, as well as the financing risks and the necessary interest rate charges. However, these are implementation details that will be worked out once the principles are agreed upon.

Trigger conditions involve the prediction of food import bills that are above a certain agreed margin over the trend of food import bills. The predicted food import bills will include as mentioned earlier *price* and *volume* components. Prices are world market prices (in agreed visible commercial international markets with appropriate volume to be considered representative of world market conditions) for key food commodities imported by LDCs and NFDICs. Predicted prices consist of futures prices (when these exist) or forecasted prices (with models developed and maintained by the FIFF, and agreed upon by the FIFF membership). As it is impossible to specify whether world price increases, especially over a short period, are due to trade related factors or other economic or natural factors, and since there is a need to be objective, no attempt will be made to specify the types of underlying causes of price shocks that will trigger FIFF financing, or make FIFF financing conditional on any of these price augmenting factors.

Import volume indicators can relate to one or more of the following: Reductions in food aid which may force the country to import more at commercial terms; Reductions in access to food on various preferential terms; Reductions in domestic production, due to variety of unforeseen, mainly natural causes and which cannot be compensated by food aid.

The triggers will involve predicted food import bill requirements in excess (by given margins) of trends that are assessed on the basis of past volumes, and agreed methods. The import bill predictions cannot be fully comprehensive, as, of necessity, they can include only the major food imports for which there are reliable international price indices.

The facility will make **financing** at normal commercial terms. The basic tenor could be six months (more than enough to export and sell the food imported under the facility onwards to the public), and interest rates will not be less than those paid by central or commercial banks in each borrowing country for international borrowing under normal conditions. This has two important implications: interest rates will differ from country to country; the facility will have a built-in capacity to resist unnecessary disbursement, as credit terms will only be attractive in times of crisis when borrowers are unable to find 'normal' credit conditions. Interest rate subsidies or a longer repayment period are inefficient, and are thus not envisioned. It should be kept in mind that the purpose of the FIFF is not to subsidize excess food imports, but to enable the realization of additional food imports needed by the country, something that may require finance beyond the various credit ceilings available by international private financial institutions for LDC and NFIDC banks and clients.

The FIFF is designed to alleviate international credit constraints for food imports. The constraints involve country specific credit ceilings by commercial banks in developed and other countries, involving loans to a given country for any purpose. There are various ways for the FIFF to overcome this constraint. One would be for the FIFF to refinance credit lines provided by these commercial banks[6] . Another mechanism is to involve the FIFF in *ex ante* tripartite agreements between perhaps an international financial institution representing both donors and recipient countries, the FIFF, and the relevant commercial banks, who would agree to increase their country's exposure in the 'trigger cases' specified by the FIFF and for amounts also specified by the FIFF. In this way, the FIFF could serve as a guarantor or reinsurer of 'excess financing exposure'. These agreements will have to be *ex ante*, so that when the time comes for the extension of credit above any given credit limits, commercial banks can immediately obtain the FIFF guarantee. The FIFF could hedge both foreign exchange risk, as well as the sovereign risk through existing and emerging commercial markets for such risk (there are such instruments currently been traded and many regional multilateral banks are interested in developing them further).

The principal **risk** for the FIFF is that it will not be reimbursed by its borrowers. This risk will be managed actively. As the facility would not set out to disturb the normal functioning of international food trade, there is a 'non-zero' risk that the local or central banks cannot be reimbursed by their local food importing clients. This would primarily be the concern of the domestic and central banks of each country, and not the FIFF. Nevertheless, lack of reimbursement by the ultimate beneficiaries of the finance may lead commercial banks to default on their obligations (or delay repayment) to the FIFF.

The facility will follow the normal patterns of food trade. In most LDCs and NFDICs, food imports are in private hands, and many of the ultimate beneficiaries of the financing will be small private companies. Perfect control of risks will be impossible, but there are several ways to reduce them, including counter guarantees from local banks, and the use of collateral management companies to keep physical control over the foodstuffs until they are sold onwards by the importer. As mentioned above the risk management activities of the FIFF will be instrumental to minimize losses. The cost of these risk management activities of the FIFF can be built into the interest rate differentials between the sources of FIFF funds, and its loans.

The FIFF would benefit from guarantees from a number of countries. Ideally, this would include a number of OECD countries, which would enable the FIFF to borrow at AAA terms. But any group of countries could provide guarantees; the risk rating of the FIFF is then likely to be that of the best among these countries or possibly a bit better than this.

As noted before, there are different ways of varying financial complexity for the FIFF to ensure that food importers obtain extra finance when conditions require it. In one model, on the back of its guarantees from member countries, the FIFF can borrow easily from the international bank and capital markets. Two types of borrowing activities can then be envisioned. The first, to be conducted at the start of the FIFF, will involve borrowing long-term to set up a small revolving fund that will provide the initial capital of FIFF. In addition to this revolving fund, the FIFF may need additional funds in a given 'bad' year. In such a year, the FIFF would borrow additional funds from international capital markets under the guarantees of the contributing countries. If the proper mechanisms have been set up beforehand, the delay between trigger conditions being breached, and money being available to extend finance to central or commercial banks could be less than two weeks. This will ensure that normal commercial imports of foodstuffs can continue uninterrupted even in times of large external shocks.

[6] This is a mechanism used for example in the USA to enable domestic banks to provide more rural loans and mortgage loans to smaller clients, with public institutions such as FannieMae providing a refinancing facility to these banks.

Assuming that the FIFF's operational costs are covered by WTO member contributions[7], there will be a fairly large gap between the financing costs that the FIFF faces, and the normal credit terms that food importers or their banks in LDCs and NFDICs are used to. The FIFF should be able to borrow at investment grade rates, and to lend at rates a few percent above this. The difference can be used for a number of purposes, such as: buying sovereign risk insurance and currency convertibility insurance to insure against default risk; buy 'call options', much as discussed in the previous section; build a lower-cost tranche (or a tranche with stronger protection against the risk of world market price spikes), allowing countries with well-targeted food distribution programmes to continue providing food at reasonable terms to certain groups. In the latter two cases, these add-ons have their own large benefits (in particular compared with many of the non-market based alternatives), and donor agencies may wish to make extra grant funds available for such purposes. LDCs and NFDICs may also wish to take out 'insurance' against the risk of world market price increases at their own cost, and the FIFF could advise such governments on this, given its own expertise and involvement in such risk management operations.

The operational costs of the FIFF will be low. The FIFF will have two core functions, and one secondary function. The first core function is to gather and analyze data on food prices, food quantities, needs, and food aid flows, in order to assess the triggers for the extension of additional credit, as well as the amounts of additional financing needed, building on work and technical capacity done in existing organizations (FAO, WFP, IFPRI, World Bank, etc), and hence would require minimum resources in terms of full time technical staff members.

The second core function is to ensure food trade finance when trigger conditions are reached for one or more countries. This requires some financial management expertise. If it is deemed that this is beyond the capacity of the FIFF, then this could be outsourced to one or more international banks or insurance companies, which would act as an agent for the FIFF and be paid on a real cost basis.

Financing needs of the FIFF. To put some numbers behind the concept, Appendix A makes some calculations of the yearly average financing needs of a FIFF of the type proposed here, as well as calculations of the maximum financing needed in an exceptional year. The computations suggest that average yearly FIFF guarantee financing for LDCs would be in the vicinity of USD 200–430 million, while the financing needs in an exceptional year may reach as much as USD 2 400 million. To put these figures in perspective the average yearly LDC commercial food import bill for all foods between 2000 and 2007 was USD 10.7 billion. Hence the FIFF average annual financing needs would constitute about 2–4 percent of yearly LDC combined commercial food imports. In a year of exceptional needs, the value of FIFF guarantee financing needed could rise to as much as 23 percent of the total LDC food import bill. If all LIFDCs were to be covered by the FIFF, then the guarantee financing needed would be in the range of USD 960–1937 million, and this constitutes around 1.8–3.7 percent of the average LIFDC food import bill for the period 2000–2007. In an exceptional year the maximum financing needed could rise to as much as USD 10 billion, which would be about 19 percent of the total LIFDC average food import bill of the same period.

[7] Alternatively, if the guarantees that it receives are good enough, the FIFF could be allowed to become self–financing in a manner similar to the World Bank, that is to say, it would be able to borrow cheaply against the guarantees even when LDCs and NFDICs do not require the support, and place the funds in higher-earning assets.

7. AN INTERNATIONAL GRAIN CLEARING ARRANGEMENT TO ASSURE FOOD IMPORT SUPPLIES

The above discussion and analysis pertains to managing the unpredictability of prices and the attendant risks, and alleviating the financing constraints faced by staple food importers. This, however, does not deal with the problem of counterparty performance risk, namely the risk of reneging on a delivery contract, faced by many food importers. In other words, the problem in this case is not so much unpredictability of food import costs, or high food import prices, or financing, but rather assurance that supplies will be delivered. This does not only pertain to short term contracts but also longer term contracts. As mentioned earlier, the basic reason for non-performance of international staple food import contracts is adverse price movements or adverse financial events that prevent a food exporter or trader to fulfil an import contract.

The basic risk of a defaulter on a delivery contract is one of damage to a trader's reputation and missing on future contracts. This risk, however, must be counterbalanced against the risk of very adverse financial outcomes for the trader, including possible bankruptcy if a contract that has not been hedged or planned appropriately, is executed. Clearly this is not an easy decision of a trader, and probably depends on factors such as the magnitude of the market under threat to future contracts, the size of the trader, the industrial structure of the trade and the number of alternative sources for the same type of contract, the financial situation of the trader, the size and possible damage to the trader's reputation, etc. One, thing, however, that seems to imply a higher risk in international trade deals compared with domestic ones, is the fact that there seems to be no contract enforcement mechanism in international staple food grain transactions.

Contracts in organized commodity exchanges are enforced because there is a clearing house which is responsible for making sure that all transactions are executed. Similarly contracts within one national legal jurisdiction can be enforced as there is a legal system to ensure contract enforcement, albeit a court based legal enforcement system is quite slow. Most international contracts are very similar to Over the Counter (OTC) contracts in the sense that is it only the financial and reputation status of the two parties that instils confidence in contract enforcement. There is no mechanism for international contract enforcement, and whatever juridical procedures exist are slow, uncertain, and costly, and cannot deal with the immediate risk of contract cancellation.

The basic missing institution is an international clearing house type of arrangement similar to the clearing houses that are integral parts of the organized commodity exchanges, which ensure that all contracts are executed. The key question is whether an international clearing type of mechanism can be envisioned to ensure the performance of staple food type of import contracts. In the sequel, we examine the components of what may be termed an **International Grain Clearing Arrangement (IGCA)**. The objective of an IGCA would be to guarantee or insure performance of grain import trade contracts (short, medium and long term) between countries or private entities.

A major function of a commodity exchange clearing house, apart from the settlement of the financial contracts, which amount to the bulk of settlements, is to ensure that physical delivery can take place, if needed. This is for instance one of the functions of the Chicago Mercantile Exchange (formerly the Chicago Board of Trade), and to ensure this a variety of rules and regulations with respect to delivery obligations are adopted by the exchange and the clearing house. In most organized exchanges, physical delivery is a very small portion of all transactions, but if a trader insists on delivery then this must be arranged by the exchange. Many exchanges have arrangements with warehouses so that physical deliveries can be made against a futures contract, and there are severe penalties for anyone with an open contract who either does fulfill the financial terms or delivers a physical commodity on it. It is these properties that would need to be emulated by an envisioned IGCA, in order to it to be viable as a guarantee institution in international staple food transactions.

Probably the best way to implement something on an international scale resembling the functions of the clearing houses of existing organized exchanges would be to **link existing or envisioned commodity exchanges**, with their respective clearing houses. In other words, it may be appropriate to think of how parts of contracts bought on one exchange could be guaranteed not only by the clearing house of the exchange in question but by clearing houses of other linked exchanges. Consider, for instance the situation of an importer, who is contemplating of purchasing at a later point of time, some months from now, a given amount of wheat or maize or another staple for which there are organized exchanges. The subsequent purchase will be done with an open tender for delivery to the location and at the time the importer desires. If the importer follows the hedging methods outlined and simulated in section 4 above then he/she may opt to buy a call option in the Chicago wheat futures or options market some months in advance of the actual tender. When the time for ordering arrives, and in case the importer cannot find anyone to respond to his tender at the time of order, the futures contract could be held to maturity and the importer could request delivery of physical grain. If he holds a call option, then he could exercise the option and buy the underlying futures contract at the strike price and then hold on to the futures contract until delivery.

The problem is that delivery at a recognized warehouse, e.g. near Chicago where the CBOT delivery locations are, may not be what the importer wants, and may need to incur considerable cost to transport those amounts to his desired import location. Hence what would be desirable is to have the possibility of taking delivery of the same amount of grain but at a location much closer to his desired destination. One way to do this would be to establish links between various commodity exchanges around the world, so that the price difference between grain stocks in different locations would be equal to the relevant cost of transport and other transactions charges.

The IGCA could be then be envisioned as a branch of the linked commodity exchanges which could in essence try to guarantee that physical supplies around the world at various exchanges are available to execute the international contracts in its member exchanges. This could be done, if part of the financial reserves of the clearing houses that are members of the IGCA could be transformed into a physical reserve, via for instance holding warehouse receipts in various reliable locations around the world. The advantage of transforming the financial reserves into physical reserves would be two fold. First, the value of the underlying reserves would fluctuate with the price of the underlying commodity. This is like marking the underlying assets to market. This would obviate the need by contracting parties to post additional margins in case the price of the commodity increases suddenly. Second, and this is perhaps a major positive aspect, if most financial reserves of the IGCA were to be transformed into warehouse receipts, the physical execution of the underlying contracts, and not only their financial settlement, could be guaranteed. The commitments in futures or warehouse receipts of the IGCA could be liquidated once the actual deliveries on the relevant contract were executed. The liquidation of the physical positions or futures holdings of the IGCA would provide the funds to return to the contracting parties their posted insurance margins. In fact, since the liquidation of the IGCA margins would result in a variable amount as prices fluctuate on the underlying warehouse receipts or futures contracts, the restitution to the contracting parties of their initial margins would be variable and close to a fixed share (minus some transactions cost) of the underlying transaction value. Hence the true cost to the two parties to an international contract would be the interest foregone or paid for the posted good faith margin. Given all the other transactions costs in an international staple food import contract this may not be too high.

The IGCA would guarantee the execution of contracts by pooling the resources of several exchange related clearing houses. This would ensure that there would be liquidity in terms of physical reserves to honor individual contracts in case of non-performance by a participant. In fact, the major underlying benefit of the IGCA would be that by investing its reserves into physical warehouse receipts or deliverable futures contracts, it would create a global physical commodity reserve stock that could be utilized to execute international staple food contracts in case of non-performance of the exporting party to a transaction. The major difference, however, of such a stock and stocks envisioned in previous discussions on global price stabilization would be that this reserve stock would be used only to make the market work, namely ensure physical delivery and not to change the fundamentals of the market, as most of the other stock holding ideas envision. In other words, the stocks held in the form of warehouse receipts or other physically executable contracts, would perform the function normally done by so-called pipeline stocks, which are held by various market participants to ensure that there is uninterrupted performance of the normal market functions of the agent. Their function would not be to stabilize or speculate, but simply to ensure liquidity in the market. The necessity for an international arrangement to have such stocks is that there is no such physical liquidity mechanism internationally. In other words one of the main functions of the IGCA would be to ensure global physical grain liquidity. The IGCA could spread the risk of non-performance or country problems by holding its commodity reserves in several geographic locations, as well as several organized exchanges.

A major risk of such an IGCA would be that a sovereign country in whose territory, the warehouses of the underlying stocks in which the IGCA has invested are physically located, could impose export restrictions or bans that may make the physical release of stocks impossible. Here is where appropriate export related disciplines could be formulated in the context of the World Trade Organization (WTO), or another regional arrangement, to prevent exactly this type of phenomenon. For instance, such rules could guarantee that export prohibitions of staple food products cannot apply to the holdings of the IGCA. If sovereign governments are members or parties of the IGCA, then they could ensure that such rules are part of any WTO agreement. Also if major International Financing Institutions (IFIs), such as the World Bank, the IMF, and other IFIs are financiers of such a IGCA, then the type of sovereign type of default could be guaranteed by these IFIs, perhaps in the same manner they provide sovereign guarantees and insurance for other investment projects. In other words, default on any of the contracts insured with the IGCA would entail default with the IFIs behind it, and this may make it harder to default. On the downside, the relevant IFIs may be required to devote part of their sovereign guarantee capacity to this.

Another major risk of the IGCA may be the possibility of default by a party. This does not necessarily have to be a supplier (in case for instance of increased prices), but could also be the buyer (in case of suddenly decreased prices), who may not be interested in a contract at some prices that may now be considered too high. In such a case, and given that the seller would be losing a portion of the value of the contract due to the decrease in price, the IGCA could compensate the seller by the difference in the original and current value of the contract insured through the IGCA. For the IGCA to ensure this type of service, it must have sufficient amount of cash or other liquid assets to be able to compensate for any contract reneging. The IGCA may be able to manage the risks of this through options contracts.

The IGCA would basically stand between a specific transaction to underwrite the performance risk in either direction – basically an OTC type of transaction. This would place the underwriter, namely the IGCA, with a lot of financial exposure, which they would need to offset on both sides of the transaction with the normal sorts of financial instruments (options, guarantees, liens etc.). These sorts of transactions are well serviced by the private sector, but not at the moment for the sorts of transactions that the IGCA is designed for. However, given that there is experience in this, these types of risk management transactions can become integrated with the IGCA operations. On the supplier side, risks such as the weather production risk could offset with weather type of derivatives or insurance, with the benefits signed over to the underwriter etc.

An essential element then of the proposed IGCA is the internationalization and linkage of commodity exchanges.

To obtain an idea of the possible size of an IGCA, recall that in 2008–09 global cereal trade amounted to 266 million metric tonnes. The cereal imports of the most cereal import dependent economies, namely the major oil exporters and the SIDS amounted to about 50 million tonnes of this total. The LDCs accounted for another 20 million tonnes. We could assume that these are approximate figures of the amounts that maybe needed to be assured in the fashion mentioned above. However, the total of 70 million tonnes may be too much as an estimate of the potential insurable commodities for a IGCA. Suppose then for the sake of the argument that half of this is insured through the IGCA. Assume that each party to the import transaction posts a 5 percent margin with the IGCA. This implies that 10 percent of the 35 million tonnes, or 3.5 million tonnes of cereal equivalent could be an amount of reserves, in financial or physical form that the IGCA may be called to manage within a year. Clearly this figure would not be the amount held at any one point in time, and in fact the actual amount to manage would be a fraction of this, perhaps 20–30 percent at any one time. This implies that the actual reserve of the IGCA at any time may not be more than 1 million tonnes grain equivalent. This, however, is quite substantial compared with anyone transaction that is likely to be executed within a year, and hence the liquidity of the IGCA may be adequate to cover any potential physical reneging of contracts. At an average price of USD 200 per tonne for cereals, the amount of money managed would not be larger than USD 200 million, which is a not a very large number, compared with the total value of grain trade.

8. SUMMARY AND CONCLUSIONS

This paper has presented various dimensions of the problem of staple food import management, and has discussed three specific ways to manage food imports. The first way involves using futures and options to manage food import price risks. The empirical analysis showed that futures prices are good predictors of subsequent global spot prices, and for these reasons they provide a good hedging medium. Hedging with futures and options seems quite viable, and in fact considerable unpredictability reduction can be obtained by using either of them. The scope for the reduction in unpredictability is larger when hedges are made with futures compared with hedging with options only.

A number of *caveats* are in order when considering the results of the simulations. Firstly, given the importance of the countries involved in global wheat 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, may make a difference to outcomes.

The second part of the paper discussed the idea of a Food Import Financing Facility.

The third part of the paper discussed the idea of an International Grain Clearing Arrangement (IGCA), starting from the observation that the major missing institution in international grain trade was an international contract enforcement institution. Several aspects of such an institution were discussed, including the possible ownership of it, the risks of defaults, the link with physical reserves, etc. It was estimated with very rough calculations that such a new institution would not weight heavily on the market and hence would not influence the fundamentals of supply and demand in global import trade. It would just facilitate trade and hence basically make sure that there is enough physical grain 'liquidity' to execute normal commercial contracts. Needless to say that the idea is at early stages and considerable more analysis and institutional design is needed before it can take be considered for implementation.

It must be emphasized that both mechanisms to manage food imports discussed in this paper aim at managing food import risks without distorting the physical markets. As the idea of market management in any form creates all sorts of problems and entails many political and managerial difficulties, it is these properties of market non-distortion that should be considered as the major attributes of any mechanism or institution to better manage food import risks.

REFERENCES

Abbott, P.C., Hurt, C. & Tyner, W.E. 2008. What's driving food prices? Issue Report. Farm Foundation. Available at http://www.farmfoundation.org/

Baltzer, K., Hansen, H. & Lind, K.M. 2008. A note on the causes and consequences of the rapidly increasing international food prices. Research Report. Institute of Food and Resource Economics, University of Copenhagen. Available at http://www.danidadevforum.um.dk/en/servicemenu/news/ theglobalfoodsituation.htm

Benninga, S.R., Eldor, R. & Zilcha I. 1984. The optimal hedge ratio in unbiased futures markets. *Journal of Futures Markets*, 4(5): 681–80.

Berlagge, L. 1972. *Foodgrain Demand Supply Policies in Bangladesh*. Massachusetts Institute of Technology. (Ph.D. dissertation)

Bruinsma, J. (ed). 2003. *World agriculture towards 2015/30. An FAO Perspective*. London, Earthscan.

Deaton, A. 1999. Commodity prices and growth in Africa. *Journal of Economic Perspectives*, 13(3): 23–40.

Debatisse, M.L., Tsakok, I., Umali, D., Claessens, S. & Somel, K. 1993. *Risk Management in Liberalising Economies: Issues of Access to Food and Agricultural Futures and Options Markets*. World Bank, Europe and Central Asia Regional Office, Middle East and North Africa Regional Office, Technical Department Report No. 12220 ECA, November 30.

Dehn, J. 2000. *The effects on growth of commodity price uncertainty and shocks.* Washington, DC, World Bank, Policy Research Working Paper No. 2455.

Demeke, M., Pangrazio, G. & Maetz, M. 2009. *Country responses to the food security crisis: Nature and preliminary implications of the policies pursued*. Unpublished paper, FAO Initiative on Soaring Food Prices.

Faruqee, R. Coleman, J.R. & Scott, T. 1997. Managing price risk in the Pakistan wheat market. *The World Bank Economic Review*, 11(2): 263–92.

Food and Agriculture Organization of the United Nations (FAO). 2009a. *Food Outlook*. December, Rome, FAO.

Food and Agriculture Organization of the United Nations (FAO). 2009b. *The State of Agricultural Commodity Markets*. Rome, FAO.

Food and Agriculture Organization of the United Nations (FAO). 2004. *The State of Agricultural Commodity Markets*. Rome, FAO.

Food and Agriculture Organization of the United Nations (FAO). 2003. *Financing normal levels of commercial imports of basic foodstuffs in the context of the Marrakesh Decision on least-developed (LDC) and net food importing developing countries (NFIDC)*. Rome, Commodities and Trade Division, FAO.

Food and Agriculture Organization (FAO) and United Nations Conference on Trade and Development (UNCTAD). 2005. *Implementing the Marrakesh Decision. A proposal to create a dedicated food import financing facility*, unpublished note, Rome.

Gilbert, C. 1996. International Commodity Agreements: An Obituary Notice. *World Development*, 24(1): 1–19.

Gürkan, A.A., Balcombe, K. & Prakash, A. 2003. Food import bills: Experiences, factors underpinning changes, and policy implications for food security of least developed food-importing developing countries, In FAO, *Commodity Market Review 2003–2004*, Rome, FAO.

Harwood, J., Heifner, R., Coble, K., Perry, J. & Somwaru, A. 1999. *Managing Risk in Farming: Concepts, Research and Analysis*. US Department of Agriculture, Economic Research Service, Agricultural Economics Report No. 774.

Heady, D. & Fan, S. 2008. Anatomy of a crisis: the causes and consequences of surging food prices. *Agricultural Economics*, 39(supplement): 375–391.

Helbling, T., Mercer-Blackman, V. & Cheng, K. 2008. Commodities boom: Riding a wave. *Finance and Development*, 45(1): 10–15.

Ivanic, M. & Martin, W. 2008. Implications of higher global food prices for poverty in low-income countries. *Agricultural Economics*, 39(supplement): 405–416.

Johnson, D.G. 1947. *Forward Prices in Agriculture*. Chicago, University of Chicago Press.

Konandreas, P., Huddleston, B. & Ramangkura, V. 1978. *Food security: An insurance approach*. Washington, DC: International Food Policy Research Institute, Research Report No. 4.

Lapan, H., Moschini G. & Hanson, S.D. 1991. Production, hedging, and speculative decisions with options and futures markets. *American Journal of Agricultural Economics*, 73(1): 66–74.

Mitchell, D. 2008. *A Note on Rising Food Prices*. Policy Research Working Paper No. 4682. Washington, DC, World Bank.

Ng, F. & Aksoy, A. 2008. Food price increases and net food importing countries: Lessons from the recent past. *Agricultural Economics*, 39 (supplement): 443–452.

Pinckney, T.C. 1989. *The demand for public storage in Pakistan*. Research Report 77. Washington DC, International Food Policy Research Institute.

Rapsomanikis, G. 2009. *The 2007/2008 Food Price Swing: Impact and Policies in Eastern and Southern Africa*. Rome, Trade and Markets Division, FAO.

Rapsomanikis, G., Hallam, D. & Conforti, P. 2003. Market integration and price transmission in selected food and cash markets of developing countries: review and applications, In: FAO. *Commodity Market Review 2003–2004*, Rome, FAO.

Rolfo, J. 1980. Optimal hedging under price and quantity uncertainty: the case of a cocoa producer. *Journal of Political Economy*, 88(1): 100–116.

Sakong, Y., Hayes, D.J. & Hallam, A. 1993. Hedging production risk with options. *American Journal of Agricultural Economics*, 75(2): 408–415.

Sarris, A. 2009a**.** Evolving structure of world agricultural market instability and requirements for new world trade rules. *In* A. Sarris & J. Morrison (eds). *The evolving structure of world agricultural trade: implications for trade policy and trade agreements*. Rome, FAO.

Sarris, A. 2009b. Factors affecting recent and future price volatility of food commodities. *Schriften der Gesellschaft fur Wirtschafts- und Sozialwissenschaften des Landbaues*, e.V., Bd. 44: 29–48

Sarris, A. 1997. *Price Variability in Cereal Markets and Risk Management Strategies for Market Participants*. Discussion paper, AGR/CA/APM/CFS(97)8, Paris, OECD.

Sarris, A.H. 1992. *Options for Public Intervention to Enhance Food Security in Ghana*. Cornell University Food and Nutrition Policy Program, Monograph No.14, October 1992.

Sarris, A.H. 1985. Food Security and Agricultural Production Strategies under Risk in Egypt, *Journal of Development Economics*, 19(1/2): 85–111.

Sarris, A., Conforti, P. & Prakash, A. 2009. *The use of organized commodity markets to manage food import price instability and risk*. Unpublished paper, FAO Trade and Markets Division.

Schnepf, R. 2008. *High Agricultural Commodity Prices: What Are the Issues?* CRS Report for Congress. Washington, DC, Congressional Research Service. Available at http://assets.opencrs.com/rpts/RL34474_20080506.pdf

Trostle, R. 2008. *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices*. ERS Report WRS-0801. Economic Research Service, US Department of Agriculture (USDA). Available at http://www.ers.usda.gov/publications/wrs0801.

Varangis, P., Larson, D. & Anderson, J.R. 2002. *Agricultural Markets and Risks: Management of the Latter not the Former*. World Bank, Policy Research Working Paper 2793.

APPENDIX
ESTIMATES OF THE FINANCING NEEDS OF THE FIFF

The purpose of this technical appendix is to make some initial estimates of the average amount of financing needed yearly to operate the FIFF. Such estimates will provide donors with the information needed to consider the magnitude of the guarantees required to set up the FIFF revolving fund. The estimates provided here are, of necessity indicative, and need to be refined further, but they illustrate the magnitudes involved.

A.1 Methodology

The method utilized consists of two parts. First indicative food import bills are calculated and analyzed to see whether they are closely related with actual food import bills. Secondly two methods for computing food import bill trends are proposed and applied, in order to examine whether the calculations lead to similar magnitudes for FIFF needs. In the sequel these methods are outlined.

A.1.1 Calculation of indicative and trend food import bills

For each of the 50 LDCs and the 77 LIFDCs consider the following basic 8 food groups: wheat, coarse grains, rice, dairy, meat, sugar, fruits and vegetables (including pulses), and oils. Let j denote the product index (j=1,..,8). For each group j annual import volumes (in tonnes) from 1961–2007 (or latest available) were compiled, and monthly series of international indicative absolute prices were also specified, as per FAO data. These prices were assumed to be the same for each country, as far as commercial imports are concerned. For groups of commodities such as fruits and vegetables, or meats, which include many commodities, the price of a representative product with a well observed international market was utilized as representative of the group. From the monthly prices annual averages were computed.

For each country i the following indicative food import bill (FIB) (not including amounts imported as food aid) was computed for each year t.

$$FIB_{it} = \sum_j p_{jt} M_{ijt} \qquad \text{(A1)}$$

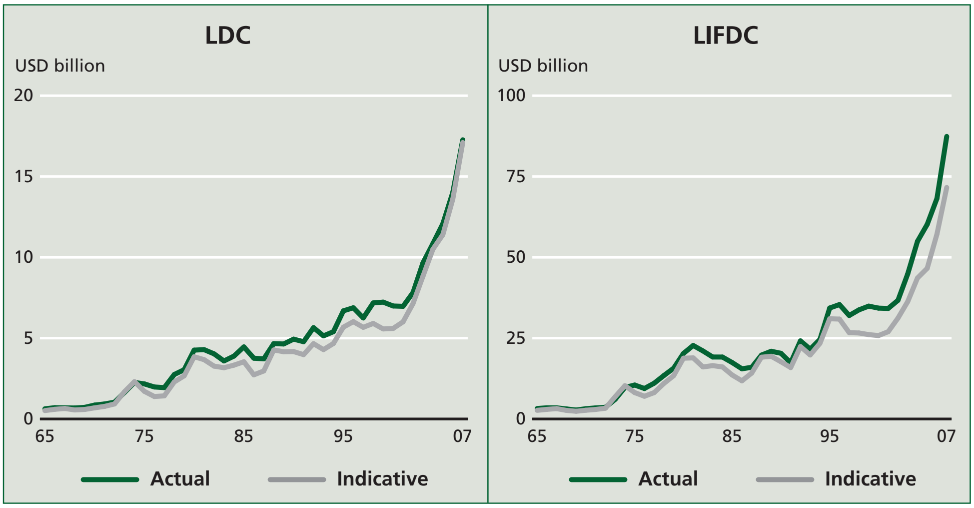
where $M_{ij,t}$ denotes the volume of commercial imports of a given commodity or commodity group j in year t, and p_{jt} is the world indicative international price of commodity j in year t.

Clearly this indicative food import bill is not necessarily equal to the actual import bill recorded for each country, as there are differences due to the actual prices paid by each country (which may differ from international indicative prices because of transport costs, different countries of origin, etc.). However, such a simple computation as above is quite easy and straightforward to implement when one needs to make predictions of food import bills. Hence, an issue is whether such an indicative import bill is correlated with the actual ex-post import bills. Figure A1 exhibits graphs of actual (as obtained from FAOSTAT) versus indicative (as estimated from equation A1) food import bills for the LDCs and the LIFDCs (which includes almost all LDCs). It can be seen that the two lines in each figure move quite closely together, which suggests that the indicative food import bills are broadly representative of the actual observed ones.

A1.2 Computation of trends in food import bills

Trends in the indicative food import bills were computed by two methods.

Figure A1. Actual versus computed indicative food import bills of LDCs and LIFDCs



Source: Author's calculations.

Method 1. Compute moving averages directly on the indicative, computed above, as follows:

$$FIB_{it}^{Trend1} = \frac{1}{K}\sum_{k=1}^{K} FIB_{i,t-k} \qquad \text{(A2)}$$

where K is an appropriate integer (in the empirical results a value of K equal to 3 is utilized, but values of 4 and 5 were also tried).

Method 2. Compute moving average trends on each of the variables in (A1) and then compute the resulting overall import bill trend.

$$p_{it}^{Trend} = \frac{1}{K}\sum_{k=1}^{K} p_{i,t-k} \qquad \text{(A3)}$$

$$M_{it}^{Trend} = \frac{1}{K}\sum_{k=1}^{K} M_{i,t-k} \qquad \text{(A4)}$$

$$FIB_{it}^{Trend2} = \sum_{j=1}^{8} p_{jt}^{trend} M_{ijt}^{trend} \qquad \text{(A5)}$$

Clearly none of these crude methods are good estimates of the trend of food import bills, and much better methods can be applied. However, the purpose of the empirical exercise here, is to estimate some ballpark figures for the financing needs of a FIFF, and for these purposes the above methods suffice.

A.1.3 Ex-post computation of above normal food import bills

For each one of the two trends computed by the two methods above, derive the following sets of deviations from the indicative food import bill in equation A1.

$$\Delta FIB_{it}^{1}(\alpha) = FIB_{it} - (1+\alpha) FIB_{it}^{trend1} \quad \text{(A6)}$$

$$\Delta FIB_{it}^{2}(\alpha) = FIB_{it} - (1+\alpha) FIB_{it}^{trend2} \quad \text{(A7)}$$

The parameter α denotes the proportion above the trend which will define an 'excess food import bill', or differently an aggregate 'import surge'. A time series of above normal or excess food import bills (EFIB) that will be used for the analysis will be computed as follows (m=1, 2 denotes the two methods for computing trends as indicated above):

$$EFIB_{it}^{m}(\alpha) = \begin{cases} \Delta FIB_{it}^{m}(\alpha) & if \quad \Delta FIB_{it}^{m}(\alpha) > 0 \\ 0 & otherwise \end{cases} \quad \text{(A8)}$$

The empirical analysis consists of first computing time series of the above EFIBs for both methods, and for various values of α for each country. The values of α simulate different potential trigger levels. For instance a value of α equal to 0.1 indicates that the FIFF is triggered when the predicted food import bill is more than 10 percent above the trend food import bill for the country.

Once the above time series for each country are computed, the following statistics of 'aggregate excess deviations from trend food import bills' for all LDCs, and LIFDCs are computed.

$$EFIB_{t}^{m}(\alpha) = \sum_{i=1}^{n} EFIB_{it}^{m}(\alpha) \quad \text{(A9)}$$

It is this latter time series that will form the basis for the empirical results.

A1.4 Computation of potential 'excess food import bills', and reliability of results

The above computations indicate the positive variations above a trend of the realized food import bills. However, they certainly do not answer the question of how much additional commercial food imports would have taken place had the facility existed over the past 40 years. The reason for this is that the actual food imports of any given country take place in the presence of the financing constraints discussed in the main part of the report. Hence, it is impossible to know what amounts of imports would have taken place if the constraint did not exist.

A better methodology for estimating the requirements for FIFF financing, would be to have a method for predicting commercial food imports, preferably the one that will be applied by the FIFF should it be instituted, and then apply this method retroactively, namely ex-post for a long period, to the countries concerned, in order to estimate the predicted food import bills, in place of what was computed above as indicative food import bills. By estimating the difference between what is predicted on the basis of this methodology and the actual food import bills, one would have a good estimate of the amounts that would have been imported in the absence of constraints. This, however, need not be done at present, as in the absence of agreement on a FIFF, there is no need for such detailed methodology.

Given, however, that the realized commercial food imports are presumably a lower bound of the commercial food imports that would have taken place if the financing constraints did not exist, one may make a reasonable estimate of the excess amount of food imports that would have taken place without the financing constraint as follows. Assume that the hypothetical excess amount of food imports that would have taken place is proportional to what was calculated above as ex-post excess food import bills. In other words one may hypothesize that the food financing constraint would indeed be binding when there is a greater need for commercial food imports, and this greater need is evidenced in the periods when the actual food imports were above the trends, as indicated above. If one further hypothesizes that the actual amount of commercial imports that would have taken place if the financing constraint did not exist is proportional to the estimated deviations, then one can compute the amounts of excess financing needed. Of course, one can assume that the financing constraint would bind at different levels of what was defined above as constituting an excess, namely values of the parameter α.

In the sequel this simple method is employed, under the assumption that the financing constraint would bind at different values of the parameter α, and that the excess food import bills that would have been realized had the constraint not existed, would amount to a fraction β of the EFIB computed in equation A9. For the empirical illustrations a fraction β=0.5 is employed.

A.2. Empirical results

The method outlined above was applied, as indicated earlier to the 50 LDCs and the 77 LIFDCs for the period 1961–2007, which includes the food crisis period of 1974–75 but only part of the recent food crisis period, as there is no data for food import bills for most countries for 2008. Table A1 indicates the actual values of the food import bills of these groups of countries for the period 2000–2007. It can be seen that for both LDCs and LIFDCs, the food import bills more than doubled in USD terms during this period.

Table A1. Actual total food import bills of LIFDCs and LDCs during 2000–2007 (in million USD)

	LIFDC	LDC
2000	34 294	6 994
2001	34 187	6 970
2002	36 702	7 819
2003	44 867	9 664
2004	54 940	10 847
2005	60 192	12 076
2006	68 228	14 016
2007	87 377	17 268
Average	52 599	10 707

Source: FAOSTAT.

Tables A2 and A3 indicate the estimated amounts of 'excess food import financing needs' that could be financed by the FIFF under the two different methods of computing the trends, as outlined above, and various values of the parameter α. The results indicate that the estimated values for FIFF required finance vary considerable both with the value of the parameter α. This may have to do with the fact that the food crisis of 1974–75 is quite close to the start of the simulation period, which is 1970. It is clear that as the value of the parameter α increases, the amount estimated declines. This is to be expected as a higher value of α, implies that it is a smaller amount of the estimated deviations that can be considered as excess food imports.

Table A2. Estimates of the total excess food import financing needs during 1969–2007 of LDCs and LIFDCs under method 1 and for different values of the parameter α (all values in million USD)

			LDC			
€	α=0.05	α=0.01	α=0.15	α=0.02	α=0.25	α=0.3
MEAN	428	374	325	279	238	204
MIN	18	11	6	4	3	0
MAX	2 428	2 160	1 896	1 633	1 388	1 164
			LIFDC			
€	α=0.05	α=0.01	α=0.15	α=0.02	α=0.25	α=0.3
MEAN	1 937	1 688	1 467	1 274	1 107	962
MIN	58	48	40	34	28	5
MAX	10 150	9 000	7 900	6 800	5 750	4 735

Source: Author's computations

Table A3. Estimates of the total excess food import financing needs during 1969–2007 of LDCs and LIFDCs under method 2 for different values of the parameter α (all values in million USD).

			LDC			
€	α=0.05	α=0.01	α=0.15	α=0.02	α=0.25	α=0.3
MEAN	431	377	327	282	242	207
MIN	19	14	9	5	3	0
MAX	2 444	2 176	1 913	1 651	1 406	1 177
			LIFDC			
€	α=0.05	α=0.01	α=0.15	α=0.02	α=0.25	α=0.3
MEAN	1 951	1 703	1 479	1 288	1 120	974
MIN	58	48	40	34	28	10
MAX	10 200	9 050	7 950	6 900	5 850	4 816

Source: Author's computations

COMMODITY MARKET REVIEW

2009–2010

IN THIS ISSUE

ISBN 978-92-5-106552-5 ISSN 1020-492X

9 789251 065525

I1545E/1/4.10/700