Isabelle Piot-Lepetit
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Foreword by John Bensted-Smith

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Editors
Isabelle Piot-Lepetit
European Commission
Joint Research Centre
Institute for Prospective Technological Studies
Edifico Expo, c/ Inca Garcilaso 3
E-41092 Seville, Spain
isabelle.piot-lepetit@ec.europa.eu

Robert M'Barek
European Commission
Joint Research Centre
Institute for Prospective Technological Studies
Edifico Expo, c/ Inca Garcilaso 3
E-41092 Seville, Spain
robert.mbarek@ec.europa.eu

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Foreword

After a decade-long period of relative stagnation in prices of main agricultural commodities, price fluctuations in the last 4 years have highlighted the need for more investigations into the topic of agricultural commodity price volatility. In fact, it now has a prominent place on the policy-making agenda.

Price changes have always been a feature of agricultural markets, as market clearing conditions require that supply matches demand.

A more recent problem is that agricultural price shocks and volatility cause uncertainty among market actors, thus preventing the market from functioning properly. Driven by the increased globalisation and the integration of financial and energy markets with agricultural commodity markets, the relationships between all sectors of the economy are evolving and becoming more complex. When a disruption, such as a regional drought, food safety alert or financial crisis, hits a particular market, the direction and magnitude of the impacts are not foreseeable. Will it impact on other markets and affect producer, consumer and trader decisions?

Understanding the nature of agricultural commodity price volatility, anticipating its emergence and managing its consequences are now more than ever of considerable interest for improving agricultural market analysis and policy development.

To this end, the European Commission's Joint Research Centre – Institute for Prospective Technological Studies (IPTS) is engaged in the analysis of price volatility in the context of agricultural and trade policy. This volume of workshop papers, which I am pleased to introduce, is one contribution arising from the current work agenda.

Seville, Spain　　　　John Bensted-Smith

Preface

This book is a collection of scientific papers on topics relevant to the research field of agricultural price volatility analysis. Contributions from this book were first developed as presentations at an international workshop organised by the European Commission's Joint Research Centre – Institute for Prospective Technological Studies (IPTS) on "Methods to Analyse Price Volatility" held on 28–29 January 2010 in Seville, Spain.

Many conferences, publications, reports and workshops have focused on the dramatic commodity price increases from 2007 to mid-2008. These contributions have tried to identify the known and new factors driving agricultural commodity price changes such as the interdependence between energy and agricultural markets, the consequences of the development of biofuels, the linkage between the depreciation of the US dollar and agricultural commodity prices, the role of financial markets, and to discuss policy responses.

This book provides an overview of methodologies that can be implemented for improving the analysis and forecast of market developments. It discusses how current modelling tools used for policy analyses can be enhanced in order to integrate price dynamics. Finally it also highlights challenges faced by policy makers when dealing with the changing nature of agricultural commodities markets.

We would like to express our gratitude to all those who have contributed to this book either by writing a chapter or by discussing the presentations during the workshop.

We also would like to thank Anna Atkinson for her support in the organising of the workshop and the editing of the book.

Seville, Spain

Isabelle Piot-Lepetit
Robert M'barek

Contents

Contributors

John Baffes Development Prospects Group (DECPG), The World Bank, Washington, DC, USA, jbaffes@worldbank.org

Christopher L. Gilbert University of Trento, Trento, Italy, christopher.gilbert@unitn.it

Linwood A. Hoffman US Department of Agriculture, Economic Research Service, Washington, DC, USA, lhoffman@ers.usda.gov

Michael Keane Department of Food Business and Development, University College Cork, Cork, Ireland, m.keane@ucc.ie

Robert M'Barek Institute for Prospective Technological Studies (IPTS), Joint Research Centre (JRC), European Commission, Seville, Spain, robert.mbarek@ec.europa.eu

C. Wyn Morgan Centre for Economic Development and International Trade (CREDIT), School of Economics, University of Nottingham, Nottingham, UK, wyn.morgan@nottingham.ac.uk

Harriet Mugera University of Trento, Trento, Italy, harriet.mugera@unitn.it

Declan O'Connor Department of Mathematics, Cork Institute of Technology, Cork, Ireland, declan.oconnor@cit.ie

Isabelle Piot-Lepetit Institute for Prospective Technological Studies (IPTS), Joint Research Centre (JRC), European Commission, Seville, Spain, isabelle.piot-lepetit@ec.europa.eu

George Rapsomanikis Trade and Markets Division, Food and Agricultural Organization of the United Nations, Rome, Italy, george.rapsomanikis@fao.org

Hadj Saadi Université Pierre Mendès France, Grenoble, France, hadj.saadi@upmf-grenoble.fr

Alexander Sarris Department of Economics, University of Athens, Athens, Greece, alekosar@otenet.gr

Jochen Schmitz Johann Heinrich von Thünen Institute (vTI), Braunschweig, Germany, jochen.schmitz@vti.bund.de

Monika Tothova Directorate General for Agriculture and Rural Development, European Commission, Brussels, Belgium, monika.tothova@ec.europa.eu

Beatriz Velazquez Directorate General for Agriculture and Rural Development, European Commission, Brussels, Belgium, beatriz.velazquez@ec.europa.eu

Oliver von Ledebur Johann Heinrich von Thünen Institute (vTI), Braunschweig, Germany, oliver.ledebur@vti.bund.de

List of Abbreviations

ACRE	Average Crop Revenue Election
ADC	Asymmetric Dynamic Covariance model
ADF	Augmented Dickey–Fuller test
ADMARC	Agricultural Development and Marketing Corporation
AGARCH	Asymmetric Generalised Autoregressive Conditional Heteroskedasticity model
AIC	Aikake Information Criterion
AMI	AgrarMarkt Informations
APARCH	Asymmetric Power Autoregressive Conditional Heteroskedasticity model
AR	Autoregressive model
ARCH	Autoregressive Conditional Heteroskedasticity model
ARIMA	Autoregressive Integrated Moving Average model
ARMA	Autoregressive Moving Average model
BEKK	Baba–Engle–Kraft–Kroner model
BIC	Bayesian Information Criterion
BRAZ	Bolsa Mercantil e de Futuros
BSE	Bovine Spongiform Encephalopathy
CAP	Common Agricultural Policy
CBOT	Chicago Board of Trade
CC	Coefficient of Correlation
CCC	Constant Conditional Correlation model
CCFF	Commodity Compensatory Financing Facility
CIF	Cost, Insurance, Freight
CME	Chicago Mercantile Exchange
CPI	Consumer Price Index
CRDW	Cointegration Regression Durbin Watson statistics
CV	Coefficient of Variation
DCC	Dynamic Conditional Correlation model
DG	Directorate General
EC	European Commission
ECNC	European Centre for Nature Conservation

EEC	European Economic Community
EGARCH	Exponential Generalized Autoregressive Conditional Heteroskedasticity model
EU	European Union
EU-10	Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia
EU-12	EU-10 and Bulgaria and Romania
EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal, Ireland, Spain, Sweden and the United Kingdom
EU-25	EU-15 and EU-10
EU-27	EU-25 and Bulgaria and Romania
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organization
FIB	Food Import Bill
FIBT	Food Import Bill Trend
FIFF	Food Import Financing Facility
FLEX	FLuctuations in EXport earnings
FNVA	Farm Net Value Added
FOB	Free On Board
GARCH	Generalised Autoregressive Conditional Heteroskedasticity model
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GJR	Glosten–Jagannathan–Runkle model
GJR-GARCH	Glosten–Jagannathan–Runkle Generalised Autoregressive Conditional Heteroskedasticity model
GTAP	Global Trade Analysis Project
HC	Heath Check CAP reform
HLG	High Level expert Group
HQIC	Hannan–Quinn Information Criterion
HRW	Hard Red Winter
i.i.d	independent and identically distributed random variable
IBOs	Inter-Branch Organizations
IDF	International Dairy Federation
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IPE	International Petroleum Exchange
IPI	Industrial Price Index
IPTS	Institute for Prospective Technological Studies
JRC	Joint Research Centre
KL	Kuala Lumpur
LAC	Latin America and the Caribbean countries
LCs	Letters of Credit
LDCs	Least-Developed Countries

LEI	Landbouw Economisch Instituut
LICs	Low Income Countries
LIFDCs	Low Income Food Deficit Countries
Log-GARCH	Logarithm Generalised Autoregressive Conditional Heteroskedasticity model
MA	Moving Average model
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MATIF	Marchés à Terme d'Instruments Financiers
MDH	Mixture of Distribution Hypothesis
MDM	Modified Diebold-Mariano test
MS	Member States
MSE	Mean Squared Error
MUV	Manufacturing Unit Value
NASS	National Agricultural Statistics Service
N-GARCH	Non-linear Generalised Autoregressive Conditional Heteroskedasticity model
NIFIDs	Net Food Importing Developing Countries
NMS	New Member States
ODCs	Other Developing Countries
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
OPEC	Organization of the Petroleum Exporting Countries
OTC	Over the Counter
POs	Producer Organizations
PPI	Producer Price Index
R&D	Research and Development
SAFEX	South African Futures market
SAP	Season-Average Price
SD	Standard Deviation
SIC	Schwarz Information Criterion
SIDS	Small Island Developing States
SMP	Skim Milk Powder
STABEX	STAbilisation of EXport earnings
TFP	Total Factor Productivity
TGARCH	Threshold Generalized Autoregressive Conditional Heteroskedasticity model
TS-GARCH	Taylor–Schwert Generalised Autoregressive Conditional Heteroskedasticity model
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade And Development
UN-FAO	United Nations-Food and Agriculture Organization
URAA	Uruguay Round Agreement on Agriculture
US	United States

USDA	United States Department of Agriculture
VEC	Vector Error Correction
VECM	Vector Error Correction Model
WASDE	World Agricultural Supply and Demand Estimates
WFP	World Food Programme
WMP	Whole Milk Powder
WTI	West Texas Intermediate
WTO	World Trade Organization
WWII	World War II
ZALF	Zentrum für Agrarlandschaftsforschung
ZMP	Zentrale Markt und Preisberichtstelle

Chapter 1
Methods to Analyse Agricultural Commodity Price Volatility

Isabelle Piot-Lepetit and Robert M'Barek

Abstract A broad set of methods are available to analyse price volatility. However, due to specific market characteristics and policy implications, agricultural commodity price volatility cannot be analysed as financial price volatility. This chapter reviews these points and outlines the content of the book.

1.1 Introduction

Agricultural commodity market quantities and prices are often random. This introduces a large amount of risk and uncertainty into the process of market modelling and forecasting. As established by Knight (1921), there exists an important distinction between risk and uncertainty.

> Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated... The essential fact is that risk means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating... It will appear that a measurable uncertainty or risk proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all (Knight, 1921).

Thus, uncertainty describes a situation where several possible outcomes are associated with an event, but the assignment of probabilities to the different outcomes is not possible. Risk permits the assignment of probabilities to the different outcomes. Volatility is allied to risk in that it provides a measure of the possible variation or movement in a particular economic variable or some function of that variable. It is usually measured either based on observed realisations of a random variable over

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I. Piot-Lepetit (✉)
Institute for Prospective Technological Studies (IPTS), Joint Research Centre (JRC), European Commission, Seville, Spain
e-mail: isabelle.piot-lepetit@ec.europa.eu

R. M'Barek
Institute for Prospective Technological Studies (IPTS), Joint Research Centre (JRC), European Commission, Seville, Spain
e-mail: robert.mbarek@ec.europa.eu

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some historical period in the case of realised volatility or from the Black–Scholes formula in the case of implicit volatility (Aizenman and Pinto, 2005). Of course the randomness of the price fluctuations varies as we observe them and their likely causes in the long, medium and short run.

In the long term, commodity markets are subject to shocks or changes in trend that range from natural catastrophes and political interventions to structural market changes. These shocks tend to be irregular in nature and cause abrupt shifts in prices usually to higher but sometimes to lower levels. Sometimes, the return of a market to normality is quick. At times, the shocks persist while at others price changes reoccur, resulting in a series of consecutive turning points. In the medium term, factors that shock commodity markets can also be of a political or cataclysmic nature, but they tend to be more related to national economic conditions or to market forces themselves. Fluctuations in market forces tend to be observed in the demand and supply conditions and underlying market equilibrium. Fluctuations in national economic conditions can cause changes in production or in interest rates and ultimately in commodity investments. Variations in weather conditions also induce changes in agricultural supply and hence in product prices. In the short term, market shocks come primarily from financial factors, particularly those related to speculation and hedging on commodity futures, options and other derivatives markets. The resulting price behaviour reflects the flow of randomly appearing information. It can be related to financial shocks such as in interest or exchange rates (Labys, 2003).

Not all markets experience volatile prices. They tend to be markets with products where the conditions of supply and demand are relatively stable from year to year and where the elasticity of demand and the elasticity of supply are both high. Only products with unstable conditions of supply and demand will experience price fluctuations from year to year. For many agricultural products, there are large seasonal variations which cause prices to rise sharply at peak times and then fall back during the off-peak periods. The effects of changes in supply can be amplified by a price-inelastic demand. When the price elasticity of demand is low, volatile shifts in market supply cause large changes in the market equilibrium price, although the equilibrium quantity traded may not change that much. Furthermore, price volatility can be magnified because of the activity of speculators in markets who are betting on future price changes. Their demand may have the effect of driving prices higher at times when stocks of these commodities are low.

The described price fluctuations which vary frequently and extensively have made market modelling and forecasting an extremely difficult task. However, an appropriate knowledge of the patterns of commodity price variability and the forces behind it would aid policy makers in providing a policy environment conducive to good risk management practices and would help farmers to better understand and manage their price risks.

1.2 Specificity of Agricultural Commodities

Long-run commodity demand is driven largely by population and income dynamics. However, demographic changes generally occur slowly and in accordance with well-known behavioural patterns. Similarly, per capita income growth usually trends upward or downward gradually and predictably with the national economy. As a result, short-term price movements are rarely driven by either of these phenomena. Change in currency exchange rates between trading nations can occur more suddenly and can have significant effects on international trade and prices. For an exporting country, a devaluation of its currency against other exporting countries has the same effect as a lowering of its export price against those competitor nations, thereby making its product more competitive. Currency exchange rate fluctuations and their economic implications are not unique to agricultural commodities, but the ups and downs of the rate affect all goods and services traded between nations. However, the level of connectivity of agricultural markets with other markets, such as energy, that may also be experiencing variations in volatility, may influence the volatility of agricultural commodities.

Agricultural commodities 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 market prices and the volatility of these prices at a given time. In general, agricultural commodity prices respond rapidly and anticipate changes in supply and demand conditions. However, certain characteristics of agricultural product markets set them apart from most volatile prices of non-farm goods and services. Three such noteworthy characteristics of agricultural crops include the seasonality of production, the derived nature of their demand and price-inelastic demand and supply functions (Schnepf, 2005).

1.2.1 Seasonality

The biological nature of crop production plays an important role in agricultural product price behaviour. Agronomic conditions such as weather and soil types may influence the viability of producing a particular crop or undertaking a livestock activity. Producers make their decisions based partly on their expectations of future yields, prices for both outputs and inputs needed to produce those outputs, and partly on government program support rates for alternative production activities. Expectations concerning international market conditions such as output prices and the possibility of unexpected changes in the trade outlook influence producers' decisions.

1.2.2 Derived Nature of Many Agricultural Product Prices

Demand for agricultural products originates with consumers who use the various food and industrial products that are produced from raw or unprocessed farm commodities. Cereals and other feedstuffs are important inputs in the livestock industry. Increasing demand for crops and oilseeds by the industrial processing sector, whether from food or biofuels processing industries or from expanding industrial pork and poultry operations, further reinforces the general price inelasticity of demand for many agricultural commodities. Feed demand for cereals and protein meals is sensitive to relative feed grain prices.

1.2.3 Price-Inelastic Demand and Supply

In general, the demand and supply of farm products are relatively price-inelastic, i.e. quantities demanded and supplied change proportionally less than prices. This implies that even small changes in supply can result in large price movements. Unexpected market news can produce potentially large swings in farm prices and incomes. On the one hand, short-term supply response to a price rise can be very limited during periods of low stock holdings, but in the longer run expanded acreage and more intensive cultivation practices could work to increase supplies. On the other hand, when prices fall, producers might be inclined to withhold their commodity from the market. The cost of storage, the length of time before any expected price rebound, the anticipated strength of a price rebound and the producer's current cash-flow situation combine to determine if storage is a viable alternative. If a return to higher prices is not expected in the near future, storage may not be viable and continued marketing may add to downward price pressure. In general, inelastic demand and supply responsiveness characterise most agricultural products, even if distinct differences in the level and pattern of responsiveness exist across commodities. This price dynamic is a characteristic of the agricultural sector and a farm policy concern.

The speed and efficiency with which the various price adjustments occur depend largely on the market structure within which a commodity is being traded. Common attributes of market structure include the followings (Schnepf, 2005):

- The number of buyers and sellers: more market participants are generally associated with increased price competitiveness;
- The commodity's homogeneity in terms of type, variety, quality and end-use characteristics: greater product differentiation is generally associated with greater price differences among products and markets;
- The number of close substitutes: more close substitutes means that buyers have greater choice and are more sensitive;
- The commodity's storability: greater storability gives the producer more options in terms of when and under what conditions to sell his products;
- The transparency of price formation: greater transparency prevents price manipulation;
- The ease of commodity transfer between buyers and sellers and among markets: greater mobility limits spatial price differences; and
- Artificial restrictions on the market processes, e.g. government policies or market collusion from a major participant: more artificial restrictions tend to prevent the price from reaching its natural equilibrium level. Some restrictions such as import barriers limit supply and keep prices high, while other types of restrictions, such as market collusion by a few large buyers, may suppress market prices.

The most comprehensive of commodity market analytical methods stem from structural models which are based in microeconomics and econometrics or other modelling theories, e.g. optimisation, programming, input–output, and computable general equilibrium. Because such structural models trace the interaction between endogenous market variables such as supply and demand and exogenous variables such as population growth or exchange rate, they can explain market behaviour and performance. It usually requires model specification, estimation and simulation. Model simulation can replicate the historical behaviour of price and quantity variables over time or space. It can provide estimates of various commodity policy impacts or forecast the variable into the future.

The most basic type of commodity model from which econometric and modelling methodologies have developed is the competitive market model. Such a model initially neglects market imperfections and assumes that commodity demand and supply interact to produce an equilibrium price reflecting competitive market conditions. Such a model may consist of a number of combined regression equations, each explaining separately, a single market or sector variable. Market models are applicable to all agricultural production. Their greatest utility is in providing a consistent framework for planning agricultural expansion, forecasting market price movements and studying the effects of regulatory policies.

Among the more difficult challenges of these structural models is to deal with the considerable uncertainty which pervades markets such as speculation, exogenous shocks, political intervention and structural changes. Greater attention has concerned macroeconomic influences on commodity markets. Agricultural commodity price analysis has also been directed by price fluctuations in the form of waves and cycles. This uncertainty is often related to endogenous instability such as that caused by price inelasticities and seasonality patterns. More recently, the short-run behaviour has been the subject of analysis with concerns regarding the stochastic or random processes associated with the discovery of futures price movements and excessive market speculation.

1.3 Analysis of Price Volatility

The recent analysis of commodity markets has been largely occupied with the explanation of the temporal or time series behaviour of prices. In the statistical literature on the analysis of economic time series, it is common practice to classify the types of movements that characterise a time series as trend, cyclical, seasonal and irregular components:

- A trend describes the long-term movement in the mean of the series;
- Seasonal effects describe the cyclical fluctuations related to the year calendar;
- Cycles concern other cyclical fluctuations not linked to the year calendar; and
- Residuals or irregular components gather together random or systematic fluctuations.

The idea that a time series may be viewed as being composed of several unobserved components plays a fundamental role in economics and the analysis of economic data. Jevons (1884) provided a rationale for eliminating regularities from economic data.

> We should learn to discriminate what is usual and normal ... from what is irregular and abnormal. It is a matter of skill and discretion to allow for the normal changes. It is the abnormal changes which are alone threatening or worthy of ... attention (Jevons, 1884, p. 181).

One of the first authors to state explicitly the composition of a time series in four types of fluctuations was Pearsons (1919):

> 1. A long-time tendency or secular trend; in many series such as bank clearings or production of commodities, this may be termed the growth element;
> 2. A wavelike or cyclical movement superimposed upon the secular trend; these curves appear to reach their crests during the periods of industrial prosperity and their troughs during periods of industrial depression, their rise and fall constituting the business cycle;
> 3. A seasonal movement within the year with a characteristic shape for each series;
> 4. Residual variation due to developments which affect individual series, or to momentous occurrences such as wars or national catastrophes, which affect a number of series simultaneously (Pearsons, 1919, p. 8).

Later work refined and systematised these notions, but the nature of the definitions has influenced the literature on methods. Two distinct purposes lie behind the division of a time series into two or more unobserved components. The most prominent involves the search of regularities governing economic fluctuations. Another purpose is the study of unobserved components for extracting the information in an economic series of any periodicity, being relatively predictable, that can serve as a guide to policy makers (Nerlove et al., 1995).

The policy challenge is not the reduction of volatility to zero but rather the elimination of excess volatility. Excessive market volatility may have an important effect on real economic activity and the functioning of capital markets. A period of extreme volatility may cause a loss of investor confidence in the solvency of trade-counterparties and thereby reduce market participation and liquidity at a time when it is most needed. Such a loss of confidence would intensify volatility and could potentially lead to a temporary breakdown in organised trading. Neoclassical investment theory predicts that higher discount rates caused by excess volatility will increase costs of capital, thereby leading firms to reduce their real investment spending, other things being constant.

The present form of the trend-cycle-seasonal-irregular model is quite different from its original form. It is now generally acknowledged that the same causal forces may affect more than one component. Recent work had provided a number of refinements in the modelling of time series and substantial technical advances in the handling of the many statistical problems inherent in this type of modelling (Nerlove et al., 1995).

A wide range of models that deal with systematic volatility have been developed since the seminal one proposed by Engle (1982). The vast majority of volatility work has often focused on series where the trajectory of the series cannot be predicted from its past as financial and stock prices. However, for many other series such as agricultural prices, this may not really be appropriate, since there is evidence that these series are cyclical, sometimes with or without trends, and require modelling within a flexible and unified framework. Within the random walk model that applied to stock prices, all shocks are permanent and this is implausible with regard to agricultural commodities, i.e. weather shocks would generally be considered transitory (Balcombe, 2009).

Realised or past volatility is most commonly measured by a standard deviation based on the history of an economic variable. The standard deviation treats negative and positive deviations from the mean symmetrically. However, there are good reasons to suspect asymmetric effects for many variables. If such asymmetries are expected, it might be prudent to attach a lower weight to positive shocks in the computation of the volatility measure (Wolf, 2005).

The time series equations can be univariate in which a single variable is explained in terms of its past statistical history or multivariate in which the past statistical history of several variables is combined. The explanation and forecasting of commodity prices using univariate and multivariate methods depend on whether the researcher is interested in long run as compared to medium-run or short-run price behaviour. The modelling of long-run behaviour involves basic linear or non-linear models. The explanation of medium-run behaviour implements models capable of generating some form of price cycles (Labys, 2003).

For analysing past volatility, several price models have been developed. The principles underlying the autoregressive conditional heteroscedasticity or ARCH model (Engle, 1982) and its generalised forms as the GARCH model (Bollerslev, 1986) posit that there are periods of relative high and low volatility, though the underlying unconditional remains unchanged. Evidence of ARCH and GARCH is widespread in series that are partly driven by speculative forces. However, these may also be present in the behaviour of agricultural 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, such as trade agreements, 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. A common statistic for measuring the variability of a data series is the coefficient of variation (CV), which expresses the dispersion of observed data values as a percentage of the mean. Since the CV is unit-free, it facilitates comparison of price changes in different directions, across different periods of time and for different commodities. Comparison of CVs across market years provides an indication of a commodity's long-run price variability. In this case, the long-run variability of commodity prices across years reflects the risk environment for agriculture relative to other sectors (Schnepf, 1999).

1.4 Aims and Scope of This Book

The aims of the book are to provide an overview of problems linked to agricultural commodity price volatility and of methodologies that can be implemented for analysing price volatility and improving market analyses and forecasts. The scope is the understanding of problems involved by price volatility in agricultural commodities markets and implications of agricultural policies on price evolutions.

The book examines the issue of price volatility in agricultural commodities markets and how this phenomenon has evolved in recent years. The factors underlying the price spike of 2007–2008 appear to be global and macroeconomic in nature, including the rapid growth in demand of developing countries, financial crisis or exchange rate movements. Some of these factors are new. They appeared as influences on price volatility only in the last decade or during the recent price shock period, for example oil prices, biofuels or financial markets.

Although volatility has always been a feature of agricultural commodity markets, the evidence suggests that volatility has increased in at least some commodity markets. Volatility peaks seem to coexist with decreased stocks. Price volatility in agricultural markets is more closely linked to oil price volatility due to the development of biofuel production and a tightened interdependence between energy and agricultural commodity markets.

Even if prices have decreased recently, the persistence of volatility points to uncertainty with regards to development of markets and the design of new agricultural policy closely related to market information. Research developed throughout the chapters of this book is based on current methodologies that can be implemented for analysing price volatility and providing direction for the understanding of price volatility and the development of new agricultural policies.

The book is composed of empirical research studies and policy analyses related to understanding the nature of agricultural commodity price movements, their explanation and their implications. Analyses are at the junction between two main economic fields: financial and agricultural market economics. The main focus is on

– The main challenges involved in price volatility in Europe and the rest of the world,
– Theoretical issues regarding the understanding of price volatility,
– Specific challenges regarding price volatility in dairy, beef and pork markets,
– The role of financial markets using agricultural commodities as derivatives,
– Relevant modelling tools for analysing price volatility transmission, and
– Policy implications of price volatility and trade liberalisation in world agricultural markets.

Chapters from this book can be read independently or consecutively depending on each reader's interest in this broad subject.

Chapter 2 (by Monika Tothova) looks at past price volatility in agricultural commodity markets in order to detect whether volatility has been increasing over time.

To see whether certain relationships can be at the EU and international levels over a given time period, it compares price volatility to other economic variables (oil prices, stocks, volume of trade in futures markets and so on). It also provides an overview of potential policy instruments for addressing price volatility.

Chapter 3 (by John Baffes) provides an analysis of the link between energy and non-energy (agricultural, metals and raw materials) prices over historical data and during the current price boom. The co-movement between agricultural commodities and energy price appears to be quite strong and has increased since 2005. Furthermore, biofuels play a less important role than originally thought in the last price peak.

Chapter 4 (by Christopher L. Gilbert and C. Wyn Morgan) provides an analysis series of world prices and shows that volatility in grain prices and some vegetable oil prices appears to have risen over the past 3 years. However, for other food commodities, there is no clear direction of change. Estimated trend volatilities decline while some others rise. Generally, price volatilities are in line with their historical evolution, except for rice and sunflower oil. They also discuss the possible evolution of food price volatility in the future and its consequences for producers and consumers all over the world.

Chapter 5 (by Declan O'Connor and Michael Keane) is devoted to the analysis of the price volatility in the dairy sector. Until recently, the EU framework has served to maintain producer prices at a higher and more stable level than those which would apply in a less regulated market. Recent changes in European policy are expected to increase price volatility in EU markets. This chapter shows that both EU and world prices have experienced substantial increases in recent years, which are exceptional in their long-term historical context.

Chapter 6 (by Isabelle Piot-Lepetit) investigates price dynamics of bovine and porcine production for the European Union (EU) as a whole and for each Member States (MS). It shows a higher dispersion of prices at the MS level. Correlation between MS prices and the EU price have increased since 2003 for bovine production and decreased for porcine production. The existence of a common price process between the EU and MS prices cannot be found, such as the leadership of the EU price in the bovine and porcine EU meat market.

Chapter 7 (by Linwood A. Hoffman) describes how USDA analyses agricultural commodity markets and provides price projections for market participants and policy makers. Projections are produced based on two models and by using current market information and analysts' judgement. One model uses price as a function of relative size of inventory while the other uses futures markets for their cash price predictive power. The predictive power of this approach during the last price shock is analysed.

Chapter 8 (by Jochen Schmitz and Oliver von Ledebur) analyses the relationships among commodities and markets. Results show that particular interrelations exist on the futures markets. However, marketplaces are not continuously linked together in the same manner. Single futures contracts of corn can exhibit distinct price patterns in the short run. As a result, volatility transmission can be interrupted or disrupted in the short run. In the long run, however, such occasional interruptions are not observable and do not play a relevant role with regard to the underlying long-run commodity market architecture and the signalling function of the price.

Chapter 9 (by Hadj Saadi) analyses the international price dynamics of primary commodity and the interdependence of international markets. It reviews literature and analyses price evolution to check if interactions and co-movements' between prices exit.

Chapter 10 (by George Rapsomanikis and Harriet Mugera) analyses how price volatility is transmitted from selected international food markets to developing countries. Results show that world price changes are partly transmitted to domestic markets of the small developing countries examined. Domestic markets are integrated with the world market, but food price adjustments are slow. Volatility spillovers are limited and take place during extreme world market volatility.

Chapter 11 (by Alexander Sarris) provides a review of the risks and food import access problems faced by various low- and middle-income net food staple importing countries and reviews pertinent policies to deal with them. Then, a proposal for a food import financing facility designed to alleviate the financing constraint of many developing food-importing countries is presented.

Chapter 12 (by Beatriz Velazquez) addresses the problem of price volatility in policy design with a specific focus on current and future European agricultural policy. It presents instruments available to deal with price volatility and discusses their advantages and disadvantages based on implementation experience.

Even if this book does not cover all topics related to methods and analysis of agricultural commodity price volatility, we expect that it will help the reader to obtain a better knowledge on the challenges linked to agricultural price volatility and the way current modelling tools might be improved for a greater accuracy of agricultural market and policy analysis.

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Chapter 2
Main Challenges of Price Volatility in Agricultural Commodity Markets

Monika Tothova

Abstract Prices of agricultural commodities undergoing rapid adjustments were in the spotlight following the "food crises" in late 2007 and early 2008, and again more recently in summer and fall of 2010, raising concerns about increased price volatility, whether temporal or structural. Although price volatility is a normal feature of markets given the seasonal production cycle and discontinuity of supply in the face of a continuing demand, a greater uncertainty of a rapidly changing economic and natural environment contributes to and magnifies its occurrence. This chapter focuses on the main challenges of price volatility in agricultural commodity markets. We start by briefly touching upon the theoretical aspects of volatility, followed by a comparison of international and European markets to identify whether one was more affected than the other by increases in price volatility. Factors, implications and preliminary policy considerations of increased volatility follow before initial conclusions on future prospects are drawn.

2.1 A Primer on Theoretical Aspects of Volatility

Volatility provides a measure of the possible variation or movement in a particular economic variable. Prices change as rapid adjustments to market circumstances. Wide price movements over a short period of time typify the term "high volatility". What constitutes a volatile market or an "excess volatility" can be subjective, sector and commodity-specific.

Two measures of volatility are used:

Historical (realised) volatility, indicating a volatility of an asset in the past, is based on observed (realised) movements of price over an historical period. It represents past price movements and reflects the resolution of supply and demand factors.

Disclaimer: The views expressed in this chapter are those of the author and should not be attributed to her affiliated institution.

M. Tothova (✉)
Directorate General for Agriculture and Rural Development, European Commission, Brussels, Belgium
e-mail: monika.tothova@ec.europa.eu

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Implicit volatility,[1] is the markets' view on how volatile an asset will be in the future. It represents the market's expectation of how much the price of a commodity is likely to move and tends to be more responsive to current market conditions.

This chapter discusses historical volatility and does not refer to implicit volatility. However, historical volatility can also serve as an indicator of the possible price changes of the assets in the future. Assets – including commodities – that have high volatility are likely to undergo larger and more frequent price changes in the future, possibly attracting market participants benefiting from frequent price changes. A casual link between volatility and uncertainty is not clearly defined: volatility thrives in the environment of uncertainty, and volatile prices themselves contribute to uncertainty for producers, processors and consumers.

A variety of measures is used to detect historical volatility, some of which are referred to in the next section.

First Challenge of Volatility: Choice of Data for Analysis: Which Type, Frequency?

Choice of representative prices to analyse price volatility and their frequency is of crucial importance. Data with higher frequency exhibit higher volatility. Volatility decreases with decreasing frequency. Cash (spot) prices, such as CIF (cost, insurance, freight), can bring additional uncertainties to the analysis since transport prices alone are very variable, influencing the result. FOB (free on board) prices are better candidates.

Commodity exchanges provide a steady stream of daily settlement prices making them ideal for analysis. However, futures markets do not exist or are not used for all commodities. In addition, some contracts, such as the wheat contract on the Chicago Board of Trade, suffer from lack of convergence between cash and future prices.

2.2 Analysis: Is There More Volatility Now?

This section looks at spot and future prices using two different approaches to determine whether the amount of volatility on agricultural commodity markets has increased.[2] Differences in price volatility on EU and world markets are also discussed.

[1] This is calculated from the Black–Scholes formula for the price of a European call option on a stock.

[2] *Volatility* and *variation* are used interchangeably in this chapter.

2.2.1 Spot Prices: An Intuitive Approach

For the "intuitive approach"-based deviations from a trend in prices, monthly price series from January 1997 to October 2010 on the EU and world agricultural commodity markets are analysed to determine whether:

1. World markets experienced higher price variation than EU markets, or
2. Price variation on international and EU commodity markets increased over time.

EU data were taken from Agriview's EU market prices[3] for representative products, and international commodity prices from international benchmarks from the World Bank or FAO (Food and Agriculture Organization). Some commodities might not be directly comparable in terms of quality and in some cases price data were not available on both world and the EU markets. Data and sources are described in Appendix 1. As discussed in the first challenge, monthly frequency can hide more serious volatility issues by averaging daily data. In addition, international reference prices for soybeans and soybean meal are CIF and thus include freight cost.

Two indicators are calculated:

1. A percentage of price observations lying outside the 20% tunnel around the price trend line. Using this method, observations just slightly over the trend line are counted the same way as peaks.
2. A coefficient of variation as a ratio of standard deviation over mean as a measure of dispersion of data points. The higher the coefficient of variation, the larger the dispersion of series and the higher the price volatility.

Tables 2.1 and 2.2 summarise the results for relatively comparable products. Table 2.1 shows percentage of observations lying outside the 20% tunnel around the trend line. Table 2.2 shows coefficient of variations.

Table 2.1 shows that over the studied period from January 1997 to October 2010, the percentage of observations outside the 20% tunnel was higher on the world markets than on the EU markets (with the exception of chicken). However, differences are noticeable in the cases of butter and Skim Milk Powder (SMP) where the percentage of observations outside the 20% tunnel was significantly higher on the world markets than in the EU (70+% compared to 20–30%). Dividing the data into two equally sized intervals (January 1997–November 2003 and December 2003–October 2010), we note that the percentage of observations outside the 20% tunnel on the world market exceeded the percentage of observations outside the 20% tunnel on the EU market for barley, wheat, maize, butter, SMP and beef during the first time period. During the second time period, from December 2003 to October 2010 which also included the periods of price hikes, we note that the absolute percentage

[3] http://www.agriview.com/

Table 2.1 Twenty percent tunnel, comparable products

20% tunnel	World prices			EU prices		
Commodity	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)
Barley	66.87	55.42	**78.31**	57.93	28.40	**86.75**
Wheat (Int. SRW, EU bread)	72.89	75.90	69.88	54.88	28.40	**80.72**
Maize	62.05	67.47	56.63	48.78	19.75	**77.11**
Butter	80.00	85.54	74.39	25.30	0	**50.60**
SMP	72.29	79.52	65.06	28.92	16.87	**40.96**
Chicken	10.84	13.25	8.43	15.66	9.64	**21.69**
Beef	22.89	22.89	22.89	6.02	6.02	6.02

The *bold figures* indicate that "volatility" (measured either as CV or number of observations outside the 20% tunnel) increased in the second period

of observations outside the 20% tunnel on the world market decreased for all products except for barley. On the EU market, the percentage of observations outside the 20% tunnel increased for all commodities except beef.

Table 2.2 summarises coefficients of variations for the products discussed in Table 2.1. Comparing coefficients of variation on the world and EU markets covering period from January 1997 to October 2010, we observe that prices on the world markets were more dispersed than prices on the EU markets, with meats being less dispersed than crops and dairy. On both the world and EU markets, the coefficient of variation increased between 1997–11/2003 and 12/2003–2010, indicating increased dispersion of prices. However, with the exception of chicken, world markets experienced more dispersed prices in the first period between 1997 and 2003 than EU markets did.

Table 2.2 Coefficient of variation, comparable products

Coefficient of variation	World prices			EU prices		
Commodity	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)
Barley	34.04	15.42	**31.05**	20.80	6.39	**26.26**
Wheat (Int. SRW, EU bread)	38.92	17.32	**33.23**	21.44	5.82	**27.54**
Maize	33.68	11.96	**30.17**	18.52	5.64	**23.23**
Butter	46.56	16.93	**35.72**	10.55	3.47	**12.84**
SMP	39.63	17.66	**33.03**	14.39	8.35	**18.31**
Chicken	13.90	5.57	**8.42**	10.71	6.15	**9.28**
Beef	21.26	9.77	**13.00**	6.84	4.07	**5.40**

Even in the second time period, with the exception of chicken, the coefficient of variation in the world price series exceeded the coefficient of variation in the EU. Price charts for comparable products are presented in Fig. 2.1.

Tables 2.3 and 2.4 show both number of observations outside the 20% tunnel and coefficient of variation for world (Table 2.3) and EU (Table 2.4) prices for which respective equivalents were not identified. On the international markets, the percentage of observations outside the 20% tunnel increased for sorghum, soybean meal and Whole Milk Powder (WMP). Coefficient of variation increased for all products between both sub-time periods, indicating higher dispersion of prices after 2003. On the EU market, the percentage of price observations outside the 20% tunnel more than doubled between both sub-time periods for crops and dairy, increased somewhat for eggs and decreased for most of the meats. The coefficient of variation increased significantly for crops and cheeses while it decreased for meats and remained relatively stable for eggs.

Although the intuitive method suffers from a number of shortcomings (e.g. it fails to properly account for seasonality), it allows one to draw preliminary conclusions:

1. Using both the number of observations outside the 20% tunnel and the coefficient of variation, from January 1997 to October 2010 world commodity markets experienced more volatility than EU markets. Coefficient of variation increased both on the world and EU markets between 01/1997–11/2003 and 12/2003–10/2010, with the EU recording more dramatic increases. However, in absolute terms the coefficient of variation remains higher on the world markets than on the EU markets during 12/2003–10/2010 for all products except for chicken where the levels are comparable.
2. Compared to 01/1997–11/2003, dispersion of prices in 12/2003–10/2010 measured by coefficient of variation increased for all commodities studied both in the EU and the world, with the exception of some meat products in the EU. However, compared to crops and dairy, volatility of meat prices is relatively low. Note that the latter time period includes price peaks, significantly shifting the mean of the time series.

2.2.2 *Volatility on the Futures Markets*

Commodity exchanges produce a stream of daily settlement data. The use of nearby futures is also justified by frequently using those futures as international reference prices. The Chicago Mercantile Exchange (CME) group offers already calculated measures of volatility.[4] For consistency for European exchanges we used settlement prices and the formula applied in the CME calculations for the milling wheat (from

[4]http://www.cmegroup.com/market-data/reports/historical-volatility.html. To annualize their volatility figures, the CME group uses an average of 252 trading days each year. Due to holidays

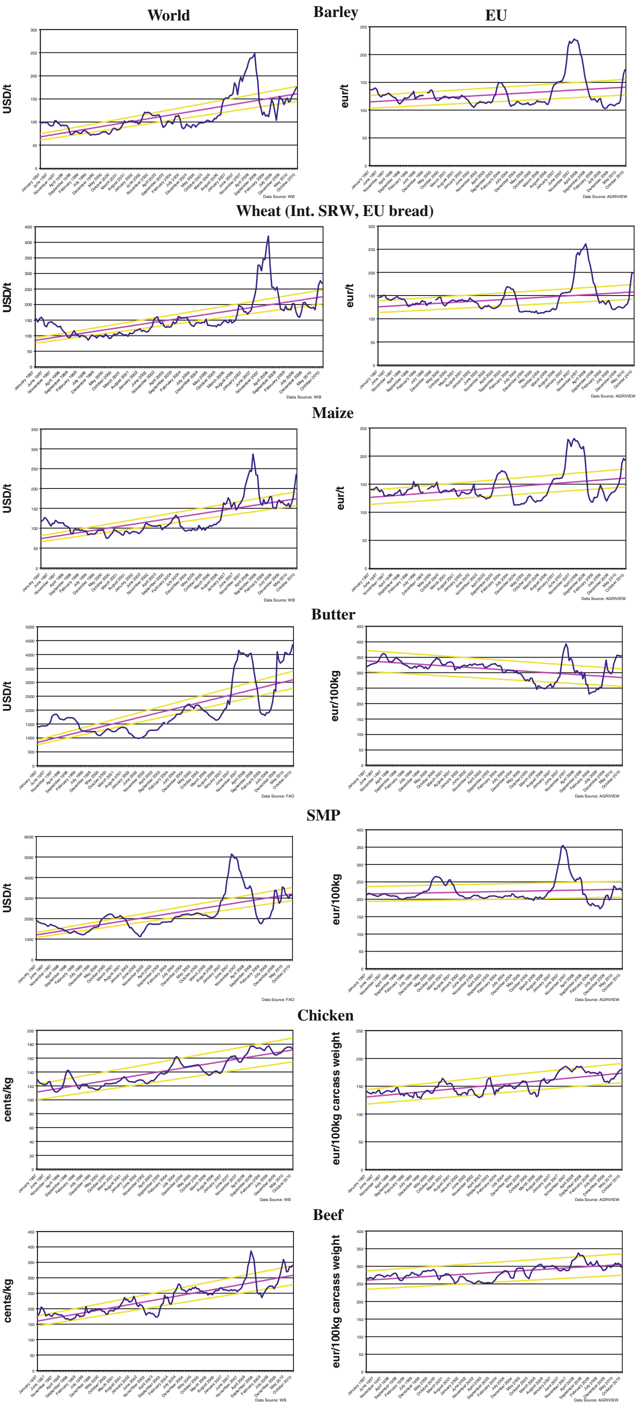

Fig. 2.1 Price charts with trend lines for comparable products

Table 2.3 World prices: 20% tunnel, coefficient of variation

20% tunnel	20% tunnel			Coefficient of variation		
Commodity	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)
HRW wheat	65.66	71.08	60.24	37.75	16.06	**31.91**
Rice Thai 5%	89.16	90.36	87.95	46.30	23.39	**39.97**
Sorghum	59.04	54.22	**63.86**	31.19	11.60	**28.33**
Soybeans	72.89	79.52	66.27	34.89	16.70	**27.58**
Soybean oil	74.70	87.95	61.45	41.40	23.81	**33.08**
Soybean meal	75.30	72.29	**78.31**	37.25	21.60	**30.80**
Cheese	57.83	62.65	53.01	37.42	10.53	**27.59**
WMP	73.49	69.88	**77.11**	40.15	13.12	**33.91**

Table 2.4 EU prices: 20% tunnel, coefficient of variation

	20% tunnel			Coefficient of variation		
Commodity	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)	01/97–10/10 (%)	01/97–11/03 (%)	12/03–10/10 (%)
Feed wheat	56.10	28.40	**83.13**	23.18	7.37	**29.47**
Durum wheat	59.15	39.51	**78.31**	33.81	12.08	**39.59**
Malting barley	59.15	32.10	**85.54**	23.51	6.02	**27.79**
Cheddar	50.00	34.94	**65.06**	17.38	5.59	**16.63**
Eidam	27.11	10.84	**43.37**	8.96	4.60	**10.21**
Young bovines	9.64	18.07	1.20	8.98	7.07	6.48
Cows	24.70	39.76	9.64	9.50	7.77	6.35
Heifers	1.81	3.61	0	7.47	4.66	**5.31**
Piglets	59.64	77.11	42.17	19.28	24.49	12.07
Pork	31.93	50.60	13.25	13.15	17.02	7.80
Eggs	43.37	36.14	**50.60**	16.18	13.71	**16.59**

September 1998 to October 2010) contract on MATIF. The formula is outlined in Appendix 2.

Different products (wheat, maize, oats, soybeans and derived products) show different price and volatility patterns. However, there are commonalities across them. Although increased volatility can occur in any given period, actual peaks differ on the basis of the commodity and developments of their fundamentals. Due to space limitation we would focus on wheat in this chapter. Figure 2.2 shows historical volatility of wheat on the Chicago Board of Trade (CBOT – part of the CME group)

and weekends, the number of actual trading days each year can differ, and as such volatility results can differ.

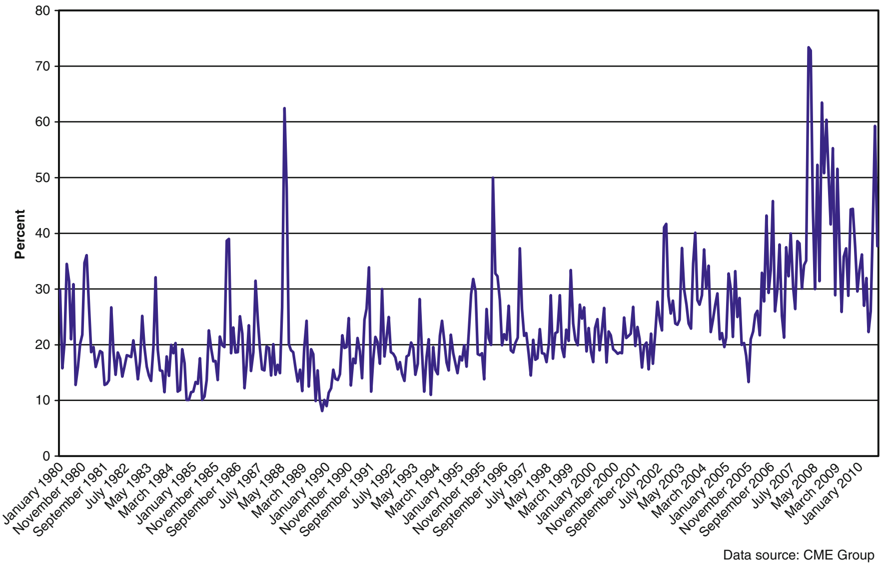

Fig. 2.2 US wheat, historical volatility, monthly annualised

on a monthly basis from January 1980 to October 2010. Wheat volatility has had an increasing trend over the observed period, ranging between 30 and 73%. In the last 4 years the average volatility has increased.

MATIF wheat experienced the highest volatility in September 2007, January 2009 and July–August 2010 when it reached around 44–48%. The summer 2010 high volatility episode accompanied poor harvest prospects in Russia and consequent export ban. However, in between those peaks, the volatility was as low as 8% (February 2010). Although experiencing peaks, wheat volatility on MATIF was relatively stable between 1998 and mid-2006 when it started increasing.

Second Challenge of Volatility: Choice of Method and Reference Period

A variety of approaches to detect volatility yielding different results are in use. Different results are also obtained using different reference periods for comparison. Crude methods applied in this chapter showed that price volatility is increasing. However, even though the presence of volatility was not increasing over a longer time frame, it is important to compare shorter time frames.

Although this chapter has not looked at the long-term data series, others (e.g. OECD/FAO, 2010) have done so and did not support a case for decreasing long-term volatility trend as the current boom of volatility does not match the heights reached in the 1970s. While correct on technical grounds, the findings are not of immediate relevance to producers who were faced with lower price variability in the preceding two decades.

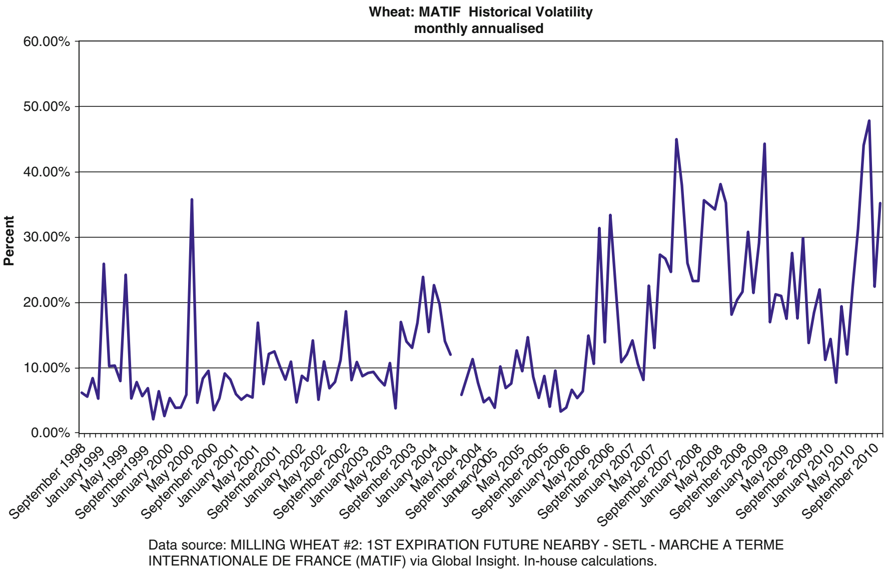

Fig. 2.3 MATIF milling wheat, historical volatility, monthly annualised

Agricultural commodities traded on European exchanges, although smaller in terms of volume, were not shielded from increased volatility. Figure 2.3 shows the development of historical volatility for milling wheat on MATIF.

2.3 Factors Influencing Price Volatility

Price volatility is driven by the same set of factors as prices – a topic studied in detail during and following the price hikes of 2007–2008 (e.g. EC, 2008; Meyers, 2009; Trostle, 2008). Among the wide variety of factors are underlying market fundamentals such as yields and stock levels; weather and changing weather patterns with their related impacts; cycles in key markets; policy driven developments including large purchases by the governments; developments outside the agricultural sector such as exchange rate and oil price movements; trade policies and their transmission; investment in agricultural production etc. Commodities for which the demand is inelastic (such as agricultural products) tend to be more volatile. Long-term structural changes are also responsible for the increase in price variability, although their effects are not immediate. Only some of the factors contributing to greater volatility are described below.

Low levels of stocks in their own right do not result in high price but provide a limited buffering capacity should increasing demand or short-term supply challenges occur. There is no single answer to the question “What normal stocks are?”.

In addition, stock management, such as stock creation and release, can affect market fundamentals and impact prices.

Climate change and *weather*-related events impact production variability and thus impact market fundamentals. So far on the EU level, no correlation has been established between the warming of the last decades and the level of crop yields, which have generally increased (EC, 2009). However, the impact of climate change might be visible already in other, more vulnerable countries.

A frequent culprit of increased price volatility is *speculation* based on investing in futures contracts on commodity markets to profit from price fluctuations. The wider and more unpredictable price changes are, the greater the possibility of realising large gains by speculating on future price movements of the commodity in question. Although the presence of "speculators" on the derivatives markets is a necessary condition for functioning markets and efficient hedging, volatility can attract significant speculative activity and destabilise markets, which are both the cause and effect of increased volatility. In thinly traded markets where only small quantities of physical goods are traded, the value of speculative trades may create false trends and drive up prices for consumers. Arguments both for (e.g. Irwin and Sanders, 2010) and against (e.g. Robles et al., 2009) "speculation" are ample, although evidence is inconclusive. While other factors and fundamentals are at play and have to be considered, there is a time overlap between increased volatility and increase in open interests on the commodity markets (Fig. 2.4). While increase in open interests and inflow of investment money increases the liquidity on the market, increased liquidity could come with increased volatility.

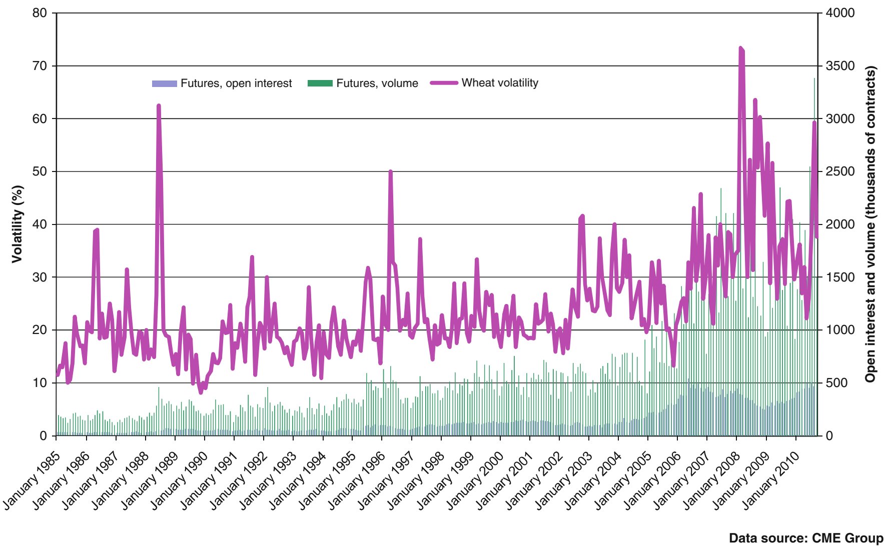

Fig. 2.4 US wheat historical volatility, futures open interest and volume monthly

Policies: Greater market orientation of agricultural policies (CAP included) relies on a greater transmission of market signals, and results in more variable prices. Policy instruments (described later) are in place to mitigate effects of price variability. Trade restrictive policies also play a role in limiting supplies, thus increasing uncertainty on the markets and price variability.

Strong co-movements with energy and other agricultural prices: Linkages with energy markets before the emergence of biofuels were one-way: oil and energy as inputs to agricultural production. Increased connection between energy and agriculture raises questions about volatility transmission from more volatile energy and oil markets in addition to changing market fundamentals, or at times without a significant change in market fundamentals. The strength of the link is not yet determined, although Du et al. (2009) found evidence of volatility spillover among crude oil, maize and wheat markets after autumn 2006 and explained it by tightened interdependence between these markets induced by ethanol production. Figures 2.5 and 2.6 show scatter charts of daily settlement data for maize and crude oil for the 2000–2004 and 2005–2010 periods. An OLS line fitted to the data reveals a stronger correlation in the 2005–2010 time period with an R-squared of over 53% when not including a trend variable, and 56% when including a trend variable to avoid spurious regression, with all estimates significant at 5% level of significance. Scatter charts for data before 2000 (not included) resemble that of 2000–2004, with no significant correlation.

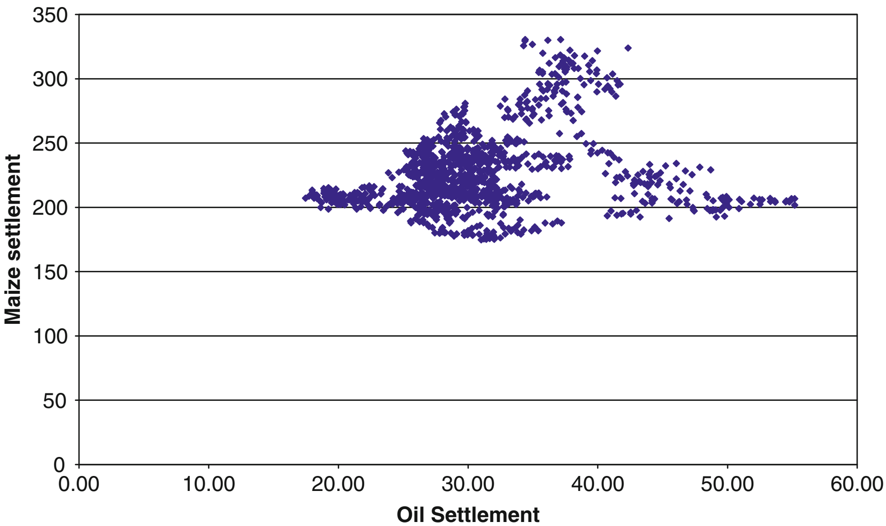

Fig. 2.5 Scatter chart of maize and crude oil settlement prices, 2000–2004

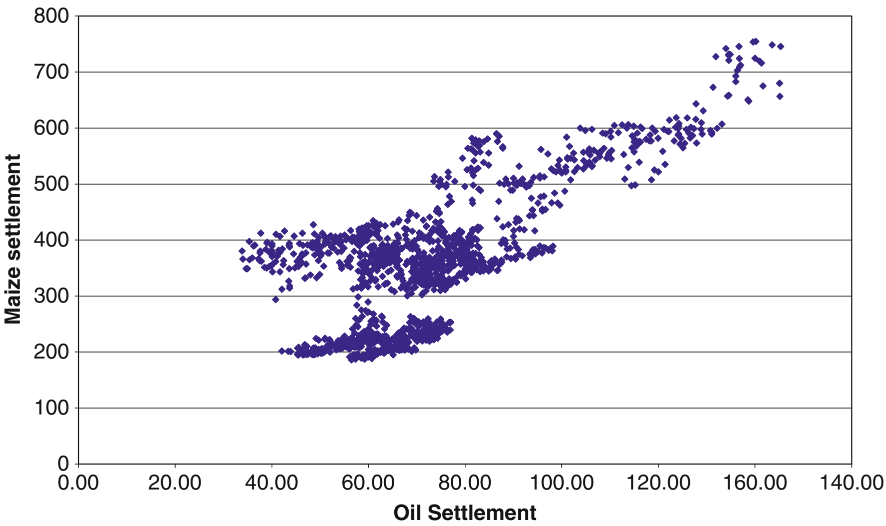

Fig. 2.6 Scatter chart of maize and crude oil settlement prices, 2005–2010

2.4 Implications of Increased Volatility

Although references are often made to "excess volatility", it is generally accepted that a certain degree of volatility is desirable, and price volatility is a normal feature of the markets. Without price adjustments, markets would come to a stall. Volatility across the commodity markets is not consistent. Although active participants on agricultural commodity markets are finding prices to be volatile, compared to energy markets, volatility remains rather low. Energy returns have been significantly more volatile than other commodity sectors. Other markets, such as metals, have experienced higher volatility than energy markets; these episodes have been brief and transitory.

In macroeconomic terms, while price hikes are beneficial for net exporting countries that benefit from improved balance of payments, they increase the import bill of net importing countries. Food security considerations play an important role. Variable prices lead to an uncertain food import bill, and high prices impact the ability of poor consumers to purchase necessary food. On the other hand, producers and net sellers benefit from increased prices.

Concerns about increased price volatility are usually voiced by producers and processors who in the absence of risk management tools are exposed to unpredictability and uncertainty associated with changing prices. High fluctuations in prices may limit the ability of consumers (processors) to secure supplies and control input costs. Due to price transmission issues, contracting and relatively low percentage of raw commodity in the processed products, consumer prices do not necessarily follow commodity prices directly. While we focus on the volatility of output prices, volatility of input prices (oil, fertiliser etc.) also affects agricultural production and decision-making.

The biggest drawback of volatility is the associated uncertainty of marketing production, investment in technology, innovation etc. The persistence in volatility reflects the continued uncertainty with regards to how market fundamentals have unfolded and how they are likely to unfold. Higher price volatility means higher costs of managing risks (such as higher margins on futures contracts and higher premiums for crop revenue insurance). It is likely that higher costs of risk mitigation would eventually translate into higher consumer prices. Commodity shocks in the form of increased prices and increased volatility can also have an impact on inflation, although this chapter abstains from analyzing the link.

A distinction has to be made between the effects of volatility itself (such as unstable prices and their impact on food security) and effects of policy reactions. Short-term policy reaction can contribute to market instability and consequently volatility, as we observed in the case of rice in spring 2008 when in the wake of increasing price levels some major exporting countries introduced export restrictions, and again in summer 2010 following an export ban in Russia.

2.5 Policy Considerations

Increased volatility can be addressed in two different ways:

1. Dealing with price volatility itself by trying to stabilise markets using price controls and supply controls (stock management).
2. Dealing with the effects of increased price volatility by employing risk management tools (crop insurance, [*functioning*] futures markets), income stabilisation mechanisms, safety nets etc.

2.5.1 Dealing with Price Volatility Itself

Price controls and supply controls go hand in hand. Past attempts to stabilise commodity prices – and thus reduce volatility – using international commodity agreements, marketing boards, supply controls, planned economies, or more explicit price setting nationally were not a great success. Since successful manipulation of market fundamentals is unlikely, a safe – but rather slippery – way to reduce or even eliminate volatility is to fix prices. However, such experiments in the past led to various forms of market failures, leading to inefficiencies, and are unlikely to gain broad support. Dawe (2009) discusses both costs and benefits of stabilising prices of staple foods. The main cost of price stabilisation is the deadweight loss by not allowing market prices to follow world prices. Among the beneficiaries of price stabilisation are consumers and producers benefitting from stable prices. In this case price stabilisation serves as a safety net program, although not the most efficient one.

The *international commodity agreements* regulating supply through production quotas for its members and maintaining buffer stocks, so that world prices remain stable, within a specified range were used from the 1950s to the 1990s. These agreements managed to sustain world prices for a number of products (notably coffee), but the eventual collapse brought about by competitive pressure from producer countries and a withdrawal of support from consumer countries has made them largely ineffective at keeping prices level. For a detail on international commodity agreements, refer to Gilbert (1996).

Stock management played an important role in international commodity agreements. Following the price hikes of 2007–2008, many advocate the role of building stocks as a way to buffer against sudden changes in prices. Proposals currently on the table address increased volatility in an *ad hoc* fashion mostly addressing issue of stocks, both virtual and real. While stocks fulfill a buffering role, they also remove commodity from the market and thus at the times of tight supply might put additional strain on it. Management of stocks also comes with a high cost of governance.

It might be possible to deal with price volatility itself in the longer term by strengthening market fundamentals, by securing supply and by introducing innovation and new technology.

2.5.2 Dealing with the Effects of Increased Price Volatility

Price volatility affects both macro and microeconomic aspects. On the macroeconomic level, price volatility influences balance of payments of both importing and exporting countries. If volatility attains a significant level, it may affect the ability of governments to plan and provide economic security and economic growth. Although price hikes draw attention to net food importing countries that see their import bills soaring, the effects of price decreases are naturally felt in net exporting countries.

Dealing with effects of increased price volatility calls for income stabilisation. One way to income stabilisation uses price stabilisation described earlier. However, price stabilisation is not a necessary condition for income stabilisation, which can be achieved by designing efficient safety nets. In the developed countries with well-established agricultural policies, many programs already contain instruments to aid income stabilisation. Where this is the case, it is important that income support be decoupled from production to minimise production and trade distortions.

Commodity price risk management uses financial instruments for managing price risks rather than reducing price volatility itself. Risks are not transferred to the government but are reallocated among private traders. Among those instruments are futures and forwards contracts, commodity swaps, call and put options, commodity-indexed bonds and long-term contracts. There is renewed interest in the range of options based on market-based risk management instruments that might help countries and individuals generate more stable and predictable incomes. Use of market-based risk management instruments requires the proper functioning of derivatives markets. However, while crop insurance and futures markets work relatively well in developed countries, extending them to developing countries might not always be feasible.

The backbone for successfully coping with commodity price volatility relies on strong institutions and management. A further development of market-based instruments that react to market signals, while at the same time helping to mitigate the effects on incomes, is important. A possible development of financial derivates could also play a role. For this to take place, a transparent regulation of commodity exchanges is a pre-requisite. Safety nets could be developed, or where they exist, be reinforced to mitigate effects of volatile prices. Currently, many developing countries are lacking safety nets as well as access to efficient saving instruments. The best long-term solution to commodity price volatility would be product diversification.

Third Challenge of Volatility: When Is Volatility Excessive? What Policies Should Be Employed?

The level of volatility is commodity-specific, differing across sectors and commodities within a sector. A question to answer is whether volatility should be prevented, risking obstruction of market signals, or whether addressing consequences of price volatility aiming at income stabilisation is more desirable.

2.6 Concluding Thoughts

Although volatility has always been a feature of agricultural commodity markets, the evidence suggests that volatility has increased at least in some commodity markets. There seems to be an overlap between periods of high prices and increased volatility. Volatility peaks also seem to coexist with decreased stocks. The chapter abstained from considering the development of fundamentals and macroeconomic factors, such as exchange rate developments.

Persistence of volatility points to uncertainty in developments of market fundamentals coupled with structural and monetary policy. Higher price volatility means higher costs of managing risks (such as higher margins on futures contracts and higher premiums for crop revenue insurance). However, with increasing biofuels production, a tightened interdependence between crude oil and commodity markets can be expected which could result in increased transmission of crude oil price volatility into agricultural commodity markets. It is likely that higher costs of risk mitigation would eventually translate into higher consumer prices.

Increased volatility highlights the presence of greater uncertainty on the market. Two broad sets of policies could be employed: (1) those that target volatility itself, such as price and supply controls, and (2) those that deal with the effects of price volatility while letting markets work, such as risk management instruments, safety nets etc. Policies based on price and supply controls do not appear to have an impressive precedent, and reduce market signals. Policies mitigating volatility or the effects of volatility should aim to address uncertainties and focus on risk management while keeping markets working.

It remains impossible to capture future price variability. However, elements from the past that resulted in the past and present variability remain active.

Appendix 1: Description of Price Series Used in Section 2.2

World grains, oilseeds, and meats: compilation of various sources by World Bank Commodity Price Data (Pink Sheet), available at http://go.worldbank.org/2O4NGVQC00

- Barley (Canada), feed, Western No. 1, Winnipeg Commodity Exchange, spot, wholesale farmers' price
- Wheat (US), no. 2, soft red winter, export price delivered at the US Gulf port for prompt or 30 days shipment
- Maize (US), no. 2, yellow, f.o.b. US Gulf ports
- Wheat (US), no. 1, hard red winter, ordinary protein, export price delivered at the US Gulf port for prompt or 30 days shipment
- Rice (Thailand), 5% broken, white rice (WR), milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok
- Sorghum (US), no. 2 milo yellow, f.o.b. Gulf ports
- Soybeans (US), c.i.f. Rotterdam
- Soybean oil (Any origin), crude, f.o.b. ex-mill Netherlands
- Soybean meal (any origin), Argentine 45/46% extraction, c.i.f. Rotterdam beginning 1990; previously US 44%
- Meat, beef (Australia/New Zealand), chucks and cow forequarters, frozen boneless, 85% chemical lean, c.i.f. U.S. port (East Coast), ex-dock, beginning November 2002; previously cow forequarters
- Meat, chicken (US), broiler/fryer, whole birds, 2-1/2 to 3 pounds, USDA grade "A", ice-packed, Georgia Dock preliminary weighted average, wholesale

World dairy prices: FAO compilation of average of mid-point of price ranges reported bi-weekly by Dairy Market News (USDA). Available at http://www.fao.org/es/esc/prices/PricesServlet.jsp?lang=en

- Butter, Oceania, indicative export prices, f.o.b.
- Cheddar Cheese, Oceania, indicative export prices, f.o.b.
- Skim Milk Powder, Oceania, indicative export prices, f.o.b.
- Whole Milk Powder, Oceania, indicative export prices, f.o.b.

EU market prices for representative products (monthly) Available at http://ec.europa.eu/agriculture/markets/

Appendix 2: Theoretical Consideration

The CME calculation of historical volatility calculation is the annualised standard deviation of the first difference in the logarithmic values of nearby futures settlement prices. Mathematically, it can be written as

$$\text{Volatility} = \text{STDEV}_{\text{Day1}}^{\text{Day}N}\left(\ln\frac{\text{Settle } PxT}{\text{Settle } PxT-1}\right)\sqrt{252}$$

where 252 is the estimated number of trade days in a year to convert volatility into annualised terms.

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Chapter 3
The Energy/Non-energy Price Link: Channels, Issues and Implications

John Baffes

Abstract One key characteristic of the recent commodity price boom has been co-movement among most prices, especially between energy and non-energy commodities. Such link is often discussed in connection (or attributed) to the use of food commodities for the production of biofuels. This chapter argues that, due to agriculture's energy-intensive nature, energy prices have played a key role even before the diversion of food commodities to the production of biofuel began. Transmission elasticity from energy to agricultural commodity prices of 0.20 is estimated for the 1960–2005 period. The econometric evidence confirms that the elasticity increased considerably when the post-2005 boom years were included in the analysis. But the chapter also finds that similar (and on some occasions larger) increases in elasticities are present in all commodity sectors, thus confirming that common factors must have played an important role during the recent boom.

3.1 Introduction

The recent commodity boom emerged in the mid-2000s after nearly three decades of low and declining commodity prices (see Fig. 3.1). The long-term decline in real prices had been especially marked in food and agriculture. Between 1975–1976 and 2000–2001, world food prices declined by 53% in real US-dollar terms. Such price declines raised concerns, especially with regard to the welfare of poor agricultural producers. In fact, one expected of the Doha Round's chief motives (and also one of its perceived main obstacles) was the reduction of agricultural support and trade barriers in high-income countries – a set of reforms that was to induce increases in commodity prices and hence improve the welfare of low-income commodity producers (Aksoy and Beghin, 2005). Starting in the mid-2000s, however, most commodity prices reversed their downward course, eventually leading to an unprecedented commodity price boom.

Disclaimer: The views of this chapter do not reflect those of the World Bank.

J. Baffes (✉)
Development Prospects Group (DECPG), The World Bank, Washington, DC, USA
e-mail: jbaffes@worldbank.org

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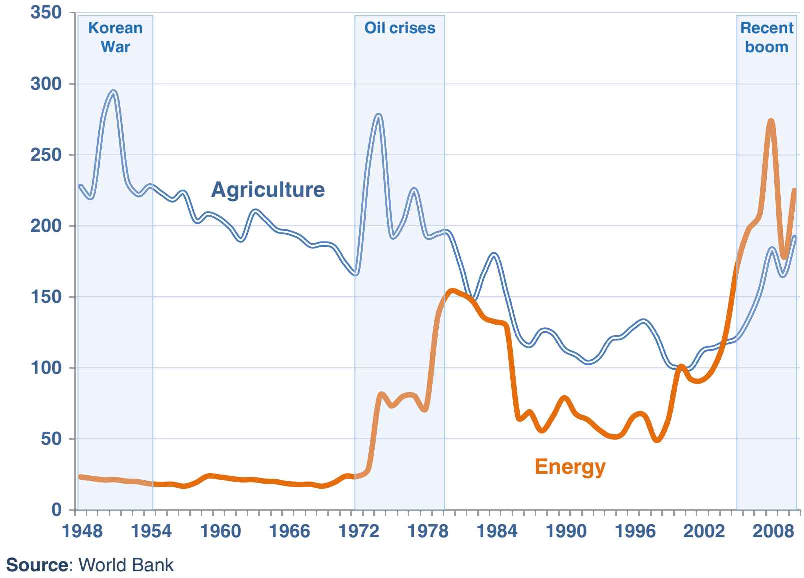

Fig. 3.1 Commodity price indices (real, MUV-deflated, 2000 = 100)

Between 2003 and 2008, nominal prices of energy and metals increased by 230%, those of food and precious metals doubled and those of fertilisers increased fourfold. The boom reached its zenith in July 2008, when crude oil prices averaged US$ 133/barrel, up 94% from a year earlier. Rice prices doubled within just 5 months of 2008, from US$ 375/ton in January to $757/ton in June.

The recent boom shares two similarities with the two earlier major commodity booms of the post-WWII period, during the Korean War and the 1970s' energy crisis (see Radetzki, 2006; Baffes and Haniotis, 2010). Each of the three booms took place against a backdrop of high and sustained economic growth as well as an expansionary macroeconomic environment, and each was followed by a severe slowdown of economic activity. And all three triggered discussions on coordinated policy actions to address food and energy security concerns.

Yet the recent boom also shows some important differences from the previous ones. By most accounts, it was the longest-lasting and the broadest in the numbers of commodities involved. It was the only one that simultaneously involved all three main commodity groups – energy, metals and agriculture – with its peak showing food and agriculture prices increasing less than all other commodity prices (World Bank, 2009). It was not associated with high inflation, unlike the boom of the 1970s (although the increase in food prices had some notable, albeit short-lived, impact on inflation). Finally, it unfolded simultaneously with the development of two other booms – in real estate and in equity markets – whose end led most developed countries to their most severe post-WWII recession.

The recent boom took place in a period when most countries, especially developing ones, sustained strong economic growth. During 2003–2007, growth in developing countries averaged 6.9%, the highest 5-year average in recent history. Yet apart from broad and prolonged economic growth, the causes of the boom were numerous, including macro and long-term as well as sector-specific and short-term factors.

Fiscal expansion in many countries and lax monetary policy created an environment that favored high commodity prices.[1] The depreciation of the US dollar – the currency of choice for most international commodity transactions – strengthened demand (and limited supply) from non-US dollar commodity consumers (and producers). Other important contributing factors include low past investment, especially in extractive commodities[2]; investment fund activity by financial institutions that chose to include commodities in their portfolios, the so-called financialisation of commodities; and geopolitical concerns, especially in energy markets.

In the case of agricultural commodities, prices were affected by the combination of adverse weather conditions, the diversion of some food commodities to the production of biofuels (notably maize in the US and edible oils in Europe) and, most importantly higher costs of production due to higher energy and fertiliser prices. In

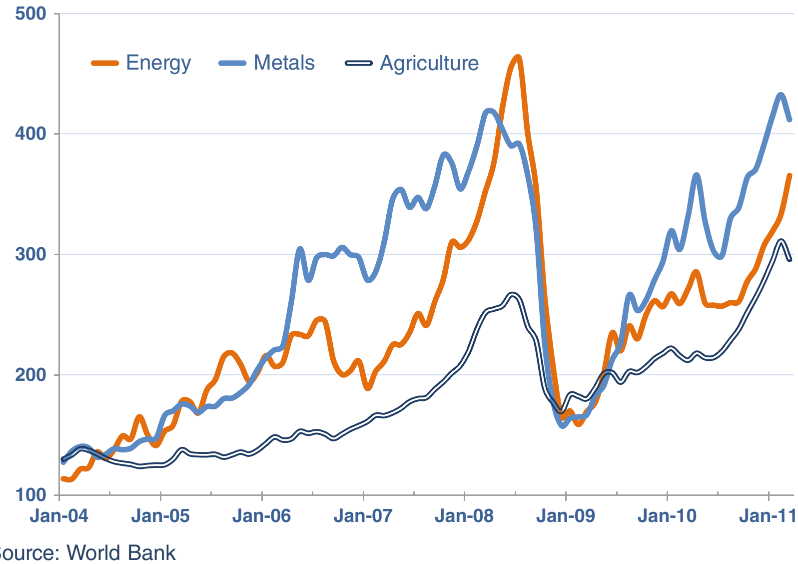

Fig. 3.2 Commodity price indices (nominal, 2000 = 100)

[1] Calvo (2008) and Frankel (2008) have argued that low interest rates played a key role during the boom.

[2] Although underinvestment has been cited very often as the key factor in the boom, this assessment is essentially derived ex-post. Certainly, any level of past investment will be considered low at high prices and high at low prices. Yet, research reported in World Bank (2009) shows that the level of investment was "right" at the time it was made. For example, during 1980–2007, R&D and investment expenditures by major multinational oil and gas companies track very closely output prices (as evidenced by their strong correlation with energy prices, $R^2 = 0.95$). Similarly, public R&D agricultural expenditures follow agricultural GDP.

turn, global stock-to-use ratios of several agricultural commodities declined to levels not seen since the early 1970s, further accelerating the price increases. Policy responses including export bans and prohibitive taxes that were introduced in 2008 to offset the impact of increasing world food prices contributed to creating the conditions for the "perfect storm."

The weakening and/or reversal of these factors, coupled with the financial crisis that erupted in September 2008 and the subsequent global economic downturn, induced sharp price declines across most commodity sectors. But most commodity prices picked up again recently and the key commodity price indices are twice as high as their early 2000s' levels (Fig. 3.2).

This chapter focuses on the interplay between energy and non-energy commodity prices. While one factor behind the link between energy and non-energy commodities, biofuels, has received considerable attention (and has been subject to heated debate), the link is much more complex and broader with a number of additional dimensions. They include high energy intensity of most agricultural commodities, transmission elasticities that may have changed overtime and the likely spillover effects from crude oil to non-energy markets through investment fund activity.

3.2 The Energy/Non-energy Price Link

It has become increasingly clear that the energy price increases of the last few years have a permanent character. In the 20 years between 1984 and 2004, the price of crude oil averaged a little more than US$ 20/barrel in real 2000 terms.[3] Now most analysts and researchers believe that the "new" equilibrium price of oil will be three to four times higher than this, with proportional changes taking place in all other types of energy, at least in the long term. If such assessment materialises, then high energy prices coupled with the high energy intensity of agricultural commodities imply that developments in non-energy (especially food) markets will depend strongly on the nature and degree of the price links between energy and non-energy commodities. Yet, the nature of the link has been analysed often in a single

[3]The low energy prices between mid-1980s and early 2000s prompted most analysts to argue that the high prices of the 1970s were an aberration and that the pre-1973 levels were the norm. For example, in its March 6, 1999, edition, the *Economist*'s leader article entitled "Drowning in Oil" concluded that (p. 19): "$10 might actually be too optimistic. We may be heading for US$ 5. Thanks to new technology and productivity gains, you might expect the price of oil, like that of most other commodities, to fall slowly over the years. Judging by the oil market in the pre-OPEC era, a 'normal' market price might now be in the US$ 5–10 range. Factor in the current slow growth of the world economy and the normal price drops to the bottom of that range." Indeed, most energy analysts were forecasting real prices to average between US$ 15/barrel and US$ 20/barrel in the long run. For example, the World Bank's nominal crude oil price forecast in 1999 was US$ 18/barrel for 2005 and US$ 19/barrel for 2010. The December 2008 WTI futures contract opened at US$ 18.88 in January 15, 2002, when it was first introduced. During 2008, crude oil prices averaged US$ 97/barrel, almost five times higher than the highest forecasts.

biofuel dimension, i.e. the diversion of food commodities to biofuels. Yet, the relationship between energy and non-energy commodities is much more complex and involves the cost side, the fact that transmission elasticities might have changed following the move from low to high energy prices and the presence of common factors.

3.2.1 The Cost Side

The channels through which energy prices affect other commodities are numerous (see, for example, FAO, 2002; Baffes, 2007; World Bank, 2009). On the cost side, energy enters the aggregate production function of most primary commodities through the use of various energy-intensive inputs and, often, transport of outputs over long distances. Some commodities have to go through an energy-intensive primary processing stage. In other cases, the main input may be a close substitute to crude oil, as when nitrogen fertiliser is made directly from natural gas. And, to the extent that some commodities are used to produce biofuels (to some degree a response to high energy prices) another important dimension is added to the energy/non-energy price link.

Because energy prices had been so low for so long, the effect of energy prices on non-energy commodities had not been placed high in the research agenda with only a few studies explicitly analyzing it (see Table 3.1). Gilbert (1989), for example, using quarterly data between 1965 and 1986 estimated transmission elasticity from energy to non-energy commodities of 0.12 and from energy to food commodities of 0.25. Borensztein and Reinhart (1994) using quarterly data from 1970 to 1992 estimated transmission elasticity to non-energy commodities of 0.11. More recently, Baffes (2007), using annual data from 1960 to 2005, estimated elasticities 0.16 and 0.18 for non-energy and food commodities, respectively. Interestingly (but not surprisingly), the transmission elasticities for food commodities are much higher than those for raw materials and metals. This is consistent with the input–output values

Table 3.1 Comparing long-run transmission elasticities

	Holtham (1988) 1967:S1–1984:S2	Gilbert (1989) 1965:Q1–1986:Q2	Borensztein and Reinhart (1994) 1970:Q1–1992:Q3	Baffes (2007) 1960–2005
Non-energy	–	0.12	0.11	0.16
Food	–	0.25	–	0.18
Raw materials	0.08	–	–	0.04
Metals	0.17	0.11	–	0.11

Notes: Holtham uses semiannual data, Gilbert and Borensztein and Reinhart quarterly and Baffes along with the present study annual. Gilbert's elasticities denote averages based of four specifications. Holtham's raw materials elasticity is an average of two elasticities based on two sets of weights. " – " indicates that the estimate is not available

Sources: Holtham (1988), Gilbert (1989), Borensztein and Reinhart (1994) and Baffes (2007) of the GTAP database, which shows that the direct energy component in the US agriculture and manufacturing sectors is 12 and 3%, respectively.

These estimates are important for several reasons. First, they share a key similarity in that they all include two of the 1970s' energy crises periods. Second, none of the papers includes the recent commodity boom, thus the biofuel or investment fund activity effect is not present. Third, and most importantly, the elasticities confirm a relatively solid response of most non-energy commodity prices to energy prices. If, for example, such response for food commodities is in the neighborhood of 0.20, as the estimates by Gilbert (1989) and Baffes (2007) suggest, then the tripling of energy prices experienced during the recent commodity boom would explain almost half of the post-2005 food price increases.

3.2.2 Biofuels

The contribution of biofuels to the recent price boom, and especially the price spike of 2007/08, has been hotly debated. Mitchell (2009) argued that biofuel production from grains and oilseeds in the US and the EU was the most important factor behind the food price increase between 2002 and 2008, accounting, perhaps, for as much as two-thirds of the price increase. Gilbert (2010), on the other hand, found little direct evidence that demand for grains and oilseeds as biofuel feedstocks was a cause of the price spike.

FAO (2008) compared a baseline scenario, which assumes that biofuel production will double by 2018, to an assumption that biofuel production will remain at its 2007 levels; it concluded that in the latter case grain prices would be 12% lower, wheat prices 7% lower and vegetable oil prices 15% lower than in the baseline scenario. OECD (2008) arrived at similar conclusions for vegetable oils, finding that their prices would be 16% lower than the baseline if biofuel support policies were abolished; eliminating biofuel subsidies would have smaller impacts on the prices of coarse grains (–7%) and wheat (–5%). Rosegrant (2008), who simulated market developments between 2000 and 2007 (excluding the surge in biofuel production), concluded that biofuel growth accounted for 30% of the food price increases seen in that period, with the contribution varying from 39% for maize to 21% for rice. Looking ahead, Rosegrant found that if biofuel production were to remain at its 2007 levels, rather than reaching its mandated level, maize prices would be lower by 14% in 2015 and by 6% in 2020.[4]

Banse et al. (2008) compared the impact of the EU's current mandate to (i) a no-mandate scenario and (ii) a mandate whereby the US, Japan and Brazil also adopt targets for biofuel consumption. They estimate that by 2020, in the baseline scenario

[4]The models used in the studies discussed in this section are the following: FAO (2008) and OECD (2008) used AGLINK; Rosegrant (2008) used IMPACT; Banse *et al.* (2008) used GTAP-E; EU (2008) used ESIM-PE; Mitchell (2009) used simple statistical analysis; and Gilbert (2010) used a CAPM-type econometric model.

(no mandate), cereal and oilseed prices will have decreased by 12 and 7%, respectively. In the EU-only scenario, the comparable changes are –7% for cereal and +2% for oilseeds. By contrast, under the "global" scenario (adding biofuel targets in US, Japan and Brazil) oilseed prices will have risen by 19% and cereal prices by about 5%. The European Commission's own assessment of the long-term (2020) impacts of the 10% target for biofuels (i.e. that renewable energy for transport, including biofuels, will supply 10% of all EU fuel consumption by 2020) predicts fairly minor impacts from ethanol production, which would raise cereals prices 3–6% by 2020, but larger impacts from biodiesel production on oilseed prices; the greatest projected impact is on sunflower (+15%), whose global production potential is quite limited. Taheripour et al. (2008) simulate the biofuel economy during 2001–2006. By isolating the economic impact of biofuel drivers (such as the crude oil price and the US and EU biofuel subsidies) from other factors at a global scale, they estimate the impact of these factors on coarse grain prices in the US, EU and Brazil at 14, 16 and 9.6%, respectively.

A joint US Department of Agriculture and Department of Energy assessment (USDE/TOT, 2008) concluded that the recent increase in maize and soybean prices appears to have little to do with the run-up in prices of wheat and rice. It found that if the amounts of corn used for ethanol and edible oil used for biodiesel in the US had remained unchanged at their 2005–2006 levels, prices in 2007–2008 would have been 15% lower for maize, 18% for soybean and 13% for soybean oil. The assessment also concluded that the impact of biofuels production in 2007 was a 3–4% increase in retail food prices and a 0.1–0.15% increase in the all-food CPI.

Clearly US maize-based ethanol production, and (to a lesser extent) EU biodiesel production affected the corresponding market balances and land use in both US maize and EU oilseeds. Yet, worldwide, biofuels account for only about 1.5% of the area under grains/oilseeds (see Table 3.2). This raises serious doubts about claims that biofuels account for a big shift in global demand. Even though widespread perceptions about such a shift played a big role during the recent commodity price boom, it is striking that maize prices hardly moved during the first period of increase in US ethanol production, and oilseed prices dropped when the EU increased impressively its use of biodiesel. On the other hand, prices spiked while

Table 3.2 Key biofuel statistics

	2000–01	2002–03	2004–05	2006–07	2008–09
Biofuels as a share of global grain and oilseed area (percent)					
EU oilseeds	0.00	0.06	0.15	0.24	0.34
US maize	0.13	0.27	0.37	0.76	1.11
Land used for US ethanol from maize as a share of (percent)					
US maize area	3.63	7.32	9.45	18.03	27.54
US grain area	0.99	2.00	2.79	5.68	8.44
World grain area	0.16	0.32	0.43	0.85	1.26

Note: The shares have been calculated based on average world yields ethanol use was slowing down in the US and biodiesel use was stabilising in the EU.

Yet while the debate has focused mostly on the amount of food crops that have been diverted to the production of biofuels, and the resulting effect on prices, less attention has been paid to a more important issue linked to this development – the level at which energy prices provide a floor to agricultural prices. Analytically, this is a very complex issue; in addition to the prices of the respective commodities (energy and feedstock for biofuels), it involves numerous other elements, including subsidies, mandates, trade restrictions and sunk costs of the biofuel industry. Therefore, analysts often use various rules of thumb to express a perceived new relationship between agricultural and crude oil prices.

One such rule is that the price of maize expressed in US$/ton is roughly double the price of crude oil in US$/barrel (thus a US$ 75/barrel price for crude oil would correspond to US$ 150/ton for maize). Other commentators (in the US) have argued that a price of US$ 3/gallon of gasoline at the pump is the level at which the maize price is determined by the crude oil price. The World Bank (2009) reported that crude oil prices above US$ 50/barrel effectively dictate maize prices; this conclusion was based on the strong correlation between the maize price and crude oil prices above US$ 50/barrel and the absence of correlation below that level. The US Government Accountability Office (2009, p. 101) while acknowledging that economists have disagreed about the circumstances that would make the 2009 US biofuel mandates non-binding (i.e. biofuels become profitable at current energy prices), it gave a range between \$80 and \$120 per barrel (the range was based on anecdotal evidence based on interviews).

3.2.3 The Empirical Evidence

This section supplements the energy/non-energy price link with some econometric evidence. Specifically, the following ordinary least squares regression, using annual data from 1960 to 2009:

$$\log({P_t}^{\mathrm{NON\_ENERGY}}) = \mu + \beta_1 \log({P_t}^{\mathrm{ENERGY}}) + \beta_2 \log(\mathrm{MUV}_t) + \beta_3 t + \varepsilon_t. \quad (3.1)$$

$P_t^{\mathrm{NON\_ENERGY}}$ denotes various commodity prices and non-energy price indices, P_t^{ENERGY} denotes the energy price index in year t (expressed in nominal dollar terms), MUV_t denotes the deflator, t is the time trend and ε_t denotes the error term; μ, β_1, β_2 and β_3 are parameters to be estimated (for more details on the composition of indices and sources of data, see Baffes, 2007 and 2009). The model is expressed in logarithms to facilitate interpretation of the parameters estimates as elasticities.

The parameter estimate of energy β_1 is expected to be positive with its magnitude depending on the effect of energy on non-energy prices through the channels discussed earlier. The effect of inflation β_2 depends on the sector in question relative to energy and can take any value. The estimate of time trend β_3, which reflects the impact of technological progress on the particular commodity sector relative to the energy sector, again can take any value but for agriculture it is expected to be higher than other sectors, a reflection of the high Total Factor Productivity (TFP) of agriculture relative to manufacture.

Parameter estimates for 11 commodity price indices based on the 1960–2005 time period are presented in Table 3.3. The results confirm that energy price movements explain a considerable part of commodity price variability as evidenced by the adjusted R^2 (which averaged 0.83 for the 11 regressions) and the significant parameter estimates of β_1 (with the exception of metals and raw materials, they are not significantly different from zero at the 1% level). The parameter estimate of the non-energy index is 0.18 and highly significant, implying that a 10% increase in energy prices is associated with a 1.8% increase in non-energy commodity prices, in the long run.

Underlying these aggregate pass-through coefficients for non-energy commodity prices are variations within sub-indices. Among the sub-indices, the highest pass-through elasticity is in fertiliser, at 0.42 – not surprisingly, since nitrogen-based fertilisers are made directly from natural gas. Interestingly, the fertiliser and energy price increases during the recent boom were in line with those experienced during the first oil shock: from 1973 to 1974 phosphate rock and urea prices increased fourfold and threefold, while the crude oil price increased from US$ 2.81/barrel to US$ 10.97/barrel.

Table 3.3 Parameter estimates for price indices, 1960–2005

	μ	β_1	β_2	$100\times\beta_3$	Adj-R^2	ADF
Non-Energy	2.00** (5.58)	0.18** (4.00)	0.51** (3.84)	–1.04** (3.01)	0.92	–3.29**
Metals	6.55** (9.75)	0.07 (1.02)	–0.48 (1.95)	0.10 (0.14)	0.59	–4.24
Fertilisers	2.37** (3.62)	0.42** (4.27)	0.16 (0.69)	–0.79 (1.68)	0.81	–4.90***
Agriculture	1.96** (5.95)	0.20** (4.57)	0.54** (4.44)	–1.53** (5.25)	0.91	–2.72*
Beverages	1.67** (2.43)	0.36** (4.16)	0.61** (2.46)	–3.27** (4.91)	0.75	–3.95***
Raw materials	0.93** (2.26)	0.02 (0.35)	0.86** (5.78)	–0.85 (2.20)	0.93	–2.89*
Food	2.39** (6.40)	0.22** (4.02)	0.41** (2.92)	–1.22 (3.93)	0.85	–2.85*
Grains	2.41** (5.47)	0.20** (3.37)	0.45** (2.84)	–1.58** (4.64)	0.79	–4.35***
Edible oils	2.75** (5.64)	0.23** (3.84)	0.34 (0.91)	–1.37** (2.94)	0.77	–2.86*
Other food	1.66** (4.45)	0.20** (2.94)	0.52** (3.77)	–0.61 (1.78)	0.87	–4.09***
Precious metals	–1.55** (4.18)	0.37** (7.49)	1.44** (10.86)	–2.43** (5.70)	0.98	–4.44***

Source: Author's estimates based on World Bank price data

Notes: The numbers in parentheses denote absolute t-values and (**) denotes parameter estimate significant at 5% level. ADF is the Augmented Dickey–Fuller (Dickey and Fuller, 1979) statistic for unit root and corresponds to the MacKinnon one-sided p-value. Asterisks denote significance at 10% (*), 5% (**) and 1% (***) levels, respectively. The lag length of the corresponding ADF equations was determined by minimising the Akaike Information Criterion

The pass-through elasticity for agriculture, estimated at 0.20, reflects a wide range among its components: beverages (0.36), food (0.22) and raw materials (0.02, not significantly different from zero). For the components of the food price index, however, the elasticity estimates fall within a very narrow range: grains (0.20), edible oils (0.23) and other food (0.20) – these groups also drive the agriculture index elasticity of 0.20 because of their high weight in the index.

Based on the same regression, the upper panel of Table 3.5 reports parameter estimates for five key food commodities; namely, wheat, maize, soybeans, rice and palm oil. With the exception of rice, the estimates for all six fall within a narrow range, from a low of 0.21 for maize and soybeans to a high of 0.28 for palm oil. Notice that the nearly uniform response of food to energy prices is in sharp contrast with estimates for metals, which show a high degree of diversity (see Chaudhri, 2001; Baffes, 2007).

The model was re-estimated by including the full sample, 1960–2010 (the observation for 2010 was based on the January–September average). Results for indices are reported in Table 3.4 while results for individual commodities are reported in the lower panel of Table 3.5. Several key conclusions emerge from the analysis. First, commodity indices respond more strongly to energy prices when the five "boom" years are included in the analysis. More importantly, the response strengthens *for all commodity price indices and commodities examined here*. For example, the elasticity for agriculture increases from 0.20 to 0.29 while that of metals becomes 0.28 (and highly significant) from effectively zero (Fig. 3.3 depicts summary results for six key indices).

Many analysts and observers have attributed the strengthening of the relationship between food and energy commodity prices to the use of biofuels as the discussion highlighted earlier. Yet, it is important to note that the strengthening of such link is more pronounced in some non-food commodities (e.g. raw materials and metals)

Table 3.4 Parameter estimates for price indices, 1960–2010

	μ	β_1	β_2	$100\times\beta_3$	Adj-R^2	ADF
Non-energy	3.40** (8.46)	0.31** (6.40)	–0.02 (0.12)	0.40 (0.90)	0.90	–3.20**
Metals	8.80** (13.55)	0.28** (4.06)	–1.33** (5.66)	2.40** (3.47)	0.46	–3.04**
Fertilisers	3.93** (5.37)	0.57** (5.58)	–0.44 (1.64)	0.81 (1.16)	0.83	–4.66***
Agriculture	2.85** (8.14)	0.29** (6.42)	0.20 (1.57)	–0.60 (1.60)	0.90	–2.64*
Beverages	2.34** (2.76)	0.42** (5.33)	0.37 (1.64)	–2.54** (3.86)	0.75	–4.83***
Raw materials	2.23** (5.19)	0.14** (2.84)	0.37** (2.38)	0.50 (1.21)	0.90	–3.47**
Food	3.21** (8.60)	0.29** (5.73)	0.10 (0.75)	–0.37 (0.98)	0.86	–2.73*
Grains	3.42** (7.43)	0.30** (5.03)	0.07 (0.41)	–0.53 (1.21)	0.79	–4.25***
Edible oils	3.65** (7.62)	0.32** (5.32)	–0.01 (0.10)	–1.43 (0.90)	0.78	–2.69*
Other food	2.13** (6.85)	0.25** (4.19)	0.34** (3.26)	–0.11 (0.27)	0.89	–4.13***
Precious metals	–0.14 (0.28)	0.50** (9.80)	0.91** (4.85)	–0.91 (1.45)	0.97	–2.79*

Source: Author's estimates based on World Bank price data
Note: See Table 3.3

Table 3.5 Parameter estimates for selected food commodity prices

	μ	β_1	β_2	$100\times\beta_3$	Adj-R^2	ADF
1960–2005						
Wheat	2.49** (5.79)	0.22** (4.12)	–0.02 (0.12)	0.40 (0.90)	0.90	–3.20**
Maize	2.59** (5.64)	0.21** (3.84)	0.35** (2.08)	–1.30** (3.34)	0.80	–3.84***
Soybeans	3.08** (8.19)	0.21** (4.45)	0.44 @ (3.19)	–1.30** (3.36)	0.82	–3.99***
Rice	2.61** (4.18)	0.15 (1.65)	0.69** (3.05)	–2.56** (4.56)	0.59	–4.71***
Palm oil	4.31** (5.41)	0.28** (2.92)	0.24 (0.82)	–1.58** (2.28)	0.60	–3.26***
1960–2010						
Wheat	3.32** (7.61)	0.31** (5.49)	0.11 (0.68)	–0.43 (1.15)	0.85	–5.01**
Maize	3.36** (7.62)	0.29** (5.45)	0.60 (0.34)	–0.50 (1.27)	0.81	–3.87***
Soybeans	3.90** (9.86)	0.28** (5.92)	0.13 (0.89)	–0.45 (1.08)	0.82	–4.10***
Rice	4.19** (6.52)	0.30** (3.41)	0.09 (0.49)	–0.91 (1.25)	0.58	–4.40***
Palm oil	5.26** (7.51)	0.37** (4.20)	–0.12 (0.47)	–0.60 (0.98)	0.65	–4.25***

Source: Author's estimates based on World Bank price data
Note: See Table 3.3

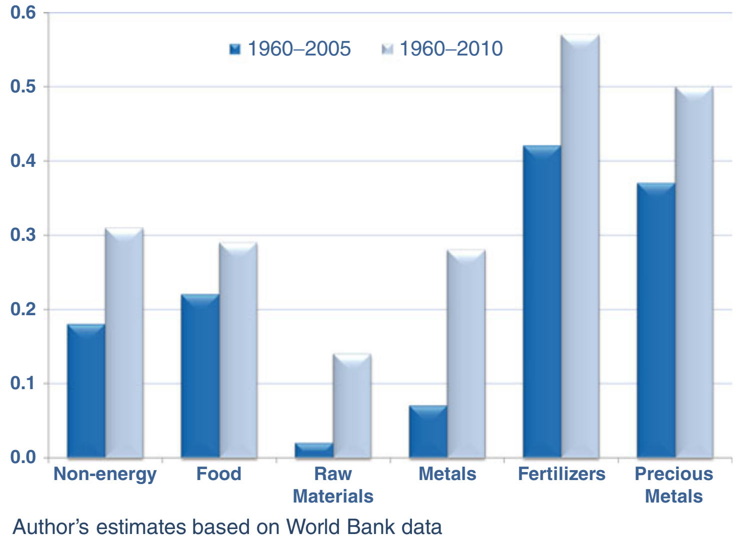

Fig. 3.3 The link between energy and non-energy commodity prices increased after 2005 (elasticities estimates from OLS)

than in food commodities, the use of which was diverted to biofuels. Thus, common factors must have played a prominent role in the recent boom, something that has been highlighted by several authors (see, e.g., Vansteenkiste, 2009 and Gilbert, 2010). Note that common and inter-related factors were also emphasised by Cooper and Lawrence (1975) in their analysis of the 1973–1974 commodity boom.

Second, food commodity prices respond to energy prices by moving in a very synchronous manner since the elasticities fall within a very narrow range, as was the case in the earlier regressions. Such result not only highlights the interdependence of agricultural markets, but also indicates that since a key determinant of food commodity prices is energy prices, analyzing food markets requires a thorough understanding of energy markets as well.

Third, though the transmission elasticities of energy prices to non-energy prices are broadly similar to one another, this is not the case with the inflation coefficient, estimates of which vary considerably in sign, magnitude and level of significance. The inflation coefficient is positive and significantly different from zero only for agriculture and some of its sub-indices, and effectively zero for metals and fertilisers (see Table 3.3). This implies that the relationship between inflation and nominal commodity prices is much more complex and, perhaps, changing over time. This should not be surprising if one considers that during 1972–1980 (a period that included both oil shocks) the MUV increased by 45%, and that during 2000–2008 it increased by only half as much. The increases in the index of nominal non-energy prices during these two 8-year periods were identical, at 170%. Again, this is consistent with the observation made earlier that one key difference between the recent commodity boom and the one of the early 1970s was their impact on inflation.

Lastly, the estimates of trend parameters are spread over a wider range than the parameter estimates of energy price pass-through and inflation. For example, the aggregate index of non-energy prices shows no trend at all when the full sample is considered, while the index of metal prices shows a 2.4% positive trend and the index of beverage prices shows a 2.5% negative trend. In some respects, this result confirms agriculture's higher TFP mentioned earlier.

3.3 Conclusion

This chapter examined in some detail the energy/non-energy commodity price link. It looked at the impact of energy prices on non-energy commodities through the cost structure, briefly reviewed the literature of the effect of biofuels on agricultural commodities and presented some quantitative evidence on the link and how such link changes when the recent boom is taken into consideration.

Three key conclusions emerge in this chapter. First, even before the recent commodity boom, the link between energy and agricultural commodity prices was quite strong and almost uniform among food prices. Thus, a considerable portion of the agricultural commodity price movements can be explained by changes in energy prices. Consider, for example, that during 1986–2003 the nominal energy index averaged 72 and increased to 224 during 2004–2009, 213% up. The agricultural price index increased by 43% during the two periods (from 119 to 170), identical to what the 0.20 transmission elasticity would imply when applied to the energy price increase ($0.20 \times 2.17 = 0.43$). When real prices are used, the actual change in the agricultural price index is 32% while the one implied by the elasticity is 35% ($0.20 \times 1.75 \approx 0.32$). Admittedly, such calculation is very simplistic since it masks considerable price variation within sub-periods. The result, however, is so important that begs the question of why the link had been overlooked. Most likely because energy prices were low for so long, they were not viewed as an important cost component in the production, primary transformation and transportation process of agricultural commodities. In a sense, that should not be surprising given that the thinking regarding energy prices not that long ago was that the "long-term equilibrium" price of crude oil would be in the neighborhood of $20/barrel much lower than the current thinking of $80/barrel.

Second, while biofuels certainly played an important role during the peak, that is, the boom (2007–2008), their role is much less important than originally thought (see, e.g., Zhang et al., 2010 and Gohin and Chantret, 2010). Furthermore, the key argument in favor of a strong biofuel effect – the increased correlation between energy and food prices – is diminished in view of the finding that similar increases in correlation are present in virtually all commodity sectors (and commodities). This result is not only confirmed by the econometric evidence presented earlier, but also it is increasingly reported in the literature (see, e.g., Tang and Xiong, 2010 and Silvennoinen and Thorp, 2010).

Third, it is becoming increasingly apparent that a number of common factors were (and still are) behind the recent commodity price boom. Important among them appears to have been the increased investment fund activity, the so-called "financialisation of commodities" that has taken place during the second half of the current decade. This activity has been facilitated by numerous factors, including the low interest rate environment (and the resulting excess liquidity), the appetite by fund managers to include commodities in their portfolios for diversification purposes and the belief that some (mostly extractive) commodities may have entered a super-cycle period that is likely to generate higher returns (for the super-cycle hypothesis, see discussions in Cuddington and Jerrett, 2008 and Radetzki et al., 2008). Increasingly the literature on the subject assigns a more important role to excess liquidity and investment fund activity (see, e.g., Frankel, 2007; Calvo, 2008; Wray, 2008 and Medlock and Jaffe, 2009).

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Chapter 4
Food Price Volatility

Christopher L. Gilbert and C. Wyn Morgan

Abstract The high food prices experienced over recent years have led to the widespread view that food price volatility has increased. However, volatility has generally been lower over the two most recent decades than previously. Over the most recent period, volatility has been high but, with the important exception of rice, not out of line with historical experience. There is weak evidence that grains' price volatility more generally may be increasing.

4.1 Volatility – Definition and Measurement

"Volatility" is both a technical term in economics and finance and a term used by laymen in discussing price developments. At the technical level, the volatility of a price or an asset return is a quantitative measure of the directionless extent of the variability of the price. Laymen tend to refer to prices as volatile when they are high. It is often the case that prices are indeed more variable when they are high since supply shortfalls and demand surges cause price to be both high and volatile. Nevertheless, a price can be both high and relatively constant, a sort of *alto piano*, or low and variable. The two usages are therefore distinct. The discussion in this chapter uses the technical definition.

It follows that volatility measures the second moment of the price distribution. The standard deviation is generally preferred to the variance itself since this is in the same units of measure as the price itself. More frequently, economists measure price volatility as the standard deviation of logarithmic prices since this is a unit-free measure. For low levels of volatility, the log standard deviation is approximately equal to the coefficient of variation.

Many economic series exhibit trends. For such series, volatility is measured relative to the trend. Measurement of volatility therefore requires that the series be detrended. Because trends are rarely linear and deterministic, detrending requires a

C.L. Gilbert (✉)
University of Trento, Trento, Italy
e-mail: christopher.gilbert@unitn.it

C.W. Morgan
Centre for Economic Development and International Trade (CREDIT), School of Economics, University of Nottingham, Nottingham, UK
e-mail: wyn.morgan@nottingham.ac.uk

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trend model. This implies a judgmental trade-off between attribution of variability to the trend and to variation about the trend. As a consequence, the volatility measure can depend on the choice of trend model in an undesirable manner. In looking at price volatility, economists often circumvent these issues by measuring volatility as the standard deviation of price returns, i.e. the standard deviation of changes in logarithmic prices. This measure has the advantage that it relates directly to the volatility concept employed in asset pricing theory in finance.

It is conventional to quote return volatilities at an annual rate. The theory of (informationally) efficient markets implies that asset price returns should be independent over time. This implies that monthly volatilities can be annualised by multiplying by $\sqrt{12}$ and daily volatilities annualised by multiplying by $\sqrt{250}$ (on the basis that there are approximately 250 trading days in the year) (Taylor, 2008). Even though many markets depart to some extent from this definition of "efficiency", it remains convenient to use these standard conversion factors. In what follows, we measure volatilities by the standard deviations of the changes in the logarithms of monthly price averages at an annualised rate.

4.2 Causes of Food Price Variability

Agricultural prices vary because production and consumption are variable. Economists distinguish between predictable and unpredictable variability, the latter being characterised in terms of shocks. Shocks to production and consumption transmit into price variability. Production can vary either because of variations in area planted or because of yield variations, the latter typically being due to weather variability. Consumption varies because of changes in incomes, changes in prices of substitutes and shifts in tastes. It is generally supposed that the most important source of price variability in agriculture is weather shocks to agricultural yields. However, demand shocks, in particular income shocks (Gilbert, 2010a) and policy shocks (Christiaensen, 2009) may also play an important role.

The extent to which given production and consumption shocks translate into price volatility depends on supply and demand elasticities which, in turn, reflect the responsiveness of producers and consumers to changes in prices. It is generally agreed that these elasticities are low over the short term, in particular within the crop year. Farmers cannot harvest what they have not planted and will almost invariably harvest everything that they have planted. Consumers are reluctant to revise habitual dietary patterns and, in poor countries, they may have few alternatives. Furthermore, the commodity raw material may comprise only a small component of many processed foods with the consequence that even large commodity price rises have a small impact on retail prices of processed food products.

Stockholding is one cause of volatility bunching. When stocks are low, relatively small production or consumption shocks can have large price impacts but when they are high, the reverse is the case. Moreover, once stock levels become high, they will remain high until consumption has exceeded production for a sufficient time to absorb past surpluses. Stockholding, therefore, results in a cyclical pattern in volatilities. World grain stocks fell to low levels by 2006 and this is seen as one cause of recent high grains price volatility. Since it takes time to rebuild stocks, it is possible that volatility levels will remain high over the next few years. But this does not imply that volatilities will be permanently higher.

Stockholding will reduce volatility so long as stocks are accumulated in periods of excess supply and released in times of excess demand. This strategy will also be profitable at least so long as the opportunity cost of capital is taken into account. However, stockholding is more effective in reducing the extent of price falls in the event of positive supply shocks (abundant harvests) than in reducing the extent of price rises in the event of shortfalls since destocking depends on the existence of a carryover from previous years. Stockholding, therefore, both reduces volatility but also gives a positive skew to the price distribution (Deaton and Laroque, 1992; Wright and Williams, 1991).

Other factors may also be important in either amplifying or attenuating volatility. Speculation, which may take the form either of speculative stockholding or of speculative purchase and sale of commodity futures or other derivative contracts, may have either a positive or a negative impact on volatility. The traditional view among economists is that speculation will tend to be stabilising (i.e. volatility reducing) because destabilising speculation will be unprofitable and will therefore not persist (FAO, 2008). This view implicitly supposes that speculation is a route by which informed agents profitably exploit private information, thereby impounding this information in market prices. However, much speculation is undertaken by trend-following investors such as Commodity Trade Advisors or by amateur traders, and there is a worry that their extrapolatively based actions may result in self-fulfilling beliefs – a randomly induced price rise, if identified as a nascent trend, may generate further buying, thereby reinforcing the initial movement (De Long et al., 1990; Gilbert, 2010b; Gilbert and Morgan, 2010; Huchet-Bourdon, 2010).

More recently, a significant group of institutional investors have started to invest in commodity futures through index-based swap transactions as a portfolio diversification strategy and to assume exposure to the commodity "asset class". In agricultural futures markets, these positions are often large in relation to total activity – up to 40% of market open interest. There is evidence that these investments may generalise price changes across markets and amplify the extent of price movements (Gilbert, 2010b; US Senate, 2009).

Food price volatility arises from shocks which can come from a number of sources, with the impact being felt differently in each separate commodity market examined. On some occasions, these shocks will be correlated. Often this will be the case if common factors simultaneously affect a range of different markets, perhaps including non-agricultural markets. This appears to have been the case in 2007–2008 when most agricultural prices and many non-agricultural prices (energy, metals and freights) rose simultaneously. It was also the case in the 1973–1974 food price spike. In cases such as these, it appears likely that there are common causal factors. There is less agreement in the identity of these causal factors but demand growth, high oil prices perhaps generating demand for grains as biofuels feedstocks, dollar depreciation and futures market speculation are all candidates in this regard (Abbot et al., 2008; Baffes, 2007; Cooper and Lawrence, 1975; Gilbert, 2010a, b; Mitchell, 2009).

4.3 Historical Review

Agricultural prices, and prices of commodities in general, were very volatile over 2006–2010. It is this burst of volatility that has prompted interest in the likely course of volatility over the longer term. Previous periods of high volatility gave rise to the same questions but the historical experience has generally been that periods of high volatility have been relatively short and interspaced with longer periods of market tranquillity. It is, therefore, recognised that it would be wrong simply to extrapolate recent and current high volatility levels into the future. Nevertheless, there is a natural concern that on this occasion, matters may have changed permanently.

Gilbert showed that agricultural price volatility was low in the 1960s but was higher in the 1970s and the first half of the 1980s (Gilbert, 2006). It generally fell back in the second half of the 1980s and the 1990s but remained well above its 1960s level. Table 4.1 updates table 4 of Gilbert (2006) looking from 1970 to 2009. The sample is divided at the end of 1989, the half-way point. The first column of the table reports the volatility estimate for the commodity over the entire 40-year period. The second column gives the estimates for 1970–1989 (top) and 1990–2009 (bottom). The third column reports the standard F test for variance equality. The test outcome is summarised in the final column.

From the first column of Table 4.1, we see that agricultural volatilities have been lowest for grains and meats and highest for fresh fruit. Fruit is perishable and storage, which can limit volatility, plays a more limited role for fruits than for the other commodities considered in the table. Columns 2 to 4 of Table 4.1 show that there was a statistically significant rise in volatility for only two commodities – bananas and rice. By contrast, nine commodities saw statistically significant falls in volatility – cocoa, tea, soybeans, three vegetable oils (soybean, groundnut and palm) and the three meat and fish products (beef, lamb and fishmeal). Overall, therefore the most recent two decades have seen lower levels of agricultural volatility than in those of the 1970s and 1980s with rice the main exception to this tendency.

In splitting the sample at the end of the 1980s, the tests reported in Table 4.1 provide a relatively crude indication of whether volatilities have been changing. It is arguable that this comparison may to a large extent be driven by the experience of the 1970s, when volatility was acute, and that the high volatility levels of the most recent years (we take 2007–2009) is out of line with the experience of the more recent past even if it is not exceptional relative to the 1970s. This is difficult to judge since, as already discussed, volatility is itself highly variable over time and periods of high volatility tend to bunch. One way of posing the question in relation to recent levels of volatility is to ask whether they were cyclically high or exceptionally high even in relation to cyclical factors.[1]

To answer this question, we consider a set of structural time series models for intra-annual volatilities. The objective is to decompose measured volatility into three

[1] In Gilbert and Morgan (2010), we used a GARCH model to address this question.

Table 4.1 Price volatilities 1970–2009

	1970–2009 (%)	1970–1989 (%)	1990–2009 (%)	Change (%)	*F*-test	Conclusion
Beverages plus sugar						
Cocoa	23.1	24.8	21.1	−3.7	1.38	Significant fall
Coffee	25.5	25.4	25.7	0.3	1.03	Insignificant rise
Sugar	27.1	27.6	26.6	−1.0	1.08	Insignificant fall
Tea	35.0	42.2	25.7	−16.5	2.69	Significant fall
Grains						
Maize (corn)	19.3	19.4	19.2	−0.2	1.01	Insignificant fall
Rice	21.1	18.9	23.3	4.4	1.52	Significant rise
Sorghum	20.4	20.2	20.6	0.4	1.05	Insignificant rise
Soybeans	22.4	24.9	19.5	−5.4	1.64	Significant fall
Wheat	20.0	19.5	20.5	1.0	1.11	Insignificant rise
Fats and oils						
Coconut Oil	32.4	30.9	33.4	2.5	1.21	Insignificant rise
Groundnut Oil	21.8	26.0	16.4	−9.6	2.52	Significant fall
Palm Oil	32.2	30.4	25.6	−4.8	1.39	Significant fall
Soybean Oil	22.8	25.9	19.2	−6.7	1.83	Significant fall
Sunflower Oil	27.2	25.8	28.6	2.8	1.23	Insignificant rise
Meat and fish						
Beef	15.0	15.9	14.0	−1.9	1.29	Significant fall
Fishmeal	22.2	26.1	17.4	−8.7	1.88	Significant fall
Lamb	15.3	17.4	12.7	−4.7	2.27	Significant fall
Fruit						
Bananas	56.1	45.2	65.5	20.3	2.10	Significant rise
Oranges	46.0	45.9	45.1	−0.8	1.08	Insignificant fall

Notes: Standard deviations of logarithmic changes in monthly average real US dollar prices at an annual rate, January 1970–December 2009. Nominal prices are deflated by the US PPI (all items)
Sources: IMF, *International Financial Statistics*, except coffee (International Coffee Organization)

components – trend, cycle and irregular – in order to separate out possible long-term changes on volatility from short-term fluctuations. To ensure that results are not driven by differences in specification across commodities, a common model is used for all nineteen commodities considered.

The volatility vol_t in year t is measured as the standard deviation of the log changes in monthly average prices over the year. To account for the skew in the volatility distribution, we model the logarithm $\ln \mathrm{vol}_t$ of this volatility. The decomposition we employ is

$$\ln \mathrm{vol}_t = \mu_t + c_t + \varepsilon_t \tag{4.1}$$

where μ_t is the volatility trend, c_t is the cycle and ε_t is an irregular component with variance σ_ε^2. The trend μ_t is modelled as deterministic but with a time-varying slope, i.e. a "smooth trend":

$$\begin{aligned} \mu_t &= \mu_{t-1} + \delta_t \\ \delta_t &= \delta_{t-1} + \nu_t \end{aligned} \tag{4.2}$$

where δ_t is the trend drift or increment and ν_t is the drift innovation. This reduces to a linear deterministic trend in the case in which the trend innovation variance $\sigma_\nu^2 = 0$. The stochastic cycle c_t is modelled as

$$\begin{pmatrix} c_t \\ c_t^* \end{pmatrix} = \rho \begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \begin{pmatrix} c_{t-1} \\ c_{t-1}^* \end{pmatrix} + \begin{pmatrix} \kappa_t \\ \kappa_t^* \end{pmatrix} \tag{4.3}$$

where λ is the cycle frequency and κ_t and κ_t^* are two mutually uncorrelated white noise disturbances with mean zero and common variance. ρ is the damping factor – see Koopman et al. (2009). If the decomposition model is well-specified, the irregular component ε_t should be serially independent. However, like all decompositions, this model should be read as descriptive and not causal.

Within this decomposition, interest focuses on two issues:

(a) the end-sample (2009) trend level of volatility, which we compare to a historical average volatility over 2000–2006; and
(b) whether the most recent (2007–2009) observations are in line with the historically observed volatility levels or whether volatilities were extraordinary over these 3 years.

Results are summarised in Table 4.2. The first two columns of the table give the average intra-annual volatility over the 7 years 2000–2006 (top) and the end-sample (2009) level of the estimated trend μ_t (bottom). The third column reports Box–Ljung test Q(10) for residual serial correlation of order 10 (Ljung and Box, 1978). Given that the model contains five parameters,[2] it is distributed as χ_5^2. The final column of the table reports predictive failure tests for 2007–2009. These are based on the forecast residuals for these 3 years obtained from the model estimated up to 2006. Write the estimated variance of the irregular component as $\hat{\sigma}_\varepsilon^2$, then, on the null hypothesis that the model remains valid out of sample, the statistic $\sum_{t=2007}^{t=2009} e_t^2 / \hat{\sigma}_\varepsilon^2 \approx \chi_3^2$. If this test rejects, we are entitled to conclude that volatilities over 2007–2009 were exceptional, but this might imply exceptionally low as well as exceptionally high.

Turning to the results, of the 19 commodities considered, 7 show an estimated trend volatility level above their 2000–2006 average (tea, maize, rice, soybeans, wheat, coconut oil and sunflower oil) while the remaining 12 commodities show a trend volatility lower than this recent average. The evidence, therefore, shows that food price volatility has in general terms continued to decline over the recent high food price period consistently with its behaviour over longer term. Against that background, however, the volatility of all four important grain commodities has risen relatively to the past. If there is a problem of rising volatility, this seems to

[2] ρ, λ and the three variances σ_ε^2, σ_ν^2 and σ_κ^2.

Table 4.2 Volatility decomposition model results

	Average 2000–06 (%)	Estimated trend 2009 (%)	Box–Ljung test Q(10,5)	Predictive failure χ^2_3
Beverages and sugar				
Cocoa	22.9	16.9	4.91 [42.7%]	4.01 [26.1%]
Coffee	21.6	20.7	9.74 [8.3%]	2.92 [40.5%]
Sugar	27.9	24.0	3.58 [61.1%]	2.31 [51.0%]
Tea	25.6	26.8	5.59 [34.8%]	0.23 [97.2%]
Grains				
Maize	18.6	22.7	**27.7 [0.0%]**	2.47 [48.1%]
Rice	12.2	21.9	3.86 [57.0%]	**15.7 [0.1%]**
Sorghum	21.4	20.2	7.92 [16.1%]	1.55 [67.1%]
Soybeans	22.2	24.2	2.96 [70.6%]	1.46 [69.1%]
Wheat	17.1	23.8	6.18 [28.9%]	1.12 [77.3%]
Fats and oils				
Coconut oil	23.2	23.5	6.69 [24.5%]	1.40 [70.7%]
Groundnut oil	18.6	16.9	**14.5 [1.3%]**	1.48 [68.7%]
Palm oil	26.8	22.0	7.76 [17.0%]	6.16 [10.4%]
Soybean oil	20.5	17.7	5.68 [33.9%]	5.87 [11.8%]
Sunflower oil	28.7	29.0	4.88 [43.1%]	**19.3 [0.0%]**
Meat and fish				
Beef	13.8	10.9	4.38 [49.7%]	**9.19 [2.7%]**
Lamb	13.0	9.7	8.97 [11.0%]	1.58 [66.5%]
Fishmeal	15.2	9.5	**12.7 [2.7%]**	4.25 [23.6%]
Fruit				
Bananas	60.9	28.5	3.01 [69.8%]	**9.32 [2.5%]**
Oranges	47.1	45.3	**11.2 [4.8%]**	0.13 [98.8%]

Note: Authors' calculations using the STAMP module of OxMetrics (Koopman et al., 2009)
Sample: January 1970–December 2009. The Box–Ljung statistic tests for up to tenth order residual serial correlation. The predictive failure statistic tests whether the residuals for 2007–2009 are drawn from the same distribution as those for 1970–2006. *P*-values are given in "[·]" parentheses. Statistically significant results (at the 5% level) are indicated in bold face
Sources: IMF, *International Financial Statistics*, except coffee (International Coffee Organization)

be confined to grains prices and not food prices more generally. The Box–Ljung tests reject independence of the irregular component (ε_t) at the 5% level for four commodities – maize, groundnut oil, fishmeal and oranges. Caution should be exercised in these cases in the interpretation of the estimated models. Although there may be merit in less parsimonious specifications in these four instances, we prefer to maintain a uniform specification across commodities.

Turning to the results of the predictive failure tests, rejections are encountered at the 5% level for four commodities – rice, sunflower oil, beef and bananas. For the remaining 15 commodities, volatility over 2007–2009, even where high, was in line with that experienced historically.

Table 4.3 lists the volatility experience over 2007–2009 for the four commodities where this has been found to be exceptional. Both rice and sunflower oil experienced very high volatilities in 2008 continuing to a diminished extent into 2009. In both cases, volatility had been very low in 2007, exceptionally so in the case of sunflower oil. Beef also exhibits an exceptionally high 2008 volatility but its 2009 volatility was close to its historical average. Instead, the volatility of banana prices was exceptionally low over 2007–2009 relative to the high values experienced historically. In summary, rice and sunflower oil are the only two commodities of the 19 considered which conform to the view that recent food price volatilities have jumped to a new high level.

Sunflower oil did experience a low, but not extraordinarily low, 2008 harvest. The major supply problem arose in Ukraine, the world's largest sunflower oil exporter, where some sunflower oil exports became contaminated with lubricant oil resulting in import bans, in particular on the part of the EU, the Ukraine's main trading partner for this product. Rice is more interesting and important. We discuss the rice market in the next section.

To summarise, this analysis has generated three conclusions:

(a) Agricultural price volatility was generally lower over the past two decades than in the 1970s and 1980s, the major exception being rice.
(b) Although many agricultural products exhibited high volatility over the 3-year periods 2007–2009, these volatilities are generally in line within historical experience. However, this is not the case with rice and sunflower oil, where recent volatility levels were exceptional.
(c) There is some evidence that volatility levels may be increasing relative to historical levels across the grains complex. However, we will need to wait for a few more years to know whether this is indeed the case.

Table 4.3 Exceptional volatility experience

	2007 (%)	2008 (%)	2009 (%)
Rice	8.2	60.6	25.9
Sunflower oil	3.9	83.3	35.7
Beef	6.0	29.3	10.1
Bananas	17.2	43.4	16.9

These findings are in line with those of other recent studies of agricultural price volatility, which used more sophisticated econometric methods but which again failed to find evidence of any general increase in volatilities (Balcombe, 2009; Gilbert and Morgan, 2010; Huchet-Bourdon, 2010; Sumner, 2009).

4.4 How Will Food Price Volatility Evolve in the Future?

Agricultural price volatility is caused by shocks to production and consumption. The extent of the volatility is determined by the variances of these shocks and by the elasticities of the supply and demand functions. Those who claim that food price volatility will be higher over a long period must believe either that shock variances have increased or elasticities have declined. Those arguments have yet to be made in a coherent way.

There are three leading possibilities in this regard:

– Some argue that *global warming* has increased the variance of agricultural production. It is certainly possible to find clear examples of specific crop-country combinations where this is the case but we are not aware of any scientific work which establishes this possibility as a general tendency. Theoretical models suggest damage to existing cropping areas if temperatures rise (FAO, 2008; Schlenker et al., 2005). It is also possible that global warming may have reduced yield variability in other more temperate areas, but these effects are less likely to have hit the headlines. In any case, it remains to be shown that increased yield variability in specific crops and countries generalises to the entire spectrum of food prices.
– Many have claimed that the demand *for food commodities,* in particular corn, sugar and vegetable oils, as biofuel feedstocks has increased the correlation between agricultural prices and the oil price (Mitchell, 2008). This allows transmission of oil price volatility to agricultural prices, in effect increasing the variance of demand shocks. If one concedes that oil price volatility has increased over time, this could lead to increased food price volatility. There has been no systematic study of the effect of biofuels demand on food price volatility, as distinct from on the level of food prices. Scientific studies of the effects of biofuels demand on food price levels fail to find clear evidence of an increased linkage between the oil price and agricultural prices over recent years (Gilbert, 2010a).
– Others have pointed the finger at *speculation.* There is no strong evidence that traditional momentum-driven speculation has increased markedly over recent years. However, the so-called "massive passive" of index-based investment in commodity futures has grown dramatically. In US Senate testimony, hedge fund manager Michael Masters argued that, by contrast with speculators who are liquidity providers, index investors absorb liquidity and hence may increase volatility (Masters, 2008). (This would amount to an effective reduction in supply and demand elasticities in the futures markets.) Again, this claim has not been substantiated by scientific research. We conjecture that any such effect may be confined

to high frequency (e.g. intraday) variation rather than the month-to-month or year-to-year volatility that is of interest to policy makers.

Overall, therefore, the theoretical factors are inconclusive, allowing the possibility that there may be permanent increases in volatility but falling well short of establishing this outcome. This tallies with the evidence on realised volatility documented above. While it would be rash to forecast that currently high volatility levels will inevitably fall back to historical levels, the evidence is consistent with the recent price spike being associated with bunched high volatility associated with cyclically low stocks and not with any underlying change in the statistical properties of the price process.

The major exception to this conclusion relates to rice. Rice is one of the major grains and is the staple food in much of Asia. It is also widely imported and consumed in Central and West Africa and in the Caribbean where it forms a major component of the diet. However, it is not closely linked in terms of either production or consumption with other major grains, maize and wheat – it is produced on different types of land and largely in different countries, and, in the main, is consumed by different groups of consumers. Rice production and consumptions shocks are not highly correlated with those in other grains. Furthermore, rice is not currently traded on a liquid futures market – futures markets exist in both Bangkok and Chicago but they attract little business. Hence, there is little transmission of price changes from other grains to rice, or vice versa. Rice prices, therefore, tend to follow their own peculiar path. Nevertheless, rice prices did rise strongly in 2007–2008 and remained high in 2009. Furthermore, the discussion earlier in this chapter singles out rice as the commodity in which volatility levels have most clearly jumped.

The rice story in 2007–2009 is peculiar and in some sense pre-modern (Christiaensen, 2009; Timmer, 2009a). There were no significant production or consumption shocks in the rice market which was in surplus through the whole of 2007–2008. Neither could futures markets factors have contributed to high volatility. However, rice is peculiar in that only a small proportion of world rice enters into international trade – most major consumers are also major producers – and that much rice which is traded is bought or sold at contracted and not free market prices. The free market is, therefore, residual and has the potential to exhibit high volatility. The initial price rise came in October 2007 when the Indian government limited rice exports in order to offset the effects of rising wheat prices of the cost of living index. Fears that this might lead to a shortfall led to panic buying by governments of poor rice-importing countries which drove prices up to unprecedented levels. Prices fell back in July 2008 when the Japanese government agreed to sell rice from its WTO stockpile. In the end, no rice was sold but the offer was sufficient to cool the market.

The international rice market is evidently highly problematic as well as politically important – most of the so-called food riots in 2007–2008 involved rice. It is urgent and important that steps are taken to avoid repeat of this episode (Timmer, 2009a). In our view, however, it would be an error to see the problems affecting the rice market as generalising to other grains markets or to wider agricultural markets.

Both the sequence of events over 2007–2009 and the volatility statistics discussed earlier underline that “rice is different”. Whether or not rice price volatility increases or declines over the coming years will depend on how well the international community addresses the particular problems of that market, not on any general tendency of volatility in general to increase or decline.

4.5 Consequences of Food Price Volatility

Grains form the major staple food across the globe and also are an input into the production of meat products and as such are key within the food price volatility question. Even within grains, there are specific issues too as we can make a distinction between the major glutinous grains of say, wheat and maize, and that of rice. Wheat is a major concern for developed (richer) nations as it is the major input to bread and pasta. Direct consumption of grains declines as societies become richer. The consequence is that the impact of high and volatile grain prices is concentrated on the poorer rather than the richer economies and on the poor rather than the rich within each economy. In general terms it is probably correct to argue that energy price volatility is more problematic than food price volatility in the richer developed economies such as Britain. In Africa, white maize is the major grain staple. Because many maize-importing countries are landlocked, maize price volatility can be very high (Dana et al., 2006). As discussed above, rice is an outlier both in terms of trade and marketing and in terms of the volatility experience.

The impact of food price volatility can be viewed at both the economy level and at the individual (producer and consumer) level, although the impact will depend on which economy and which individuals are being examined. Focusing on the economy level first, there are a number of key factors that will affect the way food price volatility will create an impact. Virtually all economies trade in food – as importers and/or exporters – and thus volatility in world food prices will potentially have trade bill effects, the net outcome of which will depend on the predisposition to net exportation of food, the extent of integration in world markets. As such, a country-by-country approach to evaluating the effect of food price volatility would need to be carried out before precise impacts could be measured and even then, specific periods of time would have to be identified over which the effects were to be measured. However, it is possible to review some of the generic outcomes alongside case studies of particular countries.

Importing, richer nations are concerned about food price volatility in terms of the impact it might have on consumer price inflation (Bloch et al., 2007). Mundlak and Larsen (1992) explored the transmission of world prices to domestic levels. They found that the null hypothesis of the law of one price rarely holds due to a number of factors, in particular the impact of exchange rates and degrees of imperfect competition within domestic supply chains. It is possible to characterise richer nations as being more open to world price effects given established trading policies, which could suggest a greater concern over volatility, but this is dampened by the relatively low expenditure on food as a proportion of national income. The same concerns arise with respect to oil price volatility but pass-through has been low over the most recent decade.

Focusing on individuals in richer nations, consumers of food, now largely in the form of processed food products, are affected to the extent that world agricultural prices are transmitted into the prices paid for products in retail outlets. Retail sectors are often imperfectly competitive (Clarke et al., 2002) and thus pass-through is often incomplete dampening volatility effects. More pertinent is the possible link to rising wage demands to compensate for higher food prices but this is now a relatively weak link given the relatively low proportion of household income spent on food (10–15% in many countries is typical). Perhaps of some interest is the relative impact on poorer consumers in rich countries who do spend a higher proportion of their income on food and thus who could potentially suffer greater welfare loss from more volatile (higher) prices. It is notable however that the high food prices in 2007–2008 were much lower on the political agenda in the rich countries, including Britain, than the high energy and fuel prices.

Despite the inherent risks in agricultural production (Mitchell, 2008), producers in many richer nations may in principle cope with these risks and the resulting food price volatility through a range of different mechanisms such as forward and futures markets and crop insurance. While these arrangements do little to reduce price volatility, they do allow producers to cope more effectively with this volatility. As such, food price volatility can bring some short-run uncertainty but in aggregate terms the welfare impact for producers in richer nations is relatively minor.

Many poorer nations are net importers of food products, either in raw or processed form. For these countries, the proportion of the import bill that goes on food is generally much higher than in richer nations. Grains are the principal commodities for concern, followed by vegetable oils. Rice is the principal grain throughout most of Asia and food security concerns, therefore, relate primarily to the adequacy of rice supplies. In Southern and Eastern Africa, white maize plays this role. Wheat, which is a temperate crop and which is consumed predominantly in the temperate zone, is of greater importance in the developed world. The major use for soybeans is in meat production and hence volatility in soybean prices feeds through into meat prices. Soybeans are substitutable in production for both wheat, maize and consequently the prices of all three grains tend to move together. Rice exhibits much lower substitutability and rice prices therefore often follow an independent course.

For governments, volatile world food prices can create major import bill uncertainty with concomitant exchange control uncertainty. Scarce foreign exchange reserves can be exhausted relatively quickly with a sudden spike in food prices as the elasticity of demand for food imports is relatively low. The FAO has shown how increasing cereal import costs as a percentage of GDP can lead to a significant widening of the current account deficit (FAO, 2008).

Many developing country governments act to stabilise the domestic prices of food staples in order to avoid importing volatility from the world market. In most cases, the countries will also be significant producers of the staple. Stabilisation will then limit the incentive for domestic farmers to respond to signals from the world market. If a sufficient number of countries act in this way, the resulting reduction in the world supply elasticity will exacerbate volatility. Where countries are net importers, stabilisation will require fiscal resources. Food price volatility, therefore, introduces volatility into government expenditure. (The same is true of oil price volatility when governments stabilise petrol and other domestic energy prices).

In the poorest nations, where poverty levels are high and where food security becomes a pressing concern, food price volatility can *in extremis* lead to great hardship for consumers and even revolt (riots in Indonesia and Haiti, e.g.), reflecting the fact that food expenditure constitutes a significant proportion of total income (70–80% of income). Large and sudden increases in prices, or indeed large increases alone, can ultimately cause hunger, poor nutrition and illness if consumers are unable to buy their staple needs. Equally, as with richer nations, there are potentially inflationary effects in poorer nations too. The FAO has shown the relationship between CPI increases and food price increases for a number of countries, for example, Egypt had seen CPI rise by 15.4% while food prices rose 24.6% (Jan 2007–Jan 2008) and Haiti 10.3 and 14.2%, respectively, for the same period (FAO, 2008).

Clearly such dramatic impacts on the population are unpalatable for governments who often employ controls on markets or subsidisation of prices to mitigate the effects. Controls can take a number of forms but in periods of very steeply rising prices, some governments have sought to limit food shortages by banning exports of staple products grown in their own country. Others try to stem the impact of higher prices by buying at the world market and then selling onto the domestic market at lower (subsidised) process. The resulting fiscal cost can cause great stress on government finance as the difference between world and domestic prices gets larger.

4.6 Combating Food Price Volatility

There have been many attempts to deal with the problems associated with price volatility. These can be reviewed in terms of the time period of interest – the short (immediate) term and the longer term. Taking the short term first, this refers to an instant and short-run response to increased volatility often in conjunction with rising price levels. Many developing and middle income countries have sought to deal with significant price volatility by either banning exports of products (such as seen in South East Asia in relation to rice) or through subsidising prices so that world market effects are not transmitted to domestic consumers. Richer nations tend not to make short-term response but instead rely on the market to adjust back to a long-run equilibrium, although where possible, judicious use of stock release can and has been utilised to smooth prices. The interesting aspect of these short-term measures and indeed some longer term ones based on insulation of the domestic market is that while domestic markets might experience a degree of greater stability as a result of intervention, the impact on the world market and more open countries is that volatility increases. Such "beggar my neighbour" policies often arise when world markets are in decline or in periods of great instability.

Longer-term policies and responses are more systematic and expansive in what they try to achieve. At the aggregate level, governments have sought to work collectively to limit fluctuations in world prices of commodities, an approach manifest in the international commodity agreements that dominated the 1960s and 1970s for a range of commodities including sugar, coffee and cocoa. Control in these markets came via buffer stocks or export quotas and restraints with the explicit aim of maintaining prices within target bands that were agreed between consumer and producer nations. Gilbert showed these arrangements were more successful in raising prices above market levels than in reducing variability (Gilbert, 1996). Moreover, over time the benefits of higher prices became eroded by rent-seeking in the exporting countries (Bohman et al., 1996). As world commodity prices fell back in the 1980s, countries tended to lose faith that intervention would deliver more stable prices and the intervention clauses of the remaining commodity agreements were allowed to lapse.

Alternative measures for stabilisation of price took the form of ex post policies such as the EU's STABEX scheme that focused less on prices *per se* but instead on the impact volatility had on a country's current account balance. Under STABEX, payments were made to those countries which experienced large current account swings due to increasing import bills or indeed a collapse in export earnings due to price declines. However, such schemes were often viewed as insensitive to specific country concerns and were quite slow to respond to crises with the consequence that their impact was probably to amplify rather than damp the effects of price cycles (Collier et al., 1999). The successor FLEX scheme is generally seen as ineffective.

In richer nations, agricultural policies have been established often with an explicit target of price volatility reduction, as seen in the original rationale for the EU's Common Agricultural Policy (CAP). While ostensibly more about raising farm incomes, as also was the case in US policy, CAP did seek to stabilise prices for both producers and consumers through input controls (set aside), output controls (buying up surpluses) and through trade restrictions (import tariffs and export subsidies). However, all three have at some stage fallen foul of GATT/WTO rules and as such are being either downplayed or removed from the policy makers' toolkit. The CAP is now set to evolve more towards environmental protection.

Instead, greater attention is being paid to market-based measures of price risk management (Morgan, 2001). Insurance markets are well-developed in most rich nations and offer some cover for crop failure but not for price risk. Futures and options markets instead provide a means to hedge price risk that is far cheaper than the alternative use of forward contracts and major exchanges in the United States, Britain and increasingly China offer contracts in a range of major commodities such as grains, soybeans and other soft commodities like sugar, coffee and cocoa. Direct uptake by producers can be limited (Pannel et al., 2007) even when communication is good, awareness of opportunities is high and the advantages would appear strong. Instead, supply chain intermediaries, who need to protect the margin between their purchase and sale prices, tend to be the main users of these tools (Dana and Gilbert, 2008).

In cases where producers do not have such conditions – in poorer nations – use of futures and options markets becomes much more difficult. A World Bank-sponsored project sought to explore ways to design intermediation between producer nations and major commodity exchanges so that the benefits of hedging could be opened to all (ITF, 1999). Dana and Gilbert review this experience and argue that the major impact is likely to be seen through the protection of supply chain intermediaries than directly by the producers themselves (Dana and Gilbert, 2008). Producers benefit indirectly from lower intermediation costs and from the greater pricing flexibility that futures-based risk management offers to their counterparties, such as grain elevator companies. They also note that in countries in which there are active domestic futures markets, many of the access problems associated with foreign exchange and anti-money laundering regulations are considerably lessened. UNCTAD has discussed the conditions under which commodity futures markets can function successfully in developing economies (UNCTAD, 2009).

The 2007–2008 food price spike has reawakened interest in food security issues. Governments, whether or not democratic, have found that they cannot afford to leave these issues to the operation of the market. Indeed, the perception on the part of the private sector that governments are unable to commit to staying outside food issues makes it difficult for private traders to ensure adequate supply until government has declared its own hand. In many developing countries, the private sector makes insufficient preparation for food supply problems knowing that government will, in the end act and government does act justifying the necessity to do so on the basis of the inadequate actions of the private sector. The question is, therefore, not whether governments should ensure food security, but how they should do so and how they should involve the private sector.

Over the past two decades, Western governments and multilateral agencies have emphasised trade over national food reserves. Food reserves were seen as expensive, inflexible and prone to generate corruption. To the extent that supply shocks are uncorrelated across countries, it is less costly to import to meet a domestic shortfall. This advice worked well until 2007 when agricultural prices rose across the board. However, in 2007–2008, exactly when many countries needed to import additional food, they found prices rising against them or, in the extreme case of rice, markets being closed with the result that supplies were not available at any price. Governments have drawn the conclusion that the advice to rely on trade was incorrect and are now attempting to re-establish food security stocks.

Governments rightly value stability in the prices of basic food commodities. The right balance of policy will vary from commodity to commodity. Many Asian rice-producing countries have long histories of successful stabilisation of domestic rice prices using a combination of import and/or export levies and food reserve stockpiles (Dawe, 2007; Timmer, 2009b). However, it seems unlikely that this experience can easily be generalised to the maize and wheat markets where there is greater geographical separation of production and consumption. Furthermore, successful domestic price stabilisation will often be at the expense of greater volatility in world rice prices, effectively pushing the costs of any shortfall on many of the world's poorest consumers.

For food importing countries, the dichotomy between reliance on trade and on national food security stocks may be too stark. Maize, wheat and soybeans all benefit from active futures trading which would allow governments to hold virtual food security stocks through contingent title to exchange stocks. Call options are the natural instrument to achieve this objective. For a relatively low price, perhaps 5–8% of contract value, governments can contract for contingent delivery at a price somewhat above current market levels in the event that the futures price at the delivery date exceeds the contract strike price. This essentially puts a ceiling on food import costs (on the contractually specified quantities) and hence on the price that the government needs to seek from purchasers. Of course, inventory in Chicago is not equivalent to inventory in one's own country so governments also need to ensure that the appropriate contingent transportation arrangements are in place. Dana and Gilbert describe the 2005 option negotiated by the Malawian government based on the South African futures market, SAFEX, which had this structure (Dana and Gilbert, 2008). It is worth pursuing this model in order that we can obtain a clearer idea of where it is likely to provide a feasible route to food security and at what cost.

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Chapter 5
Empirical Issues Relating to Dairy Commodity Price Volatility

Declan O'Connor and Michael Keane

Abstract The EU dairy industry faces an unprecedented level of change. The anticipated removal of milk quotas and the move to a less restricted global trade environment will provide the industry with both opportunities and challenges. The primary challenge will be the need for the industry to deal with more volatile prices. Active management of the risks associated with these more volatile prices will help to place the industry in a more competitive position. By quantifying the increases in EU butter and Skim Milk Powder (SMP) price volatility, this chapter demonstrates one of the consequences of the more recent reforms of EU dairy policy. Comparison with comparable world prices also provides an indication of how this volatility might evolve. This analysis employs a number of techniques to quantify the increased volatility from the simple and intuitive to more complex time series models (GARCH). In all cases increased volatility in EU dairy commodity prices is clearly evident suggesting that the challenges associated with high levels of price volatility need to be addressed as a priority.

5.1 Introduction

Until recently the policy instruments employed by the EU have very successfully isolated internal EU dairy commodity prices from the greater volatility associated with world prices. Intervention purchasing placed a floor on prices while other measures such as production quotas, export refunds, import tariffs and subsidised consumption measures helped to ensure higher and much less volatile prices than those pertaining in world markets. The greater volatility observed in world dairy commodity prices may in part be explained by the fact that these global markets are considered thin, with only 7% of output traded and four major exporters (New Zealand, EU, Australia and US) accounting for more than 80% of supply. Hence, relatively small changes to supply or demand often lead to relatively large

D. O'Connor
Department of Mathematics, Cork Institute of Technology, Cork, Ireland
e-mail: declan.oconnor@cit.ie

M. Keane
Department of Food Business and Development, University College Cork, Cork, Ireland
e-mail: m.keane@ucc.ie

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price fluctuations. As this scenario is likely to continue as trade liberates, this poses a serious concern for the EU dairy industry which accounts for approximately 14% of agricultural output and is worth about €120 billion per annum at processing level.

Price variation to some degree is both desirable and inevitable in all free markets, as it reflects the changing needs and preferences of customers and the changing cost and competitive positions of participants at all stages in the supply chain. Price movements reflecting these changes occur through the price discovery process among market participants and these price movements act as price signals to reallocate resources efficiently. While this element of changing prices may be regarded as normal and desirable in free markets, the emergence of exceptional price volatility in dairy and food markets in recent years is creating many problems for processors, farmers and other supply chain participants (Keane et al., 2009). Furthermore, the expected abolition of the milk quotas and the envisaged increase in production at farm level will require that farmers and manufacturers place greater emphasis on risk management if they are to survive and compete in this new environment. In the past it was possible in part to manage risk by diversification both within and outside of agriculture. In the future such strategies may be curtailed by the need for expansion to achieve the economies of scale and consequent specialisation required in order to survive in an increasingly competitive environment. Excessive price volatility can also lead to product reformulation which reduces dairy content. This expensive and time consuming shift is difficult to reverse. Contracting is more difficult in this environment as duration is reduced and counter party risks increase.

As a consequence of extensive market management, dairy industry participants in the EU have had little incentive to develop and use price risk management tools until recently. However, the policy environment facing the EU dairy industry continues to undergo considerable change under WTO and Common Agricultural Policy (CAP) reform. Movement towards lower levels of CAP support prices, reduced intervention and a more liberal global agricultural trading system will involve greater price volatility for dairy commodities as prices align more closely with world prices. Indeed one of the major arguments advanced against this trade liberalisation is that it would lead to transmission of international price volatility into domestic markets. The merit of this argument can only be judged by a detailed empirical analysis of price volatility in EU and international dairy markets. This study is a step in that direction as the volatility of EU and world butter and SMP prices are considered and modelled.

The chapter begins by presenting a brief outline of past and current EU dairy policy. The data used are presented next followed by a preliminary analysis which includes some of the more traditional and intuitive measures of volatility. The more advanced methodology is then presented along with its associated results. Finally the conclusions are drawn.

5.2 The Regulatory Framework of the EU Dairy Industry

The EU dairy sector is subject to the CAP. The Treaty of Rome which was signed in 1958 by the six founding members of the European Economic Community (EEC) established a common market which included agriculture. Amongst the stated objectives for agriculture in Article 39 of this treaty was "to stabilise markets". The Commission's proposals for milk and milk products were incorporated into Regulation (EEC) No. 804/68 which sets out the common organisation of the market in milk and milk products. In this and subsequent regulations the EU has sought to regulate its dairy market by intervening primarily in its butter and SMP markets.[1] In order to establish a common market with common prices, the CAP relied on a system of market interventions. Foremost amongst these market interventions are intervention buying,[2] market protection (import levies), market development (export subsidies) and a number of other subsidies designed to promote internal consumption and thus reduce surpluses within the EU. The more salient features of these policy interventions as they relate to market stability are presented in greater detail in O'Connor et al. (2009).

A milk supply quota was introduced in the EU in 1984 as a response to the growing imbalance between production and internal EU consumption and an increasing demand on EU finances of operating the schemes just outlined. One effect of introducing this quota has been that dairying has been the subject of little policy reform until the Luxembourg agreement which was agreed in June 2003. This reform has seen the introduction of the single farm payment for dairy farming in April 2005. In return for substantially reduced intervention prices, dairy farmers receive direct compensation by means of an annual payment subject to cross compliance. This payment has an obvious income stabilising effect for dairy farmers. Reform of the milk quota regime continued in the "2008 Health Check" where it was agreed that quotas will expire by April 2015. In order to ensure a 'soft landing', quotas will be increased by 1% every year between 2009–2010 and 2013–2014.[3] This latter reform also abolished the disposal aid for butter for pastry and ice cream and for direct consumption. While some market support is proposed to continue, such as private storage aid for butter, the SMP for animal feeding allowance and the aid for casein production is now optional and at the discretion of the Commission to decide if and when it should be applied. This aid may be fixed in advance or by means of tendering procedures.

In essence the EU dairy sector may be considered to have operated in a very stable and regulated policy environment prior to 2003 with an a priori expectation that EU commodity prices should reflect this stability. Similarly prices in more recent

[1]The choice of these commodities may be explained by the fact that these joint products provide a means of long-term storage for milk fat and milk protein, the two most valuable components of raw milk. It should also be noted that casein, whole milk powder, liquid milk and certain varieties of cheese have to a lesser degree also been regulated by the CAP.

[2]Intervention buying of products by government agencies is generally referred to as "intervention". The use of this term can confuse as it refers to only one form of government intervention. Henceforth, intervention will refer specifically to intervention buying, while government intervention in the market will be referred to as policy intervention. The intervention system when available places an effective floor price for the market and thus eliminates the more extreme negative price fluctuations.

[3]For Italy, the 5% increase will be introduced immediately in 2009–2010.

years should reflect a greater orientation towards global prices which are inherently more volatile. The following empirical analysis tests to see if actual market developments match this expectation.

5.3 Data and Preliminary Analysis

As stated earlier, the EU has sought to regulate its dairy market by intervening primarily in its butter and SMP markets. The special status accorded to these two commodities by the Commission suggests that any analysis of the EU dairy industry should consider these commodities in the first instance and the volatility present in these prices should be indicative of the price volatility present in dairy commodities in general.

In this study the USDA North European FOB (Free on Board) wholesale SMP and butter prices are taken as representative world prices,[4] while the EU prices are ex-dairy/factory Dutch price series sourced from Agra Europe.[5] Prior to January 2001 all EU price series were quoted in their home currency and have been converted to a common currency, the ECU/Euro (€). The exchange rates used were daily closing mid-market indications expressed as units of currency per ECU/Euro. Simple averages were calculated to derive the monthly exchange rate series. In the case of the World prices initial quotes were in US dollars and converted to ECU/Euro using corresponding exchange rates. Prices for the four series from January 1990 to September 2009 (237 months) are considered in this study. The nomenclature used to name these wholesale series follows the following convention. For each series the first letter(s) designates the location of the series (W = World and EU = EU) while the last three letters designate the product (SMP = Skim Milk Powder while BUT = Butter).

At this point an important caveat should be stated. The analysis in this study focuses on monthly price data and while these data reflect trends in the market place they also in, many cases, hide the greater volatility associated with daily or weekly data. This averaging effect cannot be avoided as comparable higher frequency data were not available so it is important to note that the level of volatility may be understated in this report.

To begin, if we define price volatility as substantial variation in price from the long-term trend, then the following provides an intuitive representation. In Fig. 5.1 the EU butter series along with its long-term trend is presented. The downward trend reflects the movement towards the lower level of intervention price over time. In order to capture the volatility of the series, two further lines are added. The first is the long-term trend value plus 10% while the second shows the long-term trend

[4] The USDA publishes a monthly high and low quotation and the series considered in this analysis is the mid point of these quotations.

[5] The butter series are reported in "Milk Product" while the SMP series are reported in "Preserved Milk" (Agra Europe).

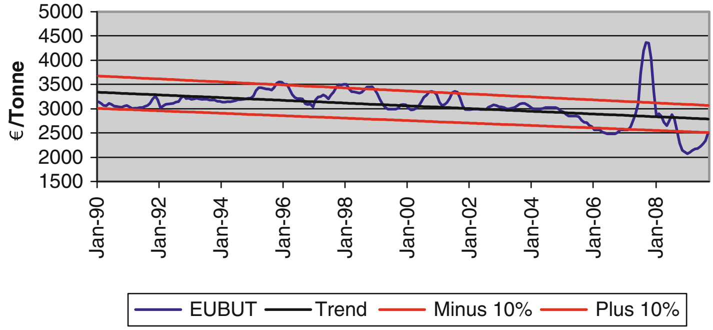


Fig. 5.1 EU butter, trend and 10% bands

value minus 10%.[6] For the purpose of this analysis any value which falls outside these 10% bands is considered a volatile observation. Taking this metric of volatility, it is clear that there were few instances of volatility in the EU butter price series prior to 2006, while from that period to the present there were relatively many and large price fluctuations outside the plus/minus 10% trend price band.

In the case of EU SMP prices (Fig. 5.2), there is a slight positive longer-term trend and, with the exception of the period around 2000/2001 and post-2006, there were few instances of volatility.

For world butter prices the longer-term trend is gradually rising. As regards volatility, prices were outside the 10% band for a number of periods between 1995 and 2005 along with the exceptional volatility of the last 2 years (Fig. 5.3).

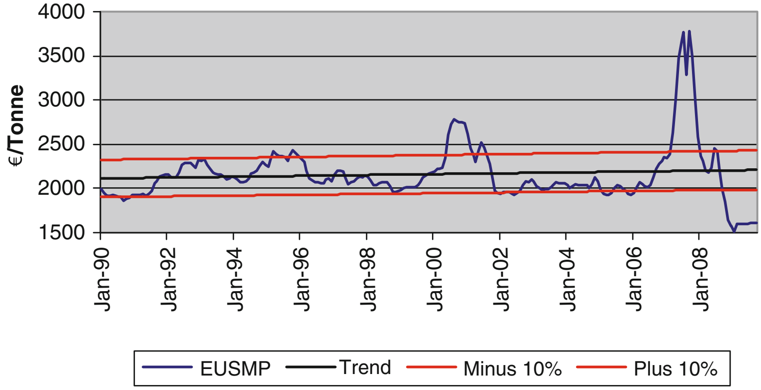


Fig. 5.2 EU SMP, trend and 10% bands

[6] It may be noted that the target price for milk under the "old" CAP was approximately 10% higher than the intervention milk price equivalent.

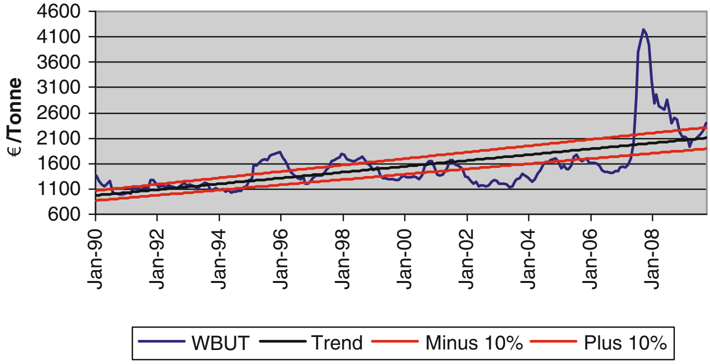


Fig. 5.3 World butter, trend and 10% bands

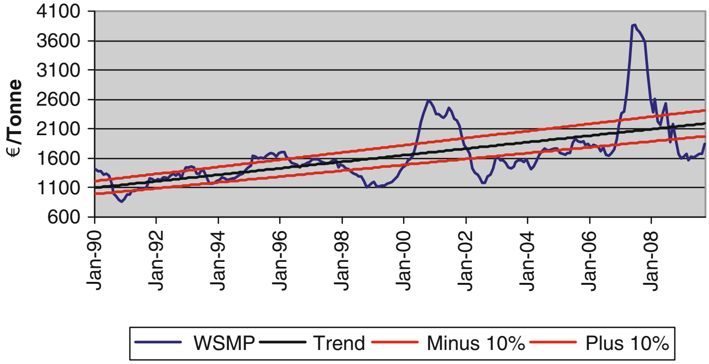


Fig. 5.4 World SMP, trend and 10% bands

An examination of Fig. 5.4 shows that for world SMP prices a clear upward trend is evident, along with a substantially greater number of volatile observations. In addition the duration of these periods of volatility appears longer than for the EU.

A summary of the frequency of volatile observations as defined above for each series is presented in Table 5.1. This shows that over the period January 1990 to September 2009 volatile prices were observed less than 22% of the time for EU butter and less than 26% for EU SMP, whereas on world markets this value is approximately 60% in both cases. Furthermore when the analysis is split into two periods, pre and post the year 2000, the far greater volatility in the latter period is striking. In the post-2000 period, almost 40% of the EU SMP values fall outside the 10% range while almost 75% of the corresponding world price series may be considered volatile. Overall, based on this simple metric of volatility, it is very clear that world prices for both SMP and butter have been much more volatile than for the EU and that all prices post-2000 have been much more volatile than for the previous decade.

Table 5.1 Frequency of volatile observations

	World		EU	
	SMP	Butter	SMP	Butter
Jan 1990–Sept 2009				
Within 10% range	39.66	40.51	74.68	78.9
% Above trend + 10%	24.47	23.21	13.50	10.55
% Below trend – 10%	35.86	36.29	11.81	10.55
Jan 1990–Dec 1999				
Within 10% range	53.3	53.3	90.0	89.2
% Above trend + 10%	20.0	30.8	7.5	10.8
% Below trend – 10%	26.7	15.8	2.5	0.00
Jan 2000–Sept 2009				
Within 10% range	25.64	27.35	59.0	68.38
% Above trend + 10%	29.06	15.38	19.7	10.26
% Below trend – 10%	45.30	57.26	21.3	21.37

The success of the EU in attaining its goal of higher and less volatile prices may be seen in Figs. 5.5 and 5.6 and in Table 5.2 where EU and world prices are compared. In both charts there is clear evidence of large price increases and declines over short periods of time (e.g. from February 2007 to May 2007 world SMP prices increased by over 60% while EU SMP prices recorded a gain of over 45%). While the greater volatility of the world series is visibly evident on close examination of these figures, precise methods of expression of this volatility are desirable.

One traditional approach to capturing the different levels of volatility is to use the Standard Deviation (SD) and Coefficient of Variation (CV) as measures of volatility. The latter is calculated as

$$\text{Coefficient of Variation} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100 \tag{5.1}$$

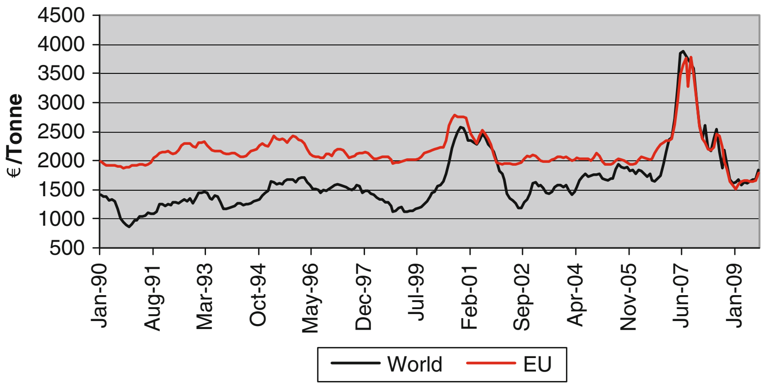


Fig. 5.5 World and EU wholesale SMP prices

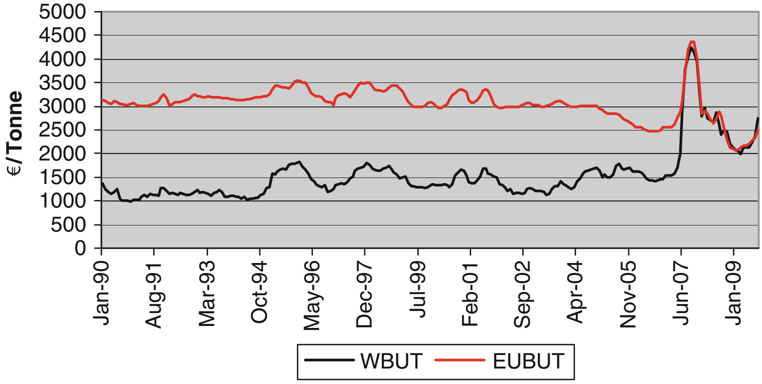


Fig. 5.6 World and EU wholesale butter prices

The mean, standard deviation and coefficient of variation of each of the series are presented in Table 5.2. Again the data are also presented for the sub periods pre- and post-2000. While the world prices series display greater standard deviations, caution is required as each of the series has different mean values and thus the CV is the more appropriate metric. The much larger coefficients of variation reported for the world price series clearly show the greater volatility associated with these series.

For butter and SMP, the world market CVs were 3.18 and 2.15 times greater than for the EU during the entire sample period, suggesting that direct exposure to the world market could lead to a more than doubling of price oscillations in the future. When the data are split into two sub-periods of the 1990s and the greater part of the last decade, the increased volatility is striking with reported volatility more

Table 5.2 A comparison of World and EU dairy prices 1990–2008

	World		EU	
	SMP	Butter	SMP	Butter
Jan 1990–Feb 2009				
Mean	1646.99	1539.85	2163.06	3063.51
Standard deviation	526.22	545.96	322.47	340.82
Coefficient of variation	31.95	35.46	14.91	11.13
Jan 1990–Dec 1999				
Mean	1341.74	1324.34	2123.68	3211.78
Standard deviation	196.06	241.29	136.46	151.47
Coefficient of variation	14.61	18.22	6.43	4.72
Jan 2000–Feb 2009				
Mean	1960.07	1760.89	2203.45	2911.44
Standard deviation	573.30	670.35	434.98	408.32
Coefficient of variation	29.25	38.07	19.74	14.02

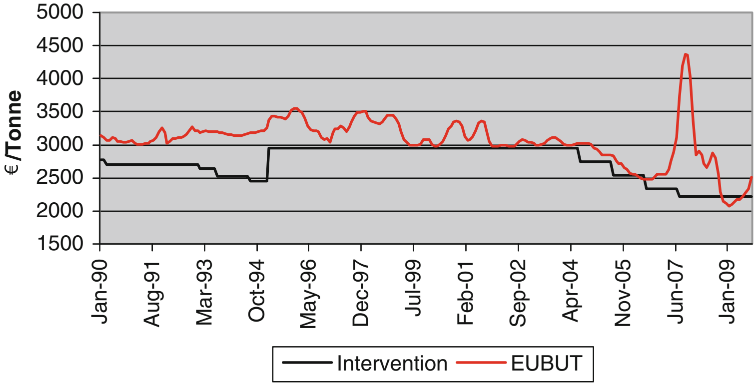


Fig. 5.7 Intervention and EU wholesale butter prices

than doubling in all cases in the period from January 2000 to September 2009. In the case of the EU, the reduction in intervention prices (see Fig. 5.7 for EU butter) has allowed greater downward movement which is reflected in a trebling of volatility while the comparable world price series experienced a doubling of volatility demonstrating that the world market itself has become much more volatile over the last decade.[7] This analysis also shows that the EU exposure to price oscillations has already moved considerably closer to world market levels, reflecting the major EU policy changes for dairying associated with the Luxembourg agreement in particular.

While standard deviation and the coefficient of variation are popular measures of volatility, their ability to fully capture price volatility is limited as they assume the variance of the price series is constant over time. Observation of Figs. 5.4 and 5.5 shows that the world prices series in particular display periods of high volatility followed by periods of lower volatility, while the price movements in all the series from late 2006 are greater than in the more distant past. In order to capture these dynamics, economic analysts engage in more detailed and complex analysis which is now presented.

5.4 More Advanced Analysis

Of the numerous technically more advanced methods of volatility measurement, the annualised standard deviation and GARCH are now described and results presented.

[7] A similar pattern is observed for SMP.

5.4.1 Annualised Standard Deviation

In more technically advanced studies of price volatility it is common practice to consider the log return of the time series rather than the price series in levels. The log return (growth rate) for each series in this study is calculated as $\ln\left(P_t/P_{t-1}\right)$.

These series are presented in graphical form in Appendix 1.[8] An examination of the graphs clearly shows the greater volatility associated with world prices and points to the success of the EU in attaining its goal of stabilising prices. A second point to be noted in these graphs is that increased volatility is displayed by all series in the most recent years. While the greater volatility of the world series is evident in these graphs, the extent of this increased volatility is better captured by the much larger coefficient of variation reported for the world series in Table 5.3.[9] Further consideration of the remaining summary statistics in Table 5.3 shows that all series display excess kurtosis and non normal distributions while both of the butter series are skewed. These results show that all series display the classical signs of volatility.

Many authors (e.g. FAO (2009) and European Commission (2009)) have used the annualised standard deviation of the change in price to compute historic volatility. The annualised standard deviation is the standard deviation multiplied by the square root of the number of measurement periods per annum which in this instance is the square root of 12. It may be represented as follows:

$$\mathrm{AnnStdDev}(r_1,\ldots,r_n) = \mathrm{StdDev}(r_1,\ldots,r_n) \times \sqrt{\text{Num Periods per Year}} \quad (5.2)$$

where $r_1, \ldots, r_n$ is a return series, i.e., a sequence of returns for n time periods.

Table 5.3 Summary statistics of series 1990/02–2009/02

	WSMP	WBUT	EUBUT	EUSMP
Sample mean	0.000607	0.001463	–0.001756	–0.000958
Standard error	0.056066	0.058993	0.029820	0.036618
t-Statistic (mean = 0)	0.163857	0.375259	–0.890932	–0.395934
	(0.870)	(0.708)	(0.374)	(0.693)
Coefficient of variation	92.35	40.32	16.98	38.27
Skewness	–0.210	1.372	–0.810	–0.287
	(0.193)	(0.000)	(0.000)	(0.076)
Kurtosis (excess)	1.641	8.874	16.768	5.782
	(0.000)	(0.000)	(0.000)	(0.000)
Normality test $\chi^2(2)$	21.30	91.37	424.18	130.04
	(0.000)	(0.000)	(0.000)	(0.000)

[8]Note the scale is identical in all panels of this chart thus highlighting the greater volatility in the world prices.

[9]These and all subsequent estimations were undertaken using PcGive software.

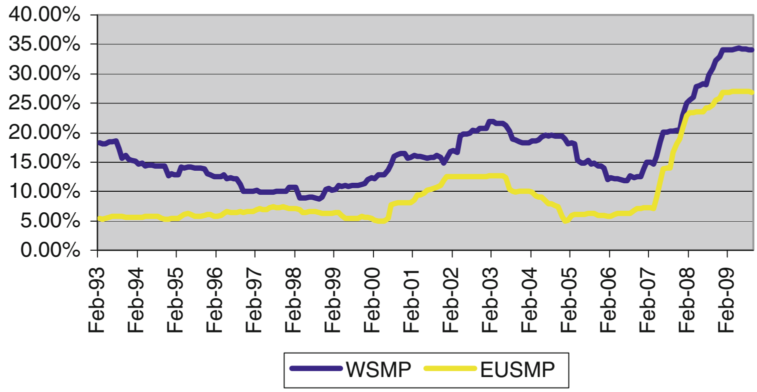


Fig. 5.8 EU and World SMP rolling 3 year annualised standard deviation

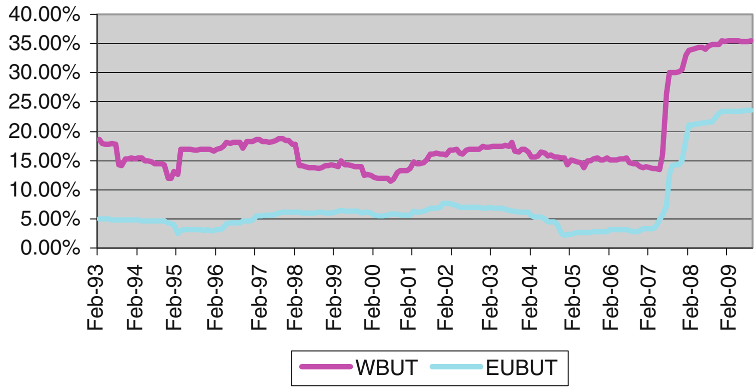


Fig. 5.9 EU and World butter rolling 3 year annualised standard deviation

In Figs. 5.8 and 5.9 rolling 3 year annualised standard deviations are presented for the SMP and butter series, respectively. It is clear from these graphs that the world price series display considerably greater volatility in particular prior to 2007. Up to this point the EU butter series may be considered on average to be three times less volatile than the world series while for SMP this is closer to two times.

5.4.2 Time Series Models (ARMA) and Conditional Heteroskedasticity Models (ARCH and GARCH)

A number of more detailed and complex approaches have been utilised by economists to model the time-varying pattern of agricultural commodity prices. Of these the moving average (MA) model, autoregressive (AR) model or the more general autoregressive integrated moving average (ARIMA) model are usually fitted to identify the structure of a time series (Box and Jenkins, 1976). More recently, more complete but complex price models have been developed with models such as the autoregressive conditional heteroskedasticity (ARCH) model (Engle, 1982), and generalised ARCH (GARCH) model (Bollerslev, 1986) receiving the most attention. ARCH models allow the shocks in more recent periods to affect the current volatility positively while the GARCH models, which generalise the ARCH model, postulates that not only previous shocks, but also previous volatilities affect current volatility. These models are now described in more detail.

The general form of the ARMA(p,q) model may be presented as

$$Y_t = X_t'\beta + \sum_{i=1}^{p} \phi_i Y_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} \tag{5.3}$$

where Y_t is the dependent variable; Y_{t-i} for $i = 1,\ 2,\ \ldots, p$ are lagged dependent variables; X_t denotes the explanatory variable vector (column vector); ε_t is the error term and assumed to be white noise; $\varepsilon_{t-j}, j = 1, 2,\ \ldots, q$ are lagged error terms; t denotes the time period; β (a column vector), φ_i and θ_j are parameters. It is important to note that in this model the error terms are assumed to be a Gaussian process with a mean of zero and a constant variance σ^2.

To describe data series with time-varying volatility, ARCH or GARCH models are utilised. These models allow the variance of error terms to change over time. An ARCH(q) model is commonly defined as:

$$Y_t = X_t'\beta + \varepsilon_t \tag{5.4}$$

where

$$\varepsilon_t \,|\Omega_{t-1} \approx N(0, h_t) \tag{5.5}$$

$$h_t = \omega + \sum_{i-1}^{q} \alpha_i \varepsilon_{t-i}^2 \tag{5.6}$$

where ε_t is the error component in the ARCH model; h_t is the time-varying variance of the error; $\Omega_{t\text{-}1}$ is the information set available at t–1; ω, α_i for $i = 1,\ 2,\ \ldots,\ q$ and β are parameters. ε_ts are not serially correlated; however, their dependency lies on the evolution of the variance.

A GARCH(p,q) model may be presented in the same manner except that lagged terms of the variance are now included and may be represented as follows:

$$h_t = \omega + \sum_{i-1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \gamma_j h_{t-j} \tag{5.7}$$

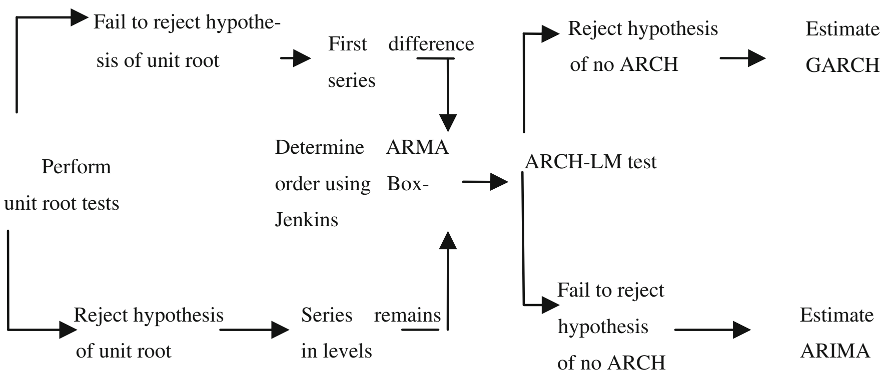
with γ_j for $j = 1,\ 2,\ \ldots, p$ as additional parameters.

The basic ARCH (q) model is considered a short memory process in that only the most recent q residuals have an impact on the current variance. The GARCH(p,q) model, however, allows longer memory processes in which all the past residuals can affect the current variance either directly or indirectly through the lagged variance terms. In this model the sum of $\alpha_i + \gamma_i$ gives the degree of persistence of volatility in the series.[10]

The closer the sum to 1, the greater the tendency of volatility to persist for longer periods. If the sum exceeds 1, it is indicative of an explosive series with a tendency to meander away from mean value. The basic framework used to quantify the volatility in the EU and world butter and SMP prices is summarised in Fig. 5.10.

Economic theory would *a priori* suggest that the volatility of the EU prices, which are insulated, would be lower than that of world prices. Furthermore, given its desire to maintain price stability, the EU policy, if successful, should translate to price series which display a more constant level of variance. In the case of world prices there should be no expectation of constant levels of variance as these markets are more fully liberalised and subject to the full effects of shocks and global events such as stock market crashes and oil crises, along with industry specific developments (e.g. in the dairy industry BSE, Foot and Mouth and policy development). This allows one to hypothesise that world prices should display time varying levels of volatility. This also suggests that world prices should be better represented as GARCH processes while EU prices prior to the 2003 reform should follow ARMA processes.

As a prerequisite to modelling the dynamics of the time series it is necessary to determine whether the series behave as stationary or non stationary processes. In accordance with standard econometric practice each of the series was tested for stationarity using the Augmented Dickey Fuller (ADF) test. This test indicates that there is strong evidence (95% confidence levels) to reject the null hypothesis of a unit root for all series (Table 5.4).[11]



Source: Moledina et al. (2003)

Fig. 5.10 Flowchart of methodology to compute conditional volatility

[10]Furthermore, the α_i and γ_i must be non-negative.

[11]Note that in the following analysis data from February 1990 to February 2009 is considered.

Table 5.4 Summary statistics of series

Series	ADF statistic	Critical value 5%
WSMP (2)	–6.098	–1.94
WBUT (0)	–9.621	–1.94
EUBUT (0)	–6.802	–1.94
EUSMP (3)	–6.418	–1.94

Note: The BIC Criterion was used to choose the lag structure which is reported in parentheses

While this table only reports the results of the models with the best lag structure as selected by the Bayesian (BIC) information criterion, each series was initially considered with 0 to 12 lags inclusive. In all models the null hypothesis of a unit root was clearly rejected.

As all of the series may be considered stationary it is now appropriate to use the Box-Jenkins methodology to determine the values of p and q in the ARMA(p,q) process. Initially the values of p and q were chosen by the BIC. The residuals from this specification were then tested for autocorrelation using the Portmanteau test up to lag 32. Where autocorrelation was detected the models were re-specified using the autocorrelation and partial autocorrelation functions for guidance. The specifications of the best fitting models are presented in Table 5.5. In all cases all the estimated coefficients are significant at the 5% level. The residuals of all the models were found to be free of autocorrelation (Test C) and thus may be considered to fit the data well. However, all models clearly display non normal residuals (Test A) and ARCH (Test B). Likewise the ARCH test up to 4 lags reported in the final column clearly highlights the need to model the mean and variance of the series simultaneously and requires that any interpretation of these models is limited as they are severely limited by these findings. This unambiguous evidence of autocorrelation is further confirmed when the squared residuals were tested.[12] At this point of the analysis it is reasonable to assume that the variances of all the series vary over time

Table 5.5 Summary of ARMA models 1990/02–2009/02

			Tests of residuals			
Series	p	q	A	B	C	ARCH 1–4 Test
WSMP	|1,3,6|	|3|	10.773 [0.005]**	27.873 [0.000]**	27.604 [0.689]	9.5294 [0.0000]
WBUT	|1,5|	0	100.16 [0.000]**	7.9960 [0.005]**	39.006 [0.255]	2.0724 [0.0854]
EUBUT	|1,6|	1	339.91 [0.000]**	11.480 [0.001]**	29.495 [0.642]	5.2400 [0.0005]
EUSMP	0	2	307.72 [0.000]**	150.63 [0.000]**	34.101 [0.463]	37.610 [0.0000]

Notes: A refers to normality test; B refers to ARCH 1-1 test; C refers to Portmanteau (36) test. No constant terms were used in the mean equations as they were insignificant in all cases

[12]These results are available from the authors on request.

Table 5.6 Summary of GARCH models 1990/02–2009/02

Series	Mean specification	GARCH order	Diagnostic tests of scaled residuals A	B	C	ARCH 1–4 test
WSMP	AR = |1,3| MA = 0	(0,1)	17.667 [0.000]**	0.063275 [0.939]	36.624 [0.304]	1.6524 [0.162]
WBUT	AR = |1,3,5| MA = 0	(0,1)	45.351 [0.000]**	0.99668 [0.371]	42.970 [0.115]	1.1524 [0.333]
EUBUT	AR = |1,2| MA = 0	(1,1)	27.279 [0.000]**	0.55181 [0.577]	55.944 [0.010]*	1.1931 [0.315]
EUSMP	AR = |1,2,5| MA = 0	(1,1)	11.728 [0.003]**	2.0367 [0.133]	59.672 [0.003]**	1.2353 [0.297]

Notes: A refers to normality test; B refers to ARCH 1-1 test; C refers to Portmanteau (36) test. No constant terms were used in the mean equations as they were insignificant in all cases

and both the mean and variance of the series should be modelled simultaneously as GARCH processes.

The results of modelling the series as GARCH processes are presented in Table 5.6. In this table the mean specification is presented in column two while the GARCH structure is presented in column three. It should be noted that the mean specification may differ from the specification in Table 5.5. This is not a cause for concern as firstly the models reported in Table 5.5 are poorly specified as evidenced by the ARCH tests and secondly both the mean and variance are now estimated together. In this case the adequacy of the models is tested based on the standardised residuals. In order to select between competing specifications the log likelihood was considered.

The results show that both of the world series are well-specified indicating that ARCH models are appropriate. While both models display non normal standardised errors, these models are free of autocorrelation and ARCH. The EU series are less well-specified as they show evidence of autocorrelation along with non normality in their GARCH(1,1) specifications. The standard deviation of the models in Table 5.6 is presented in graphical form in Appendix 2 along with a summary of the models. In all models all of the coefficients are significant at the 5% level suggesting well-specified and parsimonious models. In the EU model the sum of the alpha 1 and gamma 1 coefficients is close to one indicating a high level of persistence in volatility. Indeed, as the sum of these coefficients is very close to one (0.998) in the EU butter model, this may be interpreted as an indication that the model is not appropriate as a value of one suggests an explosive series.

Turning to the graphs, these clearly show the greater volatility of the world prices both in terms of its level and frequency.[13] Furthermore, these graphs highlight the extreme nature of the volatility experienced in 2007–2008. In the case of the EU

[13]Note the scale of the graph in this appendix is different in each instance.

Table 5.7 Summary of ARMA models 1990/02–2004/04

			Tests of residuals			
Series	*p*	*q*	A	B	C	ARCH 1–4
EUBUT	|1,4|	|1|	37.259 [0.0000]**	5.9443 [0.0158]*	45.350 [0.0745]	2.1605 [0.0758]
EUSMP	0	2	33.292 [0.0000]**	2.6897 [0.1028]	38.017 [0.2914]	0.87111 [0.4825]

Notes: A refers to normality test; B refers to ARCH 1-1 test; C refers to Portmanteau (36) test. No constant terms were used in the mean equations as they were insignificant in all cases

series there are relatively low levels of volatility prior to this period. This fits with the *a priori* expectation that the series should display a constant variance. In light of this it was considered appropriate to re-estimate the EU series as ARMA processes for the period up to April 2004. This date coincides with the implementation of reforms contained in the Luxembourg agreement and in particular the lowering of intervention prices and the quantities automatically accepted into intervention stores. These results are now presented in Table 5.7.

From this table we can see that the EU SMP series is particularly well-modelled as an ARMA process as it displays normal errors which are free from autocorrelation and ARCH. The absence of ARCH in the error terms implies that the variance of the series may be considered constant up to mid-2004 and provides clear evidence that the Commission achieved its aim of stable prices. The standard deviation of the SMP series for this period was 0.018. In the case of the butter series the evidence is less clear as there is some evidence of ARCH at the lower order along with non normality. The standard deviation of this series was 0.012.

In summary the results of this analysis broadly support *a priori* expectations. They indicate that the EU achieved its aim of providing stable prices up to the Luxembourg agreement. The high levels of volatility experienced in both world and European prices in recent years are exceptional in the long-term historical context. It is also reasonable to assume that alternative specifications of these models such as TGARCH (Threshold GARCH), AGARCH (Asymmetric GARCH) or any of the many alternatives outlined in Tsay (2005) or Enders (2004) may be more appropriate. The non normality recorded in many of the models may point to an omitted variable problem. For example, it is felt that the EU policy decisions such as intervention purchasing had the effect of placing a floor under prices and the build up of stocks therein delayed price recovery in world markets. Likewise the use of export restitutions may have delayed price recovery and response in global markets. Thus models which explicitly capture these dynamics may be more desirable and worthy of further consideration.

5.5 Conclusion

This analysis shows that up to recent years the EU policy framework has served to maintain producer prices at a higher and more stable level than that which would apply in an unregulated market by providing a number of market support measures.

World prices, which are less regulated, are thus more volatile as they are not protected to the same degree from local and global shocks. These results show that the volatility experienced in 2007–2008 is extreme from the perspective of both EU and world wholesale butter and SMP prices. It should be noted that some volatility in commodity prices is desirable as it reflects the process of markets adjusting to changes in supply and demand conditions. However, as more recent events show, the level of volatility in dairy markets can be greater than anticipated and price volatility which cannot be offset by suitable price risk management strategies can create problems for all market participants.

With regard to future developments it is reasonable to assume that the policy environment facing the EU dairy industry will continue to undergo considerable change due to WTO and CAP reform. Movement towards lower levels of CAP support prices, reduced intervention and a more liberal global agricultural trading system will involve greater price volatility for dairy commodities as prices align more closely with world prices. When considering the future form of world and EU commodity prices, the following observation from Harvey may be considered:

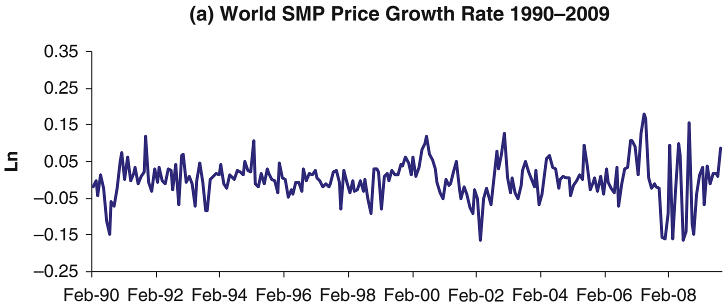
> Although a freer world market is expected to be less volatile than one characterised by high insulation rates, it is unlikely to be as stable as the protected domestic market it replaces (Harvey, 1997).

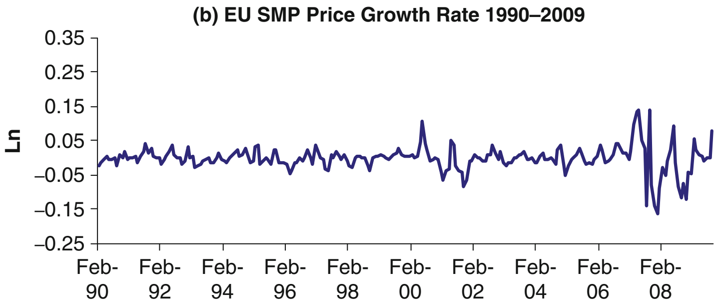
Such a view suggests that future prices will be characterised by periods of volatility comparable to those displayed by world prices in the earlier period of this study. However, if the following view as expressed by Adriaan Krijger (Chairman, International Dairy Federation (IDF) standing committee) proves more accurate:

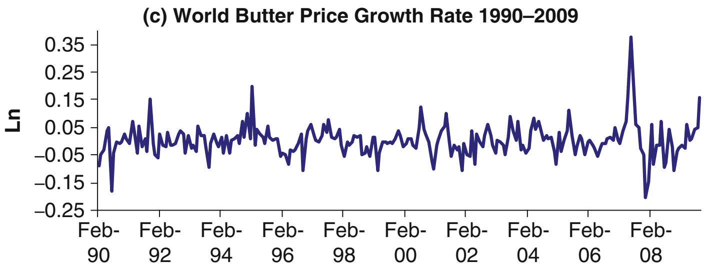
> Shorter and deeper cycles may well be the future. The real issue now is the increase in volatility and the challenge of how to cope with it (Krijger, 2008).

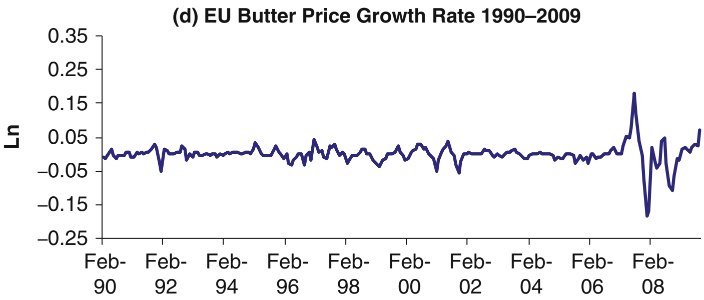
then the response of EU dairy industry participants and policy makers may require a paradigm shift. In order to deal with these increased levels of volatility, private market instruments such as futures markets and insurance products may be desirable, while price smoothing policy instruments may be required if a large exodus from the industry is to be avoided.

Appendix 1: Price Series Growth Rates





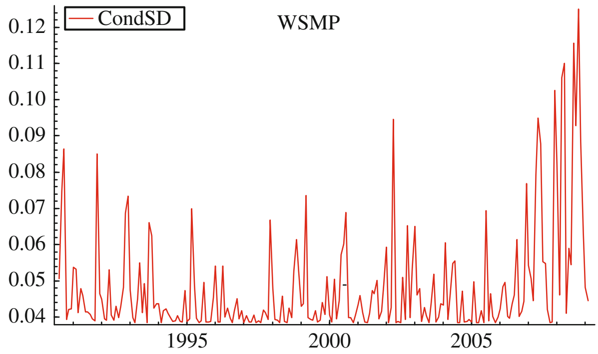




Appendix 2: GARCH Specifications and Volatility Charts

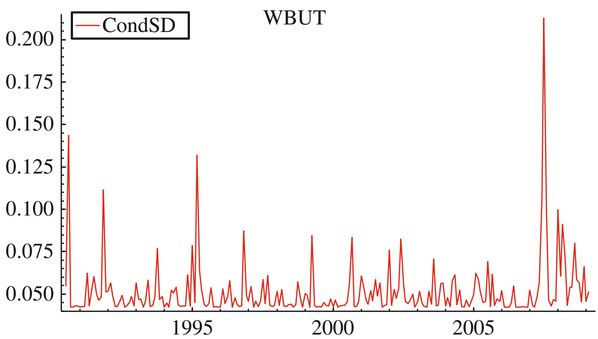
Modelling **WSMP** by restricted GARCH(0,1)
The estimation sample is: 1990 (7) to 2009 (2)

	Coefficient	Std. Error	Robust SE	*t*-Value	*t*-Prob
WSMP_1	Y 0.306072	0.06608	0.1077	2.84	0.005
WSMP_3	Y 0.208133	0.05396	0.07222	2.88	0.004
WSMP_5	Y –0.109334	0.05414	0.04732	–2.31	0.022
alpha_0	H 0.00147904	0.0001985	0.0002729	5.42	0.000
alpha_1	H 0.422738	0.1245	0.1249	3.39	0.001



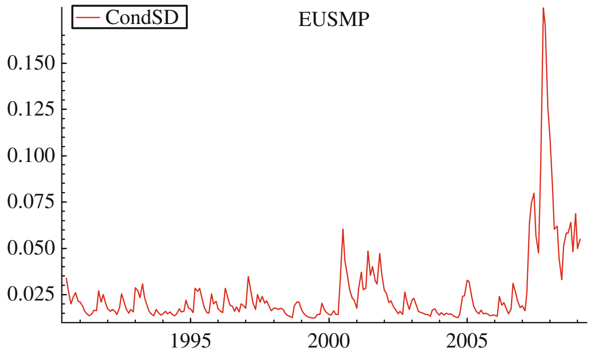
Modelling **WBUT** by restricted GARCH(0,1)
The estimation sample is: 1990 (7) to 2009 (2)

	Coefficient	Std. Error	Robust SE	*t*-Value	*t*-Prob
WBUT_1	Y 0.322282	0.07283	0.09257	3.48	0.001
WBUT_3	Y 0.0860846	0.05478	0.04244	2.03	0.044
WBUT_5	Y –0.197504	0.05109	0.09525	–2.07	0.039
alpha_0	H 0.00179056	0.0002351	0.0003257	5.50	0.000
alpha_1	H 0.422387	0.1381	0.2064	2.05	0.042



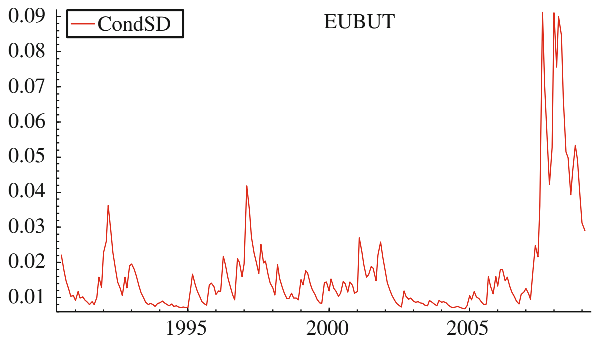
Modelling **EUSMP** by restricted GARCH(1,1)
The estimation sample is: 1990 (7) to 2009 (2)

	Coefficient	Std. Error	Robust SE	*t*-Value	*t*-Prob
EUSMP_1	Y 0.573138	0.07903	0.08233	6.96	0.000
EUSMP_2	Y –0.223628	0.07303	0.08499	–2.63	0.009
EUSMP_5	Y –0.151037	0.05120	0.06055	–2.49	0.013
alpha_0	H 7.29770e–005	2.624e–005	3.502e–005	2.08	0.038
alpha_1	H 0.454464	0.1228	0.1782	2.55	0.011
beta_1	H 0.495433	0.09554	0.1323	3.75	0.000



Modelling **EUBUT** by restricted GARCH(1,1)
The estimation sample is: 1990 (7) to 2009 (2)

	Coefficient	Std. Error	r Robust SE	*t*-Value	*t*-Prob
EUBUT_1	Y 0.767340	0.07746	0.06576	11.7	0.000
EUBUT_2	Y –0.230737	0.07680	0.06758	–3.41	0.001
alpha_0	H 1.84080e–005	6.902e–006	7.288e–006	2.53	0.012
alpha_1	H 0.409981	0.1035	0.1853	2.21	0.028
beta_1	H 0.589816	0.07456	0.1100	5.36	0.000



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Chapter 6
Price Volatility and Price Leadership in the EU Beef and Pork Meat Market

Isabelle Piot-Lepetit

Abstract This chapter investigates price dynamics of bovine and porcine production for the European Union (EU) as a whole and for each Member States (MS). The variability of production price series and the correlation between Member States price and the EU price are analysed. Furthermore, several time series models are tested in order to identify the stochastic process that generated these prices. Results show a higher dispersion of prices at the MS level. Correlation between MS prices and the EU price have increased since 2003 for bovine production and decreased for porcine production. Results are not conclusive regarding the existence of a common price process between the EU and MS prices and the leadership of the EU price in the bovine and porcine EU meat market.

6.1 Introduction

Volatility represents an important risk factor of supply, especially in agricultural products. Agricultural prices tend to be more volatile due to seasonality, inelastic demand and production uncertainty (Schnepf, 2005) and also because many agricultural products, especially fruits, vegetables and meat products, are perishable. Price fluctuations translate into a significant price risk. An increase in price volatility implies higher uncertainty about future prices. An important characteristic of meat supply response for pork and beef is the possibility of a negative short-run producer price elasticity response. This is because cattle are both a capital and consumption good. Jarvis (1974) showed that if the price of beef increases and producers expect this increase to be sufficiently permanent they may decide to retain a larger number of females in the cattle herd instead of slaughtering them at that time. The same phenomena can be described for pork supply response. Thus, an increase in price volatility implies higher uncertainty about future prices which can affect meat supply response and producers' incomes.

Disclaimer: The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.

I. Piot-Lepetit (✉)
Institute for Prospective Technological Studies (IPTS), Joint Research Centre (JRC), European Commission, Seville, Spain
e-mail: isabelle.piot-lepetit@ec.europa.eu

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Supply response analysis has long been a matter of interest in agricultural economics. Several authors have evaluated the effect of price uncertainty on agricultural supply response (see for example, Antonovitz and Roe, 1986; Antonovitz and Green, 1990; Seale and Shonkwiler, 1987; Goodwin and Sheffrin, 1982; Hutzinger, 1979; Chavas, 1999). Aradhyula and Holt (1989) and Holt and Aradhyula, (1990, 1998) included price uncertainty and volatility in modelling supply and demand by using a generalised autoregressive conditional heteroskedasticity (GARCH) model. Rezitis and Stavropoulos (2009) tested several GARCH type models to characterise the time varying in producers' expected price and price volatility in their analysis of pork supply response in Greece.

The aim of this chapter is to provide useful information on producers' price dynamics of bovine and porcine production for the European Union (EU) and Member States (MS). Based on monthly prices available at the EU and Member States level, this chapter analyses the variability of prices and their correlation with the EU price. It tries to clarify the existence of the price leadership of the EU price over MS prices.

Furthermore, each price process underlying each price series is fitted by a time series model. Five models from the current literature have been tested, namely the autoregressive moving average (ARMA) model, the autoregressive conditional heteroskedasticity (ARCH) model, the generalised autoregressive conditional heteroskedasticity (GARCH) model, the exponential generalised autoregressive conditional heteroskedasticity (EGARCH) model and the asymmetric power autoregressive conditional heteroskedasticity (APARCH) model. The selected model for each price series is the one that received the best rank based on three information criteria, namely the Schwarz, Aikake and Hannan–Quinn information criteria. Comparisons of best selected models allow us to know if EU and MS bovine and pork prices follow a similar price process, i.e. if they can be represented by using the same time series model.

This chapter is organised as follows. Section 6.2 describes the five price models used in the analysis. Results are then provided in Sections 6.3 and 6.4 for the EU15 and the EU12, respectively. The last section concludes.

6.2 Model Description

A number of approaches have been utilised by economists to model the time-varying pattern of agricultural commodity prices. Of these the moving average (MA) model, autoregressive (AR) model or the autoregressive moving average (ARMA) model were usually fitted to identify the structure of a time series (Box and Jenkins, 1970). More recently, more complex price models have been developed with models such as the autoregressive conditional heteroskedasticity (ARCH) model (Engle, 1982) and the generalised ARCH (GARCH) model (Bollerslev, 1986). ARCH models allow the shocks in more recent periods to affect the current volatility positively while GARCH models postulate that not only previous shocks, but also previous volatilities affect current volatility. Beside these standard models, two additional models are considered: the Exponential general autoregressive conditional heteroskedasticity (EGARCH) model (Nelson, 1991) and the asymmetric power ARCH model (Ding et al., 1993). These models are used to analyse the underlying stochastic process generating price series.

The mean equation of a univariate time series x_t can be described by the following stochastic process:

$$x_t = E(x_t \,|\Omega_{t-1}) + \varepsilon_t \tag{6.1}$$

where $E(\cdot\,|\cdot)$ denotes the conditional expectation operator, Ω_{t-1} the information set at time $t-1$, ε_t the residuals of the time series which describe uncorrelated disturbances with zero mean, i.e. the unpredictable part of the time series.

6.2.1 Autoregressive Moving Average (ARMA) Model

The general form of the ARMA(p,q) model of autoregressive order p and moving average order q may be presented as

$$x_t = \mu + \sum_{i=1}^{p} \varphi_i x_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} \tag{6.2}$$

where x_t is the dependent variable, x_{t-i} for $i = 1, \ldots, p$ are lagged dependent variables; ε_t is the error term and assumed to be white noise; ε_{t-j}, $j = 1, \ldots, q$ are lagged error terms; t denotes the time period and μ the mean. The autoregressive coefficients φ_i and moving average coefficients θ_j are parameters to be estimated. The error terms are assumed to be a Gaussian process with a mean of zero and a constant variance σ^2.

6.2.2 Autoregressive Conditional Heteroskedasticity (ARCH) Model

To describe data series with time-varying volatility, an ARCH model allows the variance of error terms to change over time. Engle (1982) defined the ε_t terms of the ARMA mean equation in (6.2) as an autoregressive conditional heteroskedastic process where all ε_t are of the form:

$$\varepsilon_t = z_t \sigma_t \tag{6.3}$$

and

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \tag{6.4}$$

where z_t is an independent and identically distributed (i.i.d.) variable that has a distribution with a zero mean and a unit variance. Although ε_t is serially uncorrelated, its conditional variance σ_t^2 may change over time. The ARCH(p) model is considered as a short memory process in that only the most recent p residuals have an impact on the current variance.

6.2.3 Generalised Autoregressive Conditional Heteroskedasticity (GARCH) Model

By using a GARCH model (Bollerslev, 1986), an autoregressive moving average (ARMA) model is assumed for the error variance. A GARCH(p,q) model may be presented in the same manner as the ARCH model except that the variance equation is now as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \tag{6.5}$$

If all the coefficients β_j are zero, the GARCH(p,q) model is reduced to the ARCH(p) model. The GARCH(p,q) model allows a longer memory process in which all the past residuals can affect the current variance either directly or indirectly through the lagged variance terms. The GARCH estimates have been used to identify periods of high volatility and volatility clustering. The sum $\alpha_i + \beta_i$ gives the degree of persistence of volatility in the series. The closer the sum is to 1, the greater the tendency of volatility to persist for a longer time. If the sum exceeds 1, it is indicative of an explosive series with a tendency to meander away from the mean value.

6.2.4 Exponential Generalised Autoregressive Conditional Heteroskedasticity (GARCH) Model

The EGARCH(p,q) model (Nelson, 1991) is a type of GARCH model where the variance is modelled as

$$\ln \sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i g(\varepsilon_{t-i}^2) + \sum_{j=1}^{q} \beta_j \ln \sigma_{t-j}^2 \tag{6.6}$$

where $g(\varepsilon_{t-i}^2) = \eta \varepsilon_{t-i}^2 + \lambda \left(\left| \varepsilon_{t-i}^2 \right| - E\left(\left| \varepsilon_{t-i}^2 \right| \right) \right)$ and ω, α, β, η and λ are parameters. The formulation for $g(\varepsilon_{t-i}^2)$ allows the sign and the magnitude of ε_{t-i}^2 to have separate effects on the volatility. The EGARCH model allows negative values in the variance equation.

6.2.5 Asymmetric Power Autoregressive Conditional Heteroskedasticity (APARCH) Model

The variance equation of the APARCH(p,q) model from Ding et al. (1993) can be written as

$$\sigma_t^\delta = \omega + \sum_{i=1}^{p} \alpha_i (|\varepsilon_{i-t}| - \gamma_i \varepsilon_{t-i})^\delta + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^\delta \tag{6.7}$$

where $\delta > 0$ and $-1 < \gamma_i < 1$.

This model adds the flexibility of a varying exponent with an asymmetric coefficient to take the leverage effect of the time series into account. The family of APARCH models includes the ARCH and GARCH models and five other ARCH extensions as special cases:

- ARCH model of Engle (1982) when $\delta = 2$, $\gamma_i = 0$ and $\beta_j = 0$,
- GARCH model of Bollerstev (1986) when $\delta = 2$ and $\gamma_i = 0$,
- TS-GARCH model of Taylor (1986) and Schwert (1989) when $\delta = 1$ and $\gamma_i = 0$,
- GJR-GARCH model of Glosten et al. (1993) when $\delta = 2$,
- T-GARCH model of Zakoian (1994) when $\delta = 1$,
- N-ARCH model of Higgens and Bera (1992) when $\gamma_i = 0$ and $\beta_j = 0$,
- Log-ARCH model of Geweke (1986) and Pentula (1986) when $\delta \to 0$.

6.3 Data

Monthly price series for livestock products on the European Union (EU) agricultural commodity markets both at EU and Member States (MS) levels are used in this analysis. These price series drawn from the Agriview[1] data set from the European Commission are collected on the basis of information communicated by each Member State. Selected price series concern the following products: young bovines, beef, cows, heifers, pork and piglets. The monthly data are a calculated weighed average based on the number of days in the week per month. Price series are available for the EU15 from January 1997 to October 2010, for new Member States (EU10) from May 2004 to October 2010 and for Bulgaria and Romania from January 2007 to October 2010. For the new Member States, not all series are fully available. In this study, price series where 10% of the data are missing were not selected for the analysis.

[1] http://www.agriview.com/

6.4 Price Analysis in the EU and the "Old" Member States

6.4.1 EU and MS Price Dispersion

Price dispersion in the EU and in the Member States is described by using the coefficient of variation. This statistic defined as a ratio of standard deviation over mean is a measure of the dispersion of data in the time series. A higher value of the coefficient of variation means a larger dispersion of monthly prices and *vice versa*. These figures are described in Table 6.1 (bovine production) and Table 6.2 (porcine production) for the EU15. The data were divided into two equally sized intervals (January 1997 to November 2003 and December 2003 to October 2010). The second time period includes recent price increases.

Table 6.1 Coefficient of variation and coefficient of correlation with the EU price for bovine production

	Coefficients of variation			Coefficients of correlation with EU price		
Countries	1997/01–2010/10	1997/01–2003/11	2003/12–2010/10	1997/01–2010/10	1997/01–2003/11	2003/12–2010/10
Young bovines						
EU	*8.69*	*7.07*	*6.28*			
AT	8.54	5.83	6.70	0.942	0.934	0.889
BE	8.80	8.89	8.34	0.725	0.691	**0.887**
DE	**11.70**	8.97	8.23	**0.954**	0.955	0.881
DK	**11.31**	7.05	**8.88**	0.867	0.682	**0.878**
ES	9.35	7.50	7.06	0.927	0.937	0.806
FI	8.56	7.11	**7.61**	**0.491**	–0.198	**0.773**
FR	9.13	7.56	6.46	0.954	0.959	0.872
GR	**5.99**	3.54	**5.49**	0.749	0.524	**0.676**
IT	9.22	7.64	6.56	0.940	0.921	0.873
LU	8.55	7.59	6.12	0.835	0.652	**0.865**
NL	**12.66**	14.14	7.33	0.864	0.810	**0.910**
PT	8.24	6.20	**7.75**	0.509	–0.125	**0.672**
SE	8.50	5.76	**9.94**	0.517	0.406	**0.571**
UK	9.07	5.94	**7.56**	0.619	0.028	**0.665**
Beefs						
EU	***6.84***	*4.07*	*5.40*			
AT	9.82	6.16	**7.52**	0.730	0.071	**0.718**
FR	**6.70**	6.36	3.38	0.807	0.827	0.528
IE	**11.49**	5.07	**8.22**	**0.928**	0.591	**0.977**
LU	7.18	6.81	5.26	0.711	0.478	**0.673**
SE	8.83	6.60	**10.20**	**0.612**	0.607	**0.720**
UK	9.50	5.87	**7.15**	0.867	0.413	**0.929**
Cows						
EU	*9.50*	*7.77*	*6.35*			
AT	11.64	8.48	8.16	**0.951**	0.886	**0.947**
BE	**13.67**	8.13	**10.81**	0.906	0.775	**0.918**

Table 6.1 (continued)

	Coefficients of variation			Coefficients of correlation with EU price		
Countries	1997/01–2010/10	1997/01–2003/11	2003/12–2010/10	1997/01–2010/10	1997/01–2003/11	2003/12–2010/10
DE	**14.19**	11.74	9.15	**0.953**	0.892	**0.949**
DK	10.54	8.65	**9.37**	0.906	0.874	**0.930**
ES	**8.23**	6.49	**8.44**	0.755	0.649	**0.847**
FR	**8.56**	7.71	4.47	0.931	0.900	0.856
IT	11.97	9.71	**10.13**	0.889	0.837	**0.867**
LU	11.76	7.35	**8.05**	0.913	0.872	0.815
NL	**16.99**	16.44	10.80	0.917	0.873	0.868
PT	9.76	10.14	7.11	**0.607**	0.325	**0.649**
SE	9.98	8.54	**10.94**	0.637	0.800	0.778
Heifers						
EU	*7.47*	*4.66*	*5.31*			
AT	8.89	6.29	**6.49**	0.927	0.821	**0.892**
BE	9.34	4.42	**7.99**	0.854	0.653	**0.744**
DE	13.10	9.98	**7.43**	**0.933**	0.844	**0.919**
DK	9.54	5.38	**6.80**	0.873	0.721	0.710
ES	8.03	7.40	7.39	**0.569**	0.454	**0.461**
FI	9.46	**6.06**	**8.57**	0.711	0.024	**0.810**
FR	7.81	8.26	4.07	0.747	0.647	0.600
IE	**12.22**	5.39	**8.17**	0.812	0.008	**0.847**
IT	8.00	4.07	**5.39**	0.895	0.598	**0.857**
LU	**6.53**	5.58	4.73	0.852	0.687	**0.828**
NL	**17.87**	17.94	13.46	0.720	0.700	0.545
SE	9.29	6.19	**10.74**	0.672	0.593	**0.791**
UK	9.90	6.06	**7.06**	0.763	0.034	**0.807**

Source: Own calculations
Notes: European Union (EU), Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK). Bold figures in columns 2 and 5 show extreme values of the CV and correlation. Bold figures in columns 4 and 7 show increases in volatility and correlation between both sub-time periods.

For young bovine production, the coefficient of variation (CV) is higher during the overall time period (January 1997 to October 2010) than during the first sub-time period (January 1997 to November 2003) that corresponds to the price process existing before the recent price increase, for the EU as a whole and for each Member State, except for Belgium and the Netherlands. The MS with the highest dispersion are the Netherlands (12.6%), Germany (11.7%) and Denmark (11.3%) while the lowest dispersion is for Greece (5.99%). When comparing CV's values between the sub-time periods 1997–2003 and 2003–2010, the CV is higher only for half of the MS, namely Austria, Denmark, Finland, Greece, Portugal, Sweden and the United Kingdom. The young bovine price dispersion for these MS has recently increased. Other MS are concerned by a decrease in price dispersion. The highest decrease is shown for the Netherlands, from 14 to 7%, and the highest increase for Sweden,

Table 6.2 Coefficient of variation and coefficient of correlation with the EU price for porcine production

	Coefficients of variation			Coefficients of correlation with EU price		
Countries	1997/01–2010/10	1997/01–2003/11	2003/12–2010/10	1997/01–2010/10	1997/01–2003/11	2003/12–2010/10
Pork						
EU	*13.15*	*17.02*	*7.80*			
AT	14.20	18.21	8.77	0.978	0.989	0.933
BE	15.51	20.36	8.26	0.959	0.961	0.953
DE	14.66	18.95	8.75	**0.988**	0.902	**0.974**
DK	14.16	18.26	7.59	0.920	0.944	0.905
ES	**15.84**	20.20	10.07	0.925	0.953	0.793
FI	**8.56**	10.71	5.75	**0.654**	0.721	0.363
FR	13.51	17.06	8.44	0.956	0.976	0.935
GR	15.41	19.16	10.66	0.790	0.847	0.574
IE	10.83	13.81	6.11	0.915	0.955	0.761
IT	12.99	15.34	9.66	**0.659**	0.714	0.585
LU	14.87	18.22	8.66	0.834	0.863	**0.971**
NL	**15.79**	20.46	8.84	0.956	0.967	0.967
PT	14.89	18.92	9.56	0.918	0.943	0.806
SE	9.82	11.47	7.93	0.765	0.834	0.586
UK	11.03	14.13	6.10	0.746	0.796	0.559
Piglets						
EU	*19.28*	*24.49*	*12.07*			
BE	29.95	38.01	19.53	0.820	0.944	0.519
DE	22.26	28.54	14.11	**0.957**	0.984	0.921
DK	17.85	21.23	9.00	0.710	0.853	0.400
ES	**31.06**	36.97	23.99	0.905	0.937	0.839
FI	13.36	15.65	3.74	0.524	0.655	0.288
IT	15.80	19.41	11.32	0.817	0.841	0.736
LU	22.63	23.42	13.30	0.660	0.798	0.638
NL	27.97	33.88	20.82	0.863	0.861	**0.888**
PT	19.35	19.88	18.92	0.662	0.812	0.427
SE	**10.63**	12.92	6.70	0.600	0.771	0.009
UK	28.87	31.90	11.28	**0.466**	0.602	0.490

Source: Own calculations
Notes: European Union (EU), Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK). Bold figures in columns 2 and 5 show extreme values of the CV and correlation. Bold figures in columns 4 and 7 show increases in volatility and correlation between both sub-time periods.

from 5.7 to 9.9%. For Germany, the value of its CV is maintained constant between both sub-time periods.

Regarding beef products, the dispersion at the EU level is 6.8%. Ireland is the MS with the most dispersed price (11.5%) and France with the least dispersed price (6.7%). Smallest dispersions are shown during the 1997–2003 time period. Globally, price dispersion has increased at EU and MS levels after 2003, except for France and Luxembourg. The highest increase is for Sweden, from 6.6 to 10.2%, and the lowest for Austria, from 6.16 to 7.5%.

For cattle production, the CV at the EU level is 9.5%. The Netherlands, Germany and Belgium, with respectively 16.99, 14.19 and 13.67%, are the more dispersed MS during the overall time period (1997–2010). Comparing figures for each sub-time period, six MS increase their price dispersion, namely Belgium, Denmark, Italy, Luxembourg, Spain and Sweden.

The value of the EU's CV is 7.47% for heifers. The Netherlands and Ireland have the highest price dispersion with 17.87 and 12.22%, respectively. The lowest CV is for Luxembourg (6.53%). Nine MS show an increase in their price dispersion between 1997–2003 and 2003–2010, namely Austria, Belgium, Germany, Denmark, Finland, Ireland, Italy, Sweden and the United Kingdom.

The CV for pork production (Table 6.2) is 13.15% at EU level. The highest CV are for the Netherlands (15.79%) and Spain (15.84%) while the lowest is for Finland (8.56%). For piglets, the CV at the EU level is 19.28% with the highest dispersion for Spain (31.06%) and the lowest for Sweden (10.63%). The dispersion has decreased between the two sub-time periods for both porcine productions.

6.4.2 EU Price Leadership

In order to get an initial idea of the link existing between EU and MS prices for each livestock product concerned, coefficients of correlation of MS prices with the EU price are provided in the last three columns of Table 6.1 for bovine and Table 6.2 for porcine.

Young bovine prices in Germany, Austria, Spain, France and Italy are highly correlated with the EU price with coefficients of correlation higher than 92.7%. In contrast, young bovine prices in Finland, Portugal and Sweden are weakly linked to the EU price. Their coefficients of correlation are less than 50%. Results on the two sub-samples show an increase in the correlation between young bovine prices at the MS level and the EU price, except for Austria, Denmark, Spain, France and Italy for which prices slightly decrease. Coefficients of correlation for the 1997–2003 time period are negative for Finland (–19.8%) and Portugal (–12.5%). The value for the United Kingdom is close to zero (2.8%) while it is less than 50% for Sweden (40.6%). During the 2003–2010 time period, all coefficients of correlation are above 57%. Values for Finland, Portugal and the United Kingdom are now respectively 77, 67 and 66%.

Coefficients of correlation with the EU price for beef are between 61.2 and 92.6%. However, these values are weaker during the 1997–2003 time period with a coefficient of 47.8% for Luxembourg, 41.3% for the United Kingdom and 0.7% for Austria. All coefficients of correlation increase during the 2003–2010 time period except for France for which a decrease from 82.7 to 52.8% is observed. For all other MS, values are between 67.3 and 97.7%.

Regarding cows, coefficients of correlation are between 60 and 95%. From 1997 to 2003, these coefficients are valued between 64 and 90%, except for Portugal (32.5%). From 2003 to 2010, an increase in the correlation with the EU price for almost all MS is shown. For France, Luxembourg, the Netherlands and Sweden, cattle prices slightly decrease. The coefficient of correlation of Portugal increases and reaches 64.9%.

Heifer price correlations are between 57 and 93% for the overall time period. Between 1997 and 2003, values are between 59 and 84%, except for Finland, Ireland and the United Kingdom that have a null correlation with the EU price of heifers. After 2003, almost all coefficients of correlation increase. Values are now between 54 and 92%. For MS with a null correlation in the previous time period, values become significantly higher with 81% for Finland, 84% for Ireland and 80.7% for the United Kingdom.

Coefficients of correlation of pork prices (Table 6.2) are between 65 and 99% from 1997 to 2010. When the sample is divided into two sub-samples, values are between 71% (Italy) and 98.9% (Austria) from 1997 to 2003 and between 58.5% (Italy) and 97% (Germany and Luxembourg) from 2003 to 2010. Except for Germany and Luxembourg, coefficients of correlation decrease between the two sub-time periods.

Price correlations for piglets are between 46.6% for the United Kingdom and 95.7% for Denmark from 1997 to 2010. For the first sub-sample, the range of values is between 60% for the United Kingdom and 98.4% for Germany and for the second sub-sample, from zero for Sweden and 92.1% for Denmark. Values below 50% are calculated for Germany, Finland, Portugal, Sweden and the United Kingdom. Except for the Netherlands, all coefficients of correlation decrease between the two sub-time periods.

6.4.3 EU and MS Price Models

The fitting of five time series models (ARMA, ARCH, GARCH, EGARCH and APARCH)[2] on the price series has been analysed. Each model has been ranked according to three information criteria[3]:

– SIC: Schwarz Information Criterion

$$\mathrm{SIC} = \ln(N)K - 2\ln(L_{\max}) \tag{6.8}$$

where N is the number of observations, K the number of parameters to be estimated and $L_{\max}$ the maximised value of the log-likelihood for the estimated model.

– AIC: Akaike Information Criterion

$$\mathrm{AIC} = \left(\frac{2N}{N-K-1}\right) - 2\ln(L_{\max}) \tag{6.9}$$

[2]ARMA, ARCH, GARCH, EGARCH and APARCH means ARMA(1,1), ARCH(1), GARCH(1,1), EGARCH(1,1) and APARCH(1,1).

[3]Calculations have been implemented with the ModelRisk software. http://www.vosesoftware.com/.

– HQIC: Hannan–Quinn Information Criterion

$$\mathrm{HQIC} = 2\ln(\ln(N))K - 2\ln(L_{\max}) \quad (6.10)$$

Table 6.5 (in Appendix) describes the model selection for young bovines. The EU model is an EGARCH for the overall time series and for the two sub-time series with a better adjustment for the 2003–2010 time period. The same model fits most of the MS price series (Austria, Belgium, Germany, Denmark, Spain, Finland, France, the Netherlands, Sweden and the United Kingdom). For Italy, the selected model is an ARMA while for Luxembourg, it is an ARCH model. For Greece and Portugal, the selection of only one model is difficult. Both ARCH and ARMA models are possible for Greece and both APARCH and ARCH models for Portugal. Between 1997 and 2003, most of the selected models are an EGARCH model, except for Belgium and Luxembourg (ARCH), Italy (ARMA) and Portugal (APARCH). Between 2003 and 2010, changes in model selection appear for Denmark (EGARCH to ARCH), France (EGARCH to APARCH), Italy (ARMA to EGARCH), Luxembourg (ARCH to ARMA), Portugal (APARCH to EGARCH) and Sweden (EGARCH to ARCH).

Regarding beef production (Table 6.6 in Appendix), the EU price series is fitted by an EGARCH model as for Austria, France, Ireland, Luxembourg and the United Kingdom. For Sweden, the best model is an ARMA. Changes in model selection appear mostly in the 1997–2003 time period for Austria (EGARCH to APARCH), Luxembourg (EGARCH to ARCH) and the United Kingdom (ARCH or EGARCH to ARMA). Only one change is observed from 2003 to 2010 for Sweden (ARMA to APARCH).

For cow price series (Table 6.6 in Appendix), the EU model is an EGARCH model for the overall sample and an ARCH model for each sub-time period. The EGARCH model is the dominant model at MS level. The APARCH model is selected for Italy and Portugal and the ARCH model for Luxembourg. The EGARCH model is still the dominant model between 1997 and 2003, even if EU prices are now fitted by an ARCH model. The selected model for Austria, Belgium and Portugal is the APARCH model. From 2003 to 2010, the selection of models is more diversified with an ARCH for the EU, Luxembourg and Spain, an APARCH for Austria and Sweden and an ARCH or an APARCH for the Netherlands.

Regarding heifer prices (Table 6.7 in Appendix), the EU model is an EGARCH for the overall sample and each sub-sample. The EGARCH model is always the more frequently selected. Exceptions are for Germany (ARMA), Belgium, France, Sweden (ARCH), and Denmark and the Netherlands (APARCH). Between 1997 and 2003, changes appear for Germany (ARMA to ARCH), Denmark, the Netherlands, the United Kingdom (APARCH to EGARCH), France, Sweden (ARCH to EGARCH), Ireland and Luxembourg (EGARCH to ARCH). The EGARCH model is the dominant model between 2003 and 2010, except for Denmark, the Netherlands (APARCH) and Sweden (APARCH or ARCH).

The fitted model on pork prices (Table 6.8 in Appendix) is the EGARCH model for the EU as a whole as well as for the following MS: Austria, Belgium, Germany, Denmark, Spain, France, Greece and Luxembourg. For other MS, selected models are an ARCH for Finland, France, Ireland, Portugal and the United Kingdom, an APARCH for Italy and Sweden and an ARMA or an APARCH for the Netherlands. For the 1997–2003 time period, the dominant model is an EGARCH while for the 2003–2010 time period, it is an APARCH. The main changes in the price process between both sub-time periods are the switch of an EGARCH to an APARCH model for the European Union, Austria, Belgium, Germany, Denmark, Spain, Luxembourg and Sweden, from an ARCH to an EGARCH for the United Kingdom and from an APARCH to an EGARCH for Finland.

For piglet prices, Table 6.9 in Appendix shows the greatest variability in the selected models. Between 1997 and 2010, dominant models are ARCH and EGARCH while for both sub-time periods, it is APARCH and EGARCH. During the 2003–2010 time period, the APARCH model is the reference at EU level and corresponds to the price process of Germany, Spain, Luxembourg, the Netherlands, Portugal and Sweden. Changes between the two sub-time periods appear for the EU and Sweden (EGARCH to APARCH), Belgium (APARCH to EGARCH), the United Kingdom (APARCH to ARCH), Finland (EGARCH to ARCH), Denmark (ARCH to EGARCH) and Luxembourg (ARCH to APARCH).

6.5 Price Analysis in the EU and the New Member States

Results for the new Member States (NMS) are provided in Table 6.3 for bovine production and Table 6.4 for porcine production. In each table the length of the time series is specified. Calculations have been implemented based on data availability. The following tables contain the coefficient of variation (CV) of each series, the coefficient of correlation (CC) with the EU price over the corresponding time period and the model that fits the price series.

For young bovines, the CV is higher for all NMS than the EU level. Thus, NMS prices are more dispersed than for the EU as a whole. Few prices are correlated with the EU price. The highest correlations are for the Czech Republic (87%), Poland (82%), Slovenia (90%), Lithuania (79%), Latvia (66%) and Slovakia (84%). The lowest correlations are for Hungary (24%) and Romania (50%). For Malta, the correlation is negative. Selected models are most often different from the EU model, except for the Czech Republic, Latvia and Slovakia. ARCH is the most frequent model and concerns Hungary, Latvia, Malta and Slovakia. For Romania, the selected model is an APARCH while for Poland it is an ARMA. For Slovenia, two models fit the price series, namely an ARMA and an EGARCH.

For beef price series, CVs are higher than for the EU and weak correlations with the EU price are shown in Table 6.3. The price process for Slovenia is an ARCH model, as for the EU, while it is an EGARCH for the Czech Republic.

Regarding prices for cows, all CVs are higher than for the EU as a whole. They are between 8 and 15%. Except for Romania (23%), most NMS prices are highly correlated with the EU price. Values are between 76.7% (for Hungary) and 86.8% (for the Czech Republic). The price process is an APARCH model as for the EU, except for Hungary and Slovenia that follow an EGARCH model.

Table 6.3 Coefficient of variation, coefficient of correlation with EU price and model selection for bovine production

	Time period	CV	CC	Model	–SIC	–AIC	–HIQ
Young bovine							
EU	*2004/05–2010/10*	*6*		*EGARCH*	*279.38*	*290.33*	*286.45*
CZ	2004/05–2010/10	8	0.869	EGARCH	57.06	68.01	64.13
HU	2006/12–2009/01	7	0.246	ARCH	31.76	33.90	34.31
LV	2004/05–2010/10	13	0.665	ARCH	172.64	179.34	176.86
LT	2004/10–2010/10	12	0.753	EGARCH	14.21	24.76	21.09
MT	2004/05–2010/10	10	–0.161	ARCH	183.05	189.80	187.29
PL	2004/05–2010/10	9	0.824	ARMA	290.58	299.46	296.24
RO	2007/01–2010/10	13	0.501	APARCH	101.15	109.59	107.89
SI	2004/05–2010/10	7	0.906	ARMA	353.27	362.14	358.92
				EGARCH	352.46	363.42	359.53
SK	2004/05–2010/10	10	0.837	ARCH	226.25	233.00	230.49
Beefs							
EU	*2004/05–2010/10*	*5*		*ARCH*	*359.44*	*366.19*	*363.68*
CZ	2004/05–2010/10	10	0.655	EGARCH	84.67	94.52	91.25
SI	2004/05–2010/10	9	0.566	ARCH	175.48	181.56	179.41
Cows							
EU	*2004/05–2010/10*	*5*		*APARCH*	*380.41*	*393.36*	*388.89*
CZ	2004/05–2010/10	10	0.868	APARCH	312.97	325.93	321.45
HU	2004/05–2010/10	8	0.767	EGARCH	59.98	70.93	67.05
PL	2004/05–2010/10	10	0.864	APARCH	195.32	208.27	203.80
RO	2007/01–2010/10	15	0.232	APARCH	52.13	60.57	58.87
SI	2004/05–2010/10	14	0.803	EGARCH	204.19	215.14	211.26
SK	2004/05–2010/10	11	0.874	APARCH	291.39	304.35	299.87
Heifers							
EU	*2004/05–2010/10*	*5*		*EGARCH*	*129.24*	*140.19*	*136.30*
CZ	2004/05–2010/10	9	0.867	APARCH	348.47	361.82	357.35
EE	2006/01–2010/06	11	0.464	APARCH	12.60	19.46	18.84
HU	2004/05–2010/10	9	–0.168	**GARCH**	120.60	128.78	125.93
LV	2004/05–2010/10	12	0.713	APARCH	103.98	115.70	111.93
PL	2004/05–2010/10	10	0.843	APARCH	287.87	300.83	296.35
RO	2007/01–2010/10	21	–0.014	EGARCH	0.74	8.39	6.46
SI	2004/05–2010/10	7	0.786	EGARCH	143.15	154.10	150.21
SK	2004/05–2010/10	11	0.825	ARCH	224.42	231.17	228.66

Source: Own calculations; CV: coefficient of variation; CC: coefficient of correlation
Notes: European Union (EU), Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), Slovakia (SK), Slovenia (SI), Bulgaria (BU) and Romania (RO). In Bold: Sole fitting of price series by a GARCH model.

Heifer prices in the NMS are more dispersed than in the EU and range from 7% (Slovenia) to 21% (Romania). High correlations with the EU price are observed for the Czech Republic (86.7%), Latvia (71.3%), Poland (84.3%), Slovenia (78.6%) and Slovakia (82.5%). However, only Slovenia has the same price process (EGARCH) as the EU. Estonian prices are weakly correlated to the EU price (46.4%) and follow an APARCH model. For Hungary and Romania, the correlation is negative. For most

Table 6.4 Coefficient of variation, coefficient of correlation with EU price and model selection for porcine production

	Time period	CV	CC	Model	–SIC	–AIC	–HIQ
Pork							
EU	*2004/05–2010/10*	*7*		*EGARCH*	*59.78*	*70.73*	*66.84*
CZ	2004/05–2010/10	10	0.396	APARCH	203.52	216.48	212.00
HU	2004/05–2010/10	9	0.723	APARCH	221.85	234.81	230.33
				EGARCH	223.13	234.08	230.20
MT	2004/05–2010/10	7	0.006	EGARCH	348.22	259.17	355.29
PL	2004/05–2010/10	11	0.630	APARCH	188.49	201.44	196.97
SK	2004/05–2010/10	10	0.590	APARCH	204.88	217.83	213.36
Piglets							
EU	*2004/05–2010/10*	*12*		*APARCH*	*222.59*	*235.55*	*231.07*
CZ	2004/05–2010/10	17	0.396	APARCH	180.27	193.23	188.75
				ARMA	182.55	191.43	188.20
EE	2004/05–2010/10	11	0.392	APARCH	208.25	221.21	216.73
HU	2004/05–2010/10	21	0.723	ARCH	33.91	40.66	38.15
MT	2004/05–2010/10	16	0.006	ARCH	93.55	100.29	97.79
PL	2004/05–2010/10	24	0.630	APARCH	159.42	172.38	167.90
SK	2004/05–2010/10	18	0.590	APARCH	107.26	120.22	115.74

Source: Own calculations
Notes: European Union (EU), Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), Slovakia (SK), Slovenia (SI), Bulgaria (BU) and Romania (RO)

NMS, the price process is an APARCH model. Hungarian prices are the only ones that follow a GARCH model.

Table 6.4 shows that Malta and the EU have the same pork price dispersion (CV of 7%). Both series can be fitted by an EGARCH model. However, no correlation exists between these prices. The NMS with the highest correlation is Hungary (72%). The Czech Republic is only weakly correlated to the EU price (39.6%). The dominant price process for pork prices is the APARCH model.

NMS prices for piglets are more dispersed than the EU prices, except for Estonia. Only two NMS have a high correlation with the EU price, namely Hungary (72.3%) and Poland (63%). Correlations are weak for the Czech Republic (39.6%), Estonia (39.2%) and Slovakia (59%). For Malta, the correlation is close to zero. The EU price process can be described by an APARCH model, as it can also for Estonia, Poland and Slovakia while the ARCH model fits the price data for the other NMS. For the Czech Republic, two models are selected (APARCH and ARMA).

6.6 Conclusion

This chapter analyses price processes for bovine and porcine production on the EU meat market both at the EU and MS levels. Two questions prompted this research. The first one concerns the variability of production prices for beef, cows, heifers, young bovines, pork and piglets in the EU as a whole and in each MS, and the correlation between MS prices and the EU price. The second question was on the existence of a common price process between the EU and MS price series.

Results show that MS price coefficients of variation are most often higher than that of the EU. Thus, there exists a higher dispersion of prices at MS level. Furthermore, correlations between MS prices and the EU price tend to increase since 2003 for bovine production and to decrease for porcine production. During the recent price period where significant increases in prices have been seen on agricultural commodity markets, prices of bovine production at MS level have converged to the EU price. The European market was not significantly affected by the high increase in world beef prices. Due to a stable consumption pattern and an increase in production, European beef prices were relatively stable while they were soaring in the rest of the world.

The dominant time series model that fits EU and MS (from EU15) prices is an EGARCH model. However, the split of the time period into two sub-samples allows changes to appear in price adjustments. Thus, the EGARCH model is not a stable model during the overall time period under analysis. The other most selected models are the ARCH and APARCH models. Thus, regarding the existence of a common price process in the EU at the MS, no conclusive answer can be stated. Furthermore, some price processes have changed between 1997–2003 and 2003–2010.

For NMS from EU12, prices are more dispersed than the EU price, not really correlated with the EU price and most often the underlying price process is different from the EU model. The dominant model for NMS is an APARCH model while for the EU it is an EGARCH model. Both models are designed for representing the asymmetric response of the prices to unexpected shocks and the dependence between distance observations. However, the APARCH model allows the dependence to be nonlinear.

The main conclusions from this study are that price variability has increased in the EU at the MS level and that the EU price cannot be considered as a leader price in the European meat market for bovine and porcine production.

Appendix: Tables 6.5 to 6.9 of Section 6.4.3

Table 6.5 Model selection for young bovine production

Countries	1997/01–2010/10 Model	–SIC	–AIC	–HIQ	1997/01–2003/11 Model	–SIC	–AIC	–HIQ	2003/12–2010/10 Model	–SIC	–AIC	–HIQ
Young bovines												
EU	*EGARCH*	*610.68*	*625.86*	*619.92*	*EGARCH*	*169.80*	*181.12*	*177.04*	*EGARCH*	*84.53*	*95.85*	*91.77*
AT	EGARCH	705.07	720.25	714.31	EGARCH	330.80	342.11	338.03	EGARCH	8.99	20.31	16.23
BE	EGARCH	775.69	790.88	783.93	**ARCH**	401.20	408.15	405.54	EGARCH	344.06	355.38	351.30
DE	EGARCH	411.90	427.09	421.15	EGARCH	116.20	127.52	123.44	EGARCH	291.71	303.02	298.94
DK	EGARCH	550.32	565.41	559.47	EGARCH	377.01	388.32	384.24	**ARCH**	346.42	353.37	350.76
ES	EGARCH	243.62	258.81	252.87	EGARCH	202.98	214.29	210.21	EGARCH	100.83	112.15	108.07
FI	EGARCH	350.38	365.56	359.62	EGARCH	371.95	383.27	379.19	EGARCH	39.32	50.63	46.55
FR	EGARCH	502.24	517.42	511.48	EGARCH	320.10	331.41	327.33	**APARCH**	377.01	390.41	385.69
GR	**ARCH**	902.18	911.37	907.73	EGARCH	393.33	404.65	400.57	**ARCH**	523.12	530.07	527.46
	ARMA	901.20	913.40	908.60								
IT	**ARMA**	637.27	649.47	644.67	**ARMA**	277.78	286.94	283.57	EGARCH	222.11	233.42	229.34
LU	**ARCH**	609.41	618.82	614.96	**ARCH**	266.84	273.79	271.18	**ARMA**	330.66	330.82	336.45
NL	EGARCH	483.41	498.59	492.65	EGARCH	93.31	104.63	100.55	EGARCH	373.80	385.11	381.03
PT	**APARCH**	786.16	804.30	797.25	**APARCH**	391.84	405.24	400.52	EGARCH	365.89	377.21	373.13
	ARCH	793.72	802.90	799.26								
SE	EGARCH	409.16	424.34	418.40	EGARCH	348.64	359.96	355.88	**ARCH**	316.03	322.98	320.37
UK	EGARCH	661.72	676.91	670.97	EGARCH	217.31	228.63	224.55	EGARCH	35.59	46.91	42.83

Source: Own calculations

Notes: European Union (EU), Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK). In bold: all price processes that are not fitted by an EGARCH model.

Table 6.6 Model selection for beef and cow production

	1997/01–2010/10				1997/01–2003/11				2003/12–2010/10			
Countries	Model	–SIC	–AIC	–HIQ	Model	–SIC	–AIC	–HIQ	Model	–SIC	–AIC	–HIQ
Beefs												
EU	*EGARCH*	*802.74*	*817.92*	*811.98*	***ARCH***	*431.33*	*438.29*	*435.68*	*EGARCH*	*70.60*	*81.91*	*77.83*
					EGARCH	*427.07*	*438.39*	*434.31*				
AT	EGARCH	728.85	744.03	738.09	**APARCH**	326.95	340.35	335.63	EGARCH	9.82	21.13	17.05
FR	EGARCH	597.69	612.87	606.93	EGARCH	262.21	273.53	269.45	EGARCH	419.92	431.24	427.16
IE	**ARCH**	645.37	654.56	650.92	**ARCH**	318.28	325.23	322.62	**ARCH**	315.15	322.109	319.49
	EGARCH	641.41	656.59	650.65	EGARCH	315.64	326.95	322.88	EGARCH	311.33	322.65	318.57
LU	EGARCH	514.33	529.52	523.58	**ARCH**	240.55	247.50	244.89	EGARCH	151.07	162.39	158.31
SE	**ARMA**	618.48	630.68	625.87	**ARMA**	315.76	324.92	321.54	**APARCH**	278.63	292.04	287.32
UK	**ARCH**	700.97	710.16	706.52	**ARMA**	333.52	342.68	339.30	**ARCH**	328.20	335.15	332.54
	EGARCH	696.41	711.59	705.65								
Cows												
EU	*EGARCH*	*648.87*	*644.05*	*658.11*	***ARCH***	*343.07*	*350.03*	*347.41*	***ARCH***	*401.27*	*408.23*	*405.61*
AT	EGARCH	617.62	632.81	626.87	**APARCH**	286.64	300.05	295.33	**APARCH**	327.69	341.09	336.37
BE	EGARCH	703.84	719.02	713.08	**APARCH**	327.62	341.03	336.30	EGARCH	364.38	375.70	371.62
DE	EGARCH	515.72	530.90	534.96	EGARCH	263.04	274.35	270.27	EGARCH	271.64	282.95	278.88
DK	EGARCH	613.48	628.60	622.69	EGARCH	84.72	95.89	91.89	EGARCH	240.50	251.81	247.73
ES	EGARCH	524.99	540.18	534.24	EGARCH	83.90	95.22	91.14	**ARCH**	327.68	334.64	332.03
FR	EGARCH	372.96	388.14	382.20	EGARCH	244.38	255.70	251.62	EGARCH	420.36	431.67	427.60
IT	**APARCH**	529.29	547.43	540.38	EGARCH	158.07	169.38	165.30	EGARCH	120.87	132.18	128.10
LU	**ARCH**	522.56	531.75	528.11	EGARCH	328.44	339.75	335.67	**ARCH**	210.05	217.00	214.39
NL	EGARCH	430.23	445.42	439.48	**ARCH**	258.49	265.44	262.83	**ARCH**	278.18	285.14	282.52
					EGARCH	258.13	269.44	265.36	**APARCH**	277.52	290.92	286.20
PT	**APARCH**	509.18	526.83	520.00	**APARCH**	204.99	217.66	213.34	EGARCH	361.85	372.88	368.95
SE	EGARCH	402.36	415.59	410.54	EGARCH	48.97	60.29	56.21	**APARCH**	280.28	293.69	288.97

Table 6.7 Model selection for heifer production

Countries	1997/01–2010/10 Model	–SIC	–AIC	–HIQ	1997/01–2003/11 Model	–SIC	–AIC	–HIQ	2003/12–2010/10 Model	–SIC	–AIC	–HIQ
Heifers												
EU	*EGARCH*	*864.87*	*880.05*	*874.11*	*EGARCH*	*398.17*	*409.49*	*405.41*	*EGARCH*	*166.13*	*177.38*	*173.33*
AT	EGARCH	681.11	696.29	690.35	EGARCH	144.41	155.72	151.64	EGARCH	158.74	169.99	165.95
BE	**ARCH**	907.88	917.07	913.42	**ARCH**	420.27	427.22	424.61	EGARCH	262.57	338.82	334.78
					APARCH	418.85	430.16	426.08				
DE	**ARMA**	801.67	813.87	809.06	**ARCH**	346.79	353.74	351.13	EGARCH	327.57	338.82	334.78
DK	**APARCH**	719.01	737.15	730.10	EGARCH	81.41	92.73	88.65	**APARCH**	329.42	342.74	338.07
ES	EGARCH	281.53	296.71	290.77	EGARCH	155.06	166.37	162.29	EGARCH	22.68	33.93	29.88
FI	EGARCH	448.40	462.42	457.00	EGARCH	34.51	44.72	41.25	EGARCH	205.94	215.70	212.48
FR	**ARCH**	832.76	841.95	838.31	EGARCH	90.52	101.83	97.75	EGARCH	408.37	419.62	415.58
IE	EGARCH	478.80	493.98	488.04	**ARCH**	331.42	338.37	335.76	EGARCH	256.33	267.58	263.53
IT	EGARCH	231.93	247.11	241.17	**ARCH**	299.47	306.42	303.81	EGARCH	284.93	296.17	292.13
LU	EGARCH	700.05	715.24	709.30	EGARCH	255.07	266.39	262.31	EGARCH	369.36	380.60	376.56
									ARCH	373.69	380.61	376.02
NL	**APARCH**	199.93	217.74	210.84	EGARCH	137.13	148.37	144.33	**APARCH**	53.28	66.04	61.67
SE	**ARCH**	629.87	639.06	634.42	EGARCH	283.24	294.56	290.48	**APARCH**	282.54	295.86	291.19
									ARCH	284.38	291.29	288.70
UK	EGARCH	271.91	287.09	281.15	**APARCH**	350.86	364.27	359.55	EGARCH	42.14	53.46	49.38

Source: Own calculations
Notes: European Union (EU), Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK). In bold: all price processes that are not fitted by an EGARCH model.

Table 6.8 Model selection for pork production

	1997/01–2010/10				1997/01–2003/11				2003/12–2010/10			
Countries	Model	–SIC	–AIC	–HIQ	Model	–SIC	–AIC	–HIQ	Model	–SIC	–AIC	–HIQ
Pork												
EU	*EGARCH*	*403.39*	*418.57*	*412.63*	*EGARCH*	*200.44*	*211.75*	*207.67*	***APARCH***	*265.10*	*278.51*	*273.78*
AT	EGARCH	407.82	423.01	417.06	EGARCH	161.69	173.00	168.92	**APARCH**	237.19	250.60	245.88
BE	EGARCH	57.07	72.25	66.31	EGARCH	113.68	125.00	120.92	**APARCH**	241.40	254.81	250.09
DE	EGARCH	229.86	245.04	239.10	EGARCH	122.32	133.63	129.55	**APARCH**	240.66	254.81	250.09
DK	EGARCH	490.73	505.92	499.98	EGARCH	209.92	221.23	217.15	**APARCH**	274.54	287.95	283.23
ES	EGARCH	162.37	177.56	171.62	EGARCH	143.21	154.52	150.44	**APARCH**	174.50	187.90	183.18
FI	**ARCH**	808.57	817.76	814.12	**APARCH**	331.70	345.11	340.38	EGARCH	421.19	432.50	428.42
FR	EGARCH	413.79	428.97	423.03	**APARCH**	109.92	123.33	118.91	**APARCH**	219.35	232.76	228.03
	ARCH	419.73	428.92	425.28								
GR	EGARCH	377.84	393.03	387.09	EGARCH	31.22	42.53	38.45	EGARCH	36.15	47.47	43.39
IE	**ARCH**	611.79	620.98	617.34	EGARCH	94.79	106.11	102.03	EGARCH	215.98	227.29	223.21
IT	**APARCH**	347.33	365.48	358.43	EGARCH	188.16	199.48	195.40	EGARCH	7.71	19.02	14.94
LU	EGARCH	407.93	423.12	417.17	EGARCH	193.97	205.29	201.21	**APARCH**	248.06	261 47	256.74
					APARCH	193.89	207.30	202.57				
NL	**APARCH**	372.00	390.15	383.10	EGARCH	119.53	130.84	126.76	**APARCH**	223.79	237.20	232.47
	ARMA	373.93	386.13	381.33								
PT	**ARCH**	366.89	376.08	372.44	**ARCH**	155.45	162.40	159.79	**APARCH**	112.90	126.31	121.59
SE	**APARCH**	553.34	571.49	564.44	EGARCH	249.31	260.62	256.54	**APARCH**	289.03	302.43	297.41
					ARCH	253.50	260.45	257.84				
UK	**ARCH**	502.82	512.01	508.37	**ARCH**	205.09	212.04	209.43	EGARCH	142.93	154.25	150.17

Source: Own calculations
Notes: European Union (EU), Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK). In bold: all price processes that are not fitted by an EGARCH model.

Table 6.9 Model selection for piglet production

	1997/01–2010/10				1997/01–2003/11				2003/12–2010/10			
Countries	Model	–SIC	–AIC	–HIQ	Model	–SIC	–AIC	–HIQ	Model	–SIC	–AIC	–HIQ
Piglets												
EU	**APARCH**	392.52	410.67	403.61	EGARCH	64.76	76.08	72.00	**APARCH**			
	ARCH	398.65	407.84	404.19								
BE	**ARMA**	201.27	213.47	208.67	**APARCH**	49.21	62.62	57.89	EGARCH	82.46	93.77	89.69
DE	**ARCH**	321.19	330.38	326.73	**APARCH**	110.51	123.92	119.19	**APARCH**	208.44	221.84	217.12
DK	**ARCH**	420.79	429.97	426.33	**ARCH**	173.24	180.19	177.58	EGARCH	0.94	12.26	8.18
ES	EGARCH	52.64	67.83	61.89	**APARCH**	18.03	31.44	26.71	**APARCH**	67.82	81.23	76.50
FI	**ARCH**	710.96	720.14	716.50	EGARCH	300.63	311.95	307.87	**ARCH**	388.93	395.88	393.27
IT	EGARCH	283.63	298.81	292.87	EGARCH	135.07	146.38	142.30	EGARCH	156.26	167.57	163.49
LU	EGARCH	284.27	299.81	292.87	**ARCH**	139.62	146.58	173.72	**APARCH**	163.54	176.95	172.22
NL	**APARCH**	108.12	125.94	119.03	**APARCH**	9.87	22.54	18.22	**APARCH**	92.41	105.82	101.09
PT	EGARCH	12.24	27.43	21.49	**APARCH**	78.83	92.24	87.51	**APARCH**	132.33	145.74	141.01
SE	**APARCH**	575.63	593.77	586.72	EGARCH	244.27	255.59	252.52	**APARCH**	312.68	326.09	321.36
	ARCH	584.22	593.41	589.77								
UK	**ARMA**	263.47	274.85	270.41	**APARCH**	40.60	50.75	47.93	**ARCH**	266.68	273.64	271.03

Source: Own calculations
Notes: European Union (EU), Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK). In bold: all price processes that are not fitted by an EGARCH model.

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Chapter 7
Using Futures Prices to Forecast US Corn Prices: Model Performance with Increased Price Volatility

Linwood A. Hoffman

Abstract A futures price forecasting model is presented which uses monthly futures prices, cash prices received, basis values (cash prices less futures) and marketing weights to forecast the season-average farm price for US corn. Performance of the model forecasts is examined using standard measures, such as mean absolute error, mean absolute percentage error and mean squared error. Tests for statistical differences between the futures model forecast and price projections from the US Department of Agriculture (USDA) are conducted using the Modified Diebold–Mariano test statistic. A measurement of price volatility identified the past 3 crop years, 2006/2007–2008/2009 with increased volatility compared to the prior 6 years, 2000/2001–2005/2006. Forecast errors from the futures forecast model increased during these volatile price years compared to the prior 6 year period which exhibited more stability. Suggestions are made to improve model price forecasts during periods of price volatility.

7.1 Introduction

The US Department of Agriculture analyses agricultural commodity markets on a monthly basis and publishes current year market information, including price projections, in World Agricultural Supply and Demand Estimates (WASDE) (USDA, c). The monthly WASDE price projection for a given commodity provides information that can be used by market participants and policymakers. In general, USDA's season-average price projection for a given commodity is based on analysts' judgement, econometric price forecasting models, futures model price forecasts and market information (Westcott and Hoffman, 1999; Childs and

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Disclaimer: The views presented herein are those of the author and not necessarily of the ERS or USDA.

L.A. Hoffman (✉)
US Department of Agriculture, Economic Research Service, Washington, DC, USA
e-mail: lhoffman@ers.usda.gov

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Westcott, 1997; Meyer, 1998; Plato and Chambers, 2004; Chambers, 2004 and Hoffman, 2005, 2007).

Price information continues to be important for market participants due to US agricultural policy. Price forecasts are critical to market participants making production and marketing decisions and to policy makers who administer commodity programs and assess the market impacts of domestic or international events. Passage of the 2002 Farm Act provides domestic support programs that are linked to the season-average price, such as the counter-cyclical program.[1] This program continues under the 2008 Farm Act, although an alternative program entitled Average Crop Revenue Election (ACRE) has also been linked to the season-average price.[2] Consequently, price forecasters have a renewed interest in providing reliable price forecasts of the season-average price and producers and policymakers have an interest in these forecasts' implications for the counter-cyclical payment rate and ACRE payment rate.

During the past several years, price forecasters have experienced increased forecasts errors due, in part, to increased price volatility and, consequently, price forecasting has become more of a challenge. Reasons for this volatility are many and varied. Some industry participants have suggested that new futures traders and new capital entering the market have unduly affected the level of prices and price volatility (Cooper, 2008). These concerns initially arose in energy markets but were later heard in agricultural commodity markets. An alternative argument rests on the increased dynamic nature of the commodity markets during recent years. For example, biofuel production, poor growing weather, export controls, emerging economy demand and increased production costs caused demand growth to outstrip supply growth in various commodities (Trostle, 2008). In addition, low real interest rates and a weak US dollar further fueled higher prices. Many economists and policy makers are concerned with the impacts this volatility has upon price forecasts and are interested in ways to improve their price forecasting ability during times of increased price volatility.

The objective of this paper is to present a background and presentation of a futures forecasting model for the season-average price received for US corn. The

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[1] *Counter-cyclical payments:* Counter-cyclical payments are available to producers with historic program payment acres and yields of wheat, corn, barley, grain sorghum, oats, upland cotton, long-grain and medium-grain rice, soybeans, other oilseeds, peanuts and pulse crops (dry peas, lentils, small and large chickpeas). Payments are made whenever the current effective commodity price is less than the target price. The effective price is calculated by adding: (1) the national average farm price for the marketing year, or the commodity national loan rate, whichever is higher and (2) the direct payment rate for the commodity. For more information, see: http://www.ers.usda.gov/publications/FDS/JAN05/fds05a01/.

[2] *Average crop revenue election (ACRE):* An optional revenue-based program provision introduced in the 2008 farm legislation that replaces counter-cyclical payments for those producers who elect to participate in ACRE. Once producers elect to participate, participation continues until 2012. Producers continue to receive reduced direct payments and are eligible for reduced loan deficiency payments. For more information, see: http://www.ers.usda.gov/Publications/ERR84/.

performance of the futures model forecasts is assessed, including traditional forecast accuracy measures, such as mean absolute error, mean absolute percentage error and mean squared error. The presence of a significant statistical difference between the futures model price forecasts and WASDE price projections is determined.[3] The implications of increased price volatility upon the futures model price forecasts are examined. Lastly, suggestions are made for ways to counteract the negative effects of price volatility upon price forecasts.

7.2 Review of Literature

The efficient market hypothesis provides a conceptual framework for using futures prices as a tool to forecast cash prices, supported by selected studies testing this hypothesis. The futures price is an unbiased predictor of the cash price for a given delivery location and time period based on the efficient market hypothesis (Fama, 1970, 1991). According to the efficient market hypothesis, expert forecasts should contain no predictive information other than that contained in the futures market "forecast". One common citation is that a necessary, but not sufficient, condition to reject futures market efficiency is that the alternative forecast models produce smaller mean squared forecast errors than futures-based forecasts. Also, if the futures model forecast provides the smallest mean squared error, then one cannot use the alternative forecast to generate trading profits.

A review of pricing efficiency of agricultural futures markets by (Garcia et al., 1988) found mixed evidence regarding whether forecasting models can improve on the forecast performance of futures markets. The overall results of these studies are mixed depending on the markets examined and the alternative forecasting methods. The expectation is that forecasting studies will provide mixed evidence regarding market efficiency and trading profitability. However, whether consistent statistically significant results are found repeatedly for a given forecasting method is the real question.

Kastens and Schroeder (1996) found that Kansas City July wheat futures from 1947 to 1995 outperformed econometric forecasting. Kastens et al. (1998) determined the forecast accuracy of five competing cash price forecasts over the 1987–1996 periods. Commodities examined were major grains, slaughter steers, slaughter hogs, feeder cattle, cull cows and sows. The traditional forecast method of deferred futures plus historical basis had the greatest accuracy. Adding complexity to forecasts, such as including regression models to capture nonlinear bases or biases in futures markets, did not improve accuracy.

Available evidence on individual-generated forecasts is largely consistent with an efficient market (Zulauf and Irwin, 1998). Market efficiency is expected when

[3] Future work will determine whether creating a composite forecast from futures model forecasts and WASDE projections provide improved forecasts compared to those from the futures price model. For example, see Sanders and Manfredo (2005).

investors deal with large stakes, as non-rational traders are eliminated through economics, and arbitrage opportunities can be realised. Such characteristics typify the futures and options markets where entry is easy, trading opportunities exist daily and losses are visible daily (Patel et al., 1991).

Futures prices can be viewed as forecasts for maturity month prices and structural or time-series econometric models have a difficult time to improve on the forecasts provided by futures markets (Tomek, 1997). Although a futures price may be an unbiased forecast, the variance of forecast error may be large, and increases with the forecast horizon. Therefore, accurate price forecasts are a challenge, especially for more distant time periods.

The traditional necessary condition for futures market inefficiency is the existence of alternative forecasting methods that produce mean squared forecast errors smaller than the futures market. Sanders and Manfredo (2005) examine a more exacting requirement for futures market efficiency – forecast encompassing. Using the procedure of Harvey and Newbold (2000), they tested multiple forecast encompassing using Chicago Mercantile Exchange fluid milk futures. Time series models and USDA experts provide competing forecasts. Results suggest milk futures do not encompass the information contained in the USDA forecasts at a two-quarter horizon. While the competing forecasts generate positive revenues, it is unlikely that returns exceed transaction costs in this relatively new market.

7.3 Model Background

Many prior studies using futures prices to forecast cash prices have focused on a given location, a given grade and one time period, such as harvest. Most market participants need to be able to forecast a price for a given location, a given grade and time when they plan to buy or sell a commodity. Thus, they need to predict the basis, which is the difference between the local cash price and the specified futures price. In contrast, government policy and commodity analysts are interested in forecasting a commodity's season-average price, including within-year monthly price patterns. Intra-year price patterns provide information about an expected "normal"[4] or "inverted"[5] market.

[4] Adequate supplies of a commodity usually cause the more distant futures to trade at a higher price than the nearby futures; this is referred to as a normal market. In such a market situation, the amount of the difference, or spread, between the futures months for a stored commodity tells the trader what the market will pay, on a given day, for the costs of carrying the commodity over time storage, interest and insurance. This amount is rarely equal to the full carrying charge, total cost of storage, interest rates and insurance, and it varies among different commodities (Besant, 1985, p. 70).

[5] When supply and demand indicate that a shortage exists, the premium will narrow on the deferred contract months. If a scarcity develops, the carrying charges will disappear or actually "invert". This situation is called an "inverted market" and it reflects negative carrying charges. Scarcity causes high prices in the cash and nearby futures contracts because the market gives priority to the

Although assumptions for the futures forecasting model differ slightly from those of the efficient market hypothesis, it is assumed that these differences would not invalidate the use of this hypothesis. First, the futures model forecast of the monthly US cash price received represents an aggregation of producer sales for that month and can represent spot price sales for different grade levels or sales from forward price contracts and thus could be different from a given location's cash price for No. 2 yellow corn as specified in the futures contract. The futures model uses a futures price for a specific grade of corn, US No. 2 yellow, to predict the monthly cash price received for US corn producers which is then summed into a season-average price received. Secondly, the model does not focus on a given location but on an average for the US. The monthly cash price received represents an average US price received by producers, in contrast to a specific location. A monthly national basis is computed (cash price received less futures price) and it is assumed that the difference in grades will be captured by the basis. Thus, the basis represents an average for the US, not a specific location. Thirdly, the time period is expanded from one period, such as harvest, to the entire marketing year thus requiring five futures contracts instead of one contract.

7.4 Mathematical Representation of Model

The futures forecast model for the US corn season-average farm price (SAP) made in month m for any crop year is computed as follows[6]:

$$\mathrm{SAP}_m = \begin{cases} \sum_{i=1}^{12} W_i\left(F_{i,m} + B_i\right) & \textit{for} \quad m = -3 \quad \textit{to} \quad 1 \\ \sum_{i=1}^{m-1} W_i P_i + \sum_{i=m}^{12} W_i\left(F_{i,m} + B_i\right) & \textit{for} \quad m = 2 \quad \textit{to} \quad 12 \end{cases} \tag{7.1}$$

The forecast of the season-average farm price received made in month m is equal to SAP_m. The marketing weight (percent) for marketing year month i is equal to W_i. The farm price received in marketing year month i is equal to P_i. The observed monthly futures settlement price (day of WASDE release) in month m for the nearby futures contract of month i is equal to $F_{i,m}$. The expected basis, B_i, is equal to farm price received in month i, minus average futures price in month i for the

present and discounts the future. Essentially the market is saying to the contract holder that it will pay a premium for the commodity if it is delivered now (Besant, 1985, p. 71).

[6] The first expression in Eq. (7.1) refers to futures derived forecasts of the season-average price, and the second expression of Eq. (7.1) refers to the composite of actual and futures derived forecasts of the season-average price.

nearby futures contract.[7] This basis is usually a negative number. The crop year has 12 months (i), September through August, $i = 1,2,3,\ldots,12$. The season-average price forecasts are made monthly (m), $m = -3,-2,-1,0,1,2,3,\ldots,12$, May through August (16 months); in September $m = i$. This forecast period follows the WASDE forecast period.

The futures forecasting model consists of several components: futures prices, farm prices received, basis values (farm price received less futures) and marketing weights. The season-average price-received forecast is derived from a summation of weighted forecasts of the producer price received for each month of the marketing year. These monthly forecasts are derived from the futures contracts traded throughout the marketing year. For each marketing year month, the forecast begins with the nearby futures contract price except when the contract expires in that month, in which case the next nearby contract is used. Next, the monthly futures price is adjusted by a basis (derived from a 5-year moving average farm price less a 5-year moving average futures price) to compute the US monthly farm price forecast. These monthly farm price forecasts are then weighted based on monthly marketing weights reported by USDA.

Thus, the forecast of the season-average corn price received is derived from 12 monthly farm price forecasts, which in turn are based on five futures contracts traded throughout the marketing year.[8] The forecast period for each marketing year covers 16 months beginning in May which is 4 months before the start of the marketing year. The forecast period concludes with August, the last month of their marketing year. The forecasts are made monthly to coincide with the release of USDA's WASDE projections.

The season-average forecast is initially based entirely on futures prices, but these prices are replaced with the actual monthly average price received by farmers, as they become available from USDA's National Agricultural Statistics Service (NASS) (Table 7.1 in Appendix). A midmonth farm price received for September, the first month of the marketing year, becomes available in late September.

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[7] The nearby futures price is always used except when the forecast month coincides with the closing month of the nearby futures contract. For this situation, the next nearby futures contract is selected. This procedure is followed because futures prices for the maturing contract may be affected by a decline in liquidity during the month of maturity. Also, a contract usually closes about the third week of the month, and using the current futures contract during its closing month would lower the number of observations that could be used to calculate the average monthly closing price and corresponding basis.

[8] This procedure provides a spot forecast based on the nearby or deferred contract, but the national average monthly price reported by the National Agricultural Statistics Service (NASS) is the price actually received for the crop that was delivered for the given month, which may be more than or less than the simple average of the daily average of prices posted by elevators for spot delivery. For example, July and August 2004 NASS prices were above the average of daily spot prices because farmers were delivering grain at prices that were contracted in the spring when corn prices were higher. Thus, there may be some error introduced by a time lag from when the farmer priced the grain to when it was actually delivered and recorded by NASS. Futures prices are based on "today's" values.

Consequently, the season-average price forecast becomes a composite of futures forecasts and farm prices received beginning with the October forecast, the 6th month of the 16-month forecasting period.

7.4.1 Model Variables and Data Sources

7.4.1.1 Futures Prices

Five futures contracts are used for the model and these contracts close in the months of December, March, May, July and September. The model uses the #2 yellow corn futures contract for corn which is traded with the CME Group, formerly Chicago Board of Trade. Daily futures settlement prices by contract are obtained from the CME Group for corn marketing years 1975 through 2008.

7.4.1.2 Farm Price Received

The monthly price received by US producers is provided by the NASS, US Department of Agriculture. Through sampling, NASS collects sales from producers to first buyers. The price is determined by dividing sales by quantity sold. This price represents all grades and qualities. These prices are reported monthly and also annually. Prices received by producers are obtained from *Agricultural Prices*, published by USDA's National Agricultural Statistics Service (USDA, b).

7.4.1.3 Basis

The basis used in this model is equal to the farm price received less the futures price. The basis is computed as a 5-year moving average of the monthly US price received by producers less a monthly average of the nearby futures closing price observed for the particular month. For example, the September basis for corn is a 5-year moving average of the difference between the September average cash price received by producers and September's average settlement price of the nearby December futures contract. This basis calculation reflects a composite of basis-influencing factors because it represents an average of US conditions, rather than a specific geographic location.[9] Also since the cash price received consists of different quality levels but the futures price is for No. 2 yellow corn, the basis could vary differently (perhaps more) than when computing a basis for a specific grade level. A 5-year moving average of these monthly bases is updated annually.

[9] Several factors affect the basis and help explain why the basis varies from one location to another. Some of these factors include: local supply and demand conditions for the commodity and its substitutes, transportation and handling charges, transportation bottlenecks, availability and costs of storage, drying capacities, grain quality and market expectations.

7.4.1.4 Marketing Weights

The monthly marketing weight by crop is provided by the NASS. Monthly corn marketed, monthly quantity sold expressed as a percent of total marketing year quantity sold, are used to construct a weighted season-average price. The monthly marketing weights are used to compute a price weight for each month. The monthly price weight is equal to the monthly farm price received multiplied by the monthly marketing weight.

A 5-year moving average of these monthly weights is computed and updated annually. These data are collected for marketing years 1975 through 2008. Marketing weights by month for 1975 through 1976 marketing years are published in the 1977 December issue of *Crop Production* (USDA, a). The marketing weights for the remaining marketing years, 1977 through 2008, are published in the various annual summaries of *Agricultural Prices* (USDA, b).

7.4.2 Futures Model Forecast Procedure: An Example

Following the general mathematical representation of the model presented in Eq. (7.1), this section provides an illustration of the detailed steps needed to provide a monthly season-average price forecast. Table 7.2 (in Appendix) illustrates this method used in deriving the December forecast of the season-average US corn price received for crop year 2009–2010, based on futures settlement prices as of December 10, 2009 (the day of WASDE release).

7.4.2.1 Step 1

The futures settlement prices for December 10, 2009, are gathered for the contracts that are trading. Futures prices for the 2009–2010 crop year are from the following contracts: March, May, July, and September 2010 and are inserted in column B of the model's spreadsheet (Table 7.2 in Appendix).

The futures price entered for December 2009, January 2010 and February 2010 (column C) represents the closing price of the nearby March 2010 contract, as of December 10, 2009. The closing price for the May 2010 contract is used for the months of March and April. The closing price for the July 2010 contract is used for the months of May and June and the September 2010 contract is used for the months of July and August. For those months when a futures contract matures, the next nearby contract is used because of greater potential price stability.

7.4.2.2 Step 2

A 5-year (2004/2005–2008/2009 crop years) moving average monthly basis (monthly cash price minus the nearby futures price) is found in column D. This average basis is updated during the first week of October, a time when the full-month August cash price is available and thus completes all monthly cash prices for the prior marketing year.

A forecast of the monthly average farm price received (column E) is computed by adding the typically negative basis (column D) to the monthly futures price (column C).

7.4.2.3 Step 3

The actual monthly average farm prices received are shown in column F, as they become available. The monthly cash prices in column F represent the average price received for September, October, and mid-month November. On December 10, 2009, the actual full-month October and mid-month November cash prices were entered as obtained from *Agricultural Prices* issued on November 30, 2009.

7.4.2.4 Step 4

The actual and forecast farm prices are spliced together in column G. The price forecast for crop year 2009–2010, as computed on December 10, 2009, uses actual cash prices from column F for September through November 2010 and futures forecasts for December 2009 through August 2010 (column E).

Monthly marketing weights, expressed as a percent of total crop year marketings, are found in column H. A 5-year moving crop year average is used, 2004/2005–2008/2009, and is updated in early October after the release of the September *Agricultural Prices* report.

A weighted forecast of the season-average US farm price received is found in column I. This forecast is computed by multiplying the monthly marketing weights in column H by the monthly farm prices in column G and then summing their products.

7.5 Measuring Model Forecast Performance

Forecast performance measures are computed for crop years 1980 through 2005.[10] Tests are conducted for the presence of a significant statistical difference between the futures model price forecasts and an alternative forecast, price projections from USDA's monthly *WASDE* report (1980–2009) (USDA, c).[11,12]

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[10]Future calculations will update these performance measures. However, for the time being it was determined that the present time span would be representative of any differences between the WASDE projections and the futures model forecasts.

[11]Since the futures model deviates from the original assumptions of the efficient market hypothesis, the futures model forecasts will not be used to test for futures market efficiency.

[12]These statistical tests are performed for crop years 1980 through 2005.

Three traditional forecast accuracy measures are used to examine the accuracy of both forecast methods; the mean absolute error (MAE), the mean absolute percentage error (MAPE) and the mean squared error (MSE).

$$\text{Mean absolute error (MAE)} = 1/n \sum_{t=1}^{n} \left|E_t\right| \tag{7.2}$$

$$\text{Mean absolute percentage error (MAPE)} = 1/n \sum_{t=1}^{n} \left|(A_t - F_t)/\, A_t\right| \times 100 \tag{7.3}$$

$$\text{Mean squared error (MSE)} = 1/n \sum_{t=1}^{n} E_t^2 \tag{7.4}$$

The error provides information on a positive or negative deviation from the actual price but the mean error may be small, as the positive and negative errors tend to offset each other. The mean absolute error addresses this problem by taking the absolute value of each error. The absolute percentage error provides still more information than the prior measure because it relates the relative size of the error to the actual price A_t. The mean squared error has the advantage of being easier to handle mathematically and is often used in statistical optimisation and is used in the Modified Diebold–Mariano test statistic, which is explained later.

Monthly futures model forecasts are compared to the monthly WASDE projections in order to compare the performance of the futures model forecasts.[13] Tests are conducted to determine whether forecasts from the futures model generate statistically smaller forecast errors than the WASDE projections. The test statistic used to determine whether differences in the errors from two forecast methods are statistically significant is the Modified Diebold–Mariano test (MDM). This test involves specifying a cost-of-error function, $g(e) = \textit{squared error}$, of the forecast errors e and testing pair-wise the null hypothesis of expected equality of forecast performance. Harvey et al. (1997) argue that critical values from the Student's t distribution with n–1 degrees of freedom should be computed for the two different forecast methods. The test statistic is:

$$\text{MDM} = \left[\frac{n + 1 - 2\,h + n^{-1}h(h-1)}{n}\right]^{1/2} \times \left[n^{-1}\left(\hat{\gamma}_{\text{o}} + 2\sum_{k=1}^{h-1}\hat{\gamma}_k\right)\right]^{-1/2} \overline{d} \tag{7.5}$$

where $\hat{\gamma}_k = n^{-1}n\sum_{t=k+1}(d_t - \overline{d})(d_{t-k} - \overline{d})$ is the estimated kth autocovariance of d_t and $\overline{d}$ is the sample mean of d_t. This statistic is computed for one-step ahead forecasts where $h = 1$ and $d_t = g(e_{1t}) - g(e_{2t})$, $\overline{d}$ is the average difference across all forecasts. The null hypothesis is $E[g(e_{1t}) - g(e_{2t})] = 0$ and the alternative hypothesis is $E[g(e_{1t}) - g(e_{2t})] \neq 0;\ t = 1, \ldots, n$, where n=26. Since $h = 1$, Eq. (7.5) becomes

[13]The futures forecast is determined from the settlement futures prices on the day of the WASDE release. Mid-points of the projected price range from the WASDE report are used.

$$\text{MDM} = (n-1)^{1/2} \times \left[n^{-1} \left(\sum_{t=1}^{n} \left(d_t - \overline{d} \right)^2 \right) \right]^{-1/2} \overline{d} \tag{7.6}$$

Specific definitions for the MDM test applied to the futures model forecasts and WASDE projections are given next. When testing the significant differences of the squared errors of the futures forecasts and the WASDE projections, $g(e_{\text{ftm}}) = e^2{}_{\text{fmt}}$ is the squared error for the futures model forecasts (day of WASDE release) and $g(e_{\text{wtm}}) = e^2{}_{\text{wmt}}$ is the squared error for the WASDE price projections. The corn forecast error for each forecast period (m), May through August, $m = -3$ $-2, -1, 0, 1, 2, 3, \ldots, 12$ is used for each crop year, where t = crop year forecast 1980 through 2005. The difference between the squared errors of the futures model forecast and WASDE projections at time t is $d_{\text{mt}} = e_{\text{fmt}} - e_{\text{wmt}}$. The average difference across these forecasts, crop years 1980–2005, is $\overline{d}_{\text{mt}}$ for each forecast period. The MDM test statistic for the futures model forecasts and WASDE projections is referred to as MDM_{mt} for each forecast period (m) across all crop years (t). The null hypothesis is $E[g(e_{\text{fmt}}) - g(e_{\text{wmt}})] = 0$ and the alternative hypothesis is $E[g(e_{\text{fmt}}) - g(e_{\text{wmt}})] \neq 0$.

7.6 Measure of Price Volatility

Futures price volatility is measured by the absolute value of the daily percentage change in the natural logarithm of closing nearby corn futures prices for corn marketing years, 2000/01 through 2008/09. The absolute daily percentage change is expressed as

$$P = \left| \ln(F_t / F_{t-1}) \right| \times 100 \tag{7.7}$$

where P is the absolute daily percentage change, F_t is the nearby futures price for day t and F_{t-1} is the nearby futures price for day t–1.[14]

Two sub-intervals were selected. One period was chosen to capture a historical period with more price stability, G1 = 2000/01 through 2005/06, and the other period was chosen to capture a perceived volatile period, G2 = 2006/07 through 2008/09. A test for statistical difference between the means of the two time periods was computed using a test for differences between the means (Snedecor and Cochran, 1989). Test statistic T = mean of G1 – mean of G2/square root of (variance of G1/sample size of G1) plus (variance of G2/sample size of G2). The null hypothesis is that mean of G1 – mean of G2 = 0. The alternative hypothesis is that mean of G1 – mean of G2 ≠ 0.

[14] This is a standard measurement of price volatility since its use in the Black–Scholes option pricing model (Black and Sholes, 1973).

7.7 Futures Model Forecast Performance

As expected, the mean absolute error and mean absolute percentage error declined for later months in the annual forecast cycle for both the futures model forecasts and the WASDE projections (Table 7.3 in Appendix) (Hoffman et al., 2007).[15] While the percentage error for each of these accuracy measures differs slightly by forecast period, both reinforce the general findings regarding the size of the error. The general decline in these forecast errors occurs because additional market information becomes available throughout the forecast cycle. First there is the March planting intentions report for each year and there are planting progress reports throughout the planting period, official acreage planted estimates in June, crop condition reports throughout the growing period, estimated yield and production estimates in August, followed by quarterly stock reports, actual cash prices beginning in October, and monthly production estimates through January, with January estimates usually being the closest to final numbers. Since supply is fairly well estimated by January, remaining forecast error would seem to come from changing domestic and export demand scenarios, or changing crop conditions during the new growing season for the new domestic crop.

Information's effect on the forecast error is further illustrated by focusing on the mean absolute percentage error for 1980 through 2005 crop years. For example, this error measure declined by 2 percentage points between the second and third forecast months (June and July) for either forecast method, reflecting, in part, new crop information such as the June acreage report and crop progress and conditions ratings. The MAPE dropped another 2 to 3 percentage points between July and August for either forecast method reflecting, in part, information on the new crop's estimated yield and crop progress. The difference between the August and September is less pronounced.

The difference between the September and October forecasts represents a 1 to 2 percentage point decline in the MAPE for either forecast method. This difference reflects, in part, information from the grain stock report (beginning inventories to start the new crop year), production information on the new crop and an estimate of the mid-month cash price received for September. It should be reiterated that forecasts from May through September rely fully on futures prices for the monthly price forecasts but the October and later forecasts use actual monthly farm prices received as they become available.

The decline in the MAPE begins to slow with October. The percentage error declines by about 1 percentage point per month from October to February, reflecting additional information on demand and additional cash price estimates for each month. Additional information, for monthly exports becomes available from the Census Bureau approximately 2 months after the month observed.

[15] Statistical differences between the means of these two forecast methods will be tested in the next section.

Furthermore, the rate of decline continues to slow between January and July as the average forecast error declines a total of about 3 percentage points for either forecast method over this 6-month period. The January to July period reflects information from additional cash prices, the grain stock reports and additional use information.

Potential sources of error for the futures model forecast are the 5-year average basis value or the 5-year average marketing weights. In some years, the basis is far different than the 5-year average. This is especially true in years of rapidly increasing futures prices or years of rapidly declining futures prices.

A statistical difference was not found between the futures model forecasts and WASDE projections (Table 7.3 in Appendix). The MDM test as found in Eq. (7.6) is used to test the statistical difference in mean squared error from both forecasting methods for each of the 16 monthly forecast periods. The null hypothesis states that the squared errors from either method are equal. Therefore, we must reject the null hypothesis to find statistical differences in the forecasts. The critical values of t are 2.78 and 2.06, respectively, using a 1% or 5% significance level and a t distribution with (n–1) degrees of freedom. The modified Diebold–Mariano test statistics are shown in Table 7.3. Since the MDM test statistics are smaller than the critical t value of 2.06 for the forecast periods, we cannot reject the null hypothesis which states that the difference in forecasts errors of the two forecast methods are equal to zero.

7.8 Implications of Price Volatility

Recently, much attention has been given to increasing price volatility (Fig. 7.1). Volatility is not in and of itself detrimental to the market if prices are reacting to fundamentals, such as increased changing information about production, stocks and use, but volatility is detrimental if prices fluctuate without regard to fundamental

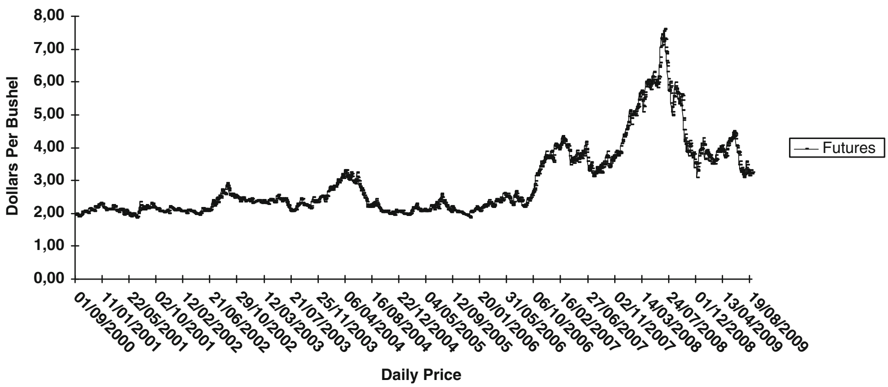

Fig. 7.1 Daily nearby corn futures settlement prices (CME Group), 09/01/2000 to 08/31/2009

factors. High volatility presents resource allocation challenges for policy makers, firms, producers and consumers. Three common explanations of how volatility may be influenced include: (1) information flows that commonly occur on a seasonal basis due to crop conditions or the changing information available as time to maturity decreases in futures contracts, (2) economic variables based on supply and demand conditions and (3) market structure, which refers to the relative positions of speculators and hedgers and the role of traders in futures markets (Streeter and Tomek, 1992). Regardless of which factor is causing the volatility, a measurement of this price volatility is provided for the past 9 corn crop years, 2000–2001 through 2008–2009 (Fig. 7.2).

Two periods were selected: one period to represent price stability, 2000–2001 through 2005–2006, and one period to represent price volatility 2006–2007 through 2008–2009. The average level of volatility increased between these two time periods and the means between the two time periods were found to be statistically significant (Table 7.4 in Appendix).[16] Average annual volatility (daily percentage change) during more stable years, 2000–2001 through 2005–2006 ranged from 0.9 to 1.3% with an average of 1.1%, in comparison to an annual average of 1.8% during the latter 3 year period.

A comparison of the mean absolute error and mean absolute percentage error for the futures model forecasts from the 2000–2001 to 2005–2006 period to the 2005–2006 to 2008–2009 period revealed an increase in the average error due, in part, to increased volatility (Table 7.5 in Appendix). It is interesting to note that there is a large increase in forecast error for the months that typically have a larger forecast

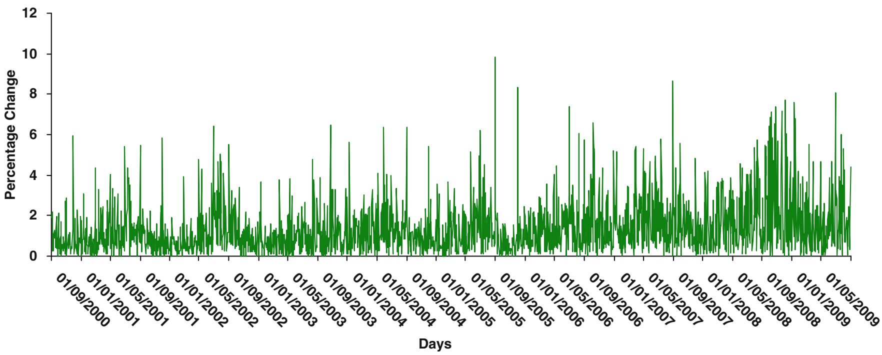

Fig. 7.2 Absolute daily natural logarithm (percentage change) in the nearby corn futures settlement prices, 09/01/2000–08/31/2009

[16] An Informa Economics (2008) study and a study by Aulerich et al. (2009) found increased volatility for grains and soybeans during their study periods of recent years. The Informa Economics study found no persuasive evidence that index traders or money managers caused increased volatility as some have alleged.

error, May through January, and so this increase in forecast error is likely to be important to both forecasters and forecast users.

An example of the impact of price volatility's effect on the futures model forecasts can be seen by comparing Fig. 7.3, forecasts from crop year 2004–2005 representative of stable prices, to forecasts from crop years representative of volatile prices, 2006–2007, 2007–2008 and 2008–2009, Figs. 7.4, 7.5 and 7.6. In 2004–2005, a period of less volatility, the season average price forecast was well-established for either forecast method by September with declining errors for the remainder of the forecast period from October through August.

The volatility that occurred during the latter three crop years had impacts on the pricing models. For example, during the 2006–2007 crop year futures forecasts ranged from \$2 per bushel during the first half of the forecast period to generally the \$3 per bushel range during the second half of the forecast period (Fig. 7.4). Futures model forecasts tended to remain above the actual season-average price of \$3.04 per bushel and WASDE projections, beginning in October because the average 5-year basis did not include the large increase in basis that was being experienced later in the 2006–2007 crop year.

In the 2007–2008 crop year, futures forecasts were generally in the \$3 per bushel range during the first half of the forecast period but generally increased to the \$4 range in the later half of the forecast period (Fig. 7.5). Again the futures model forecasts tended to remain above the actual season-average price of \$4.20 per bushel and WASDE projections from January through August, because the average 5-year basis did not include the large increase in basis that was being experienced later in the 2007–2008 crop year.

In crop year 2008–2009, futures forecasts went from \$5 to \$7 during the early part of the forecast period to the \$3–4 range in the later part of the forecast period (Fig. 7.6). Again the futures model forecasts tended to remain above the actual season-average price of \$4.06 per bushel and WASDE projections for the early part of the forecasting period, but once the 5-year-average basis was changed in October, futures model forecasts were below or nearly equal to WASDE projections.[17]

Forecasting accuracy appeared to improve for both forecasting methods during the later part of the 2008–2009 crop year because of a more stable price environment. Such price volatility appears to warrant a more time sensitive basis calculation instead of the 5-year average. During this period of price volatility the basis tended to widen significantly more than during the earlier more stable period, 2000–2001 to 2005–2006.[18]

[17] The 5-year-average basis included two of the volatile basis years of 2006–2007 and 2007–2008.

[18] During the recent period of price volatility, some grain elevators have created new forward contracts that pass the futures margin and transportation costs to the producer, resulting in a quoted basis that may be adjusted downwards depending upon circumstances.

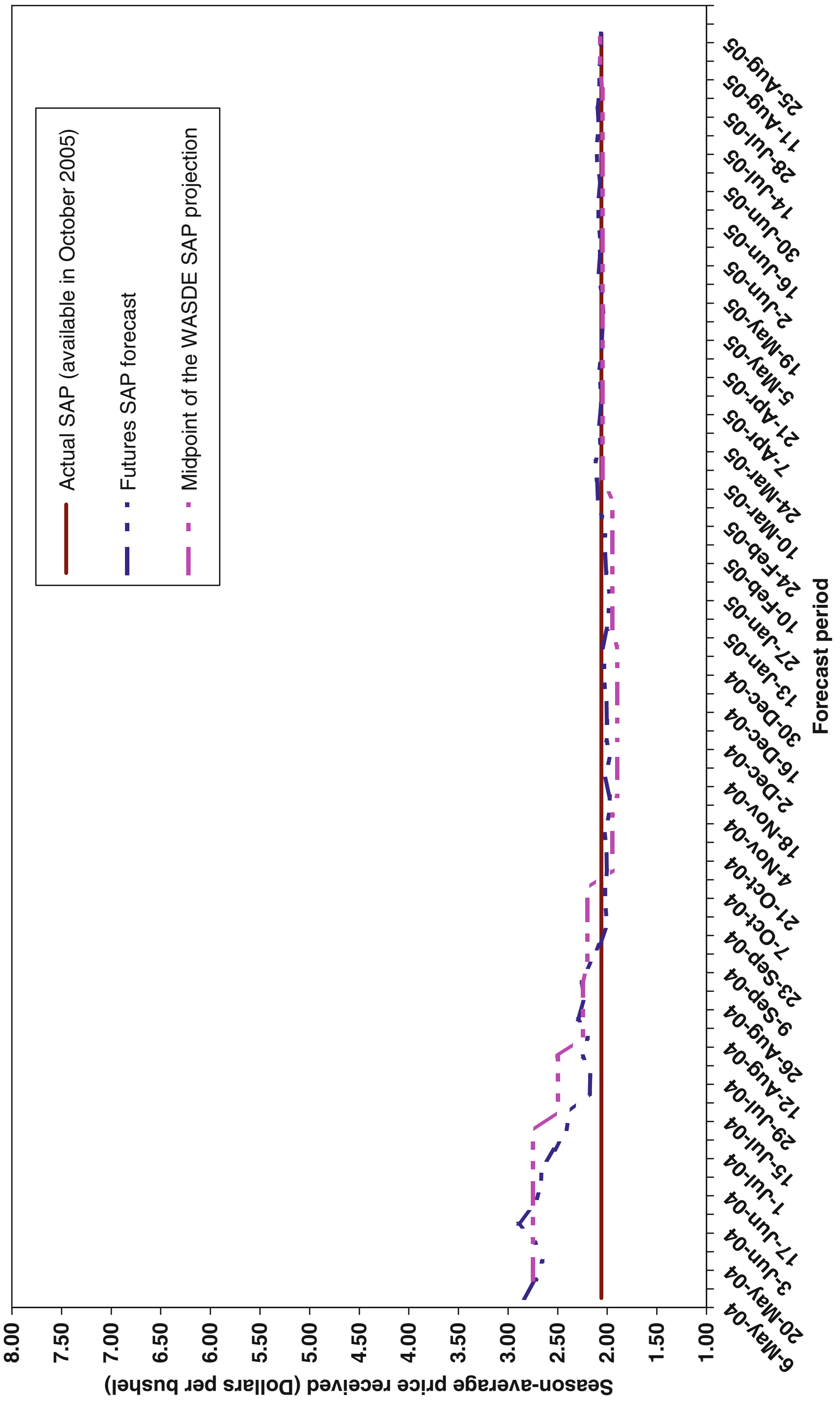

Fig. 7.3 Futures forecast of US corn producers' season-average price received (SAP), marketing year 2004–2005

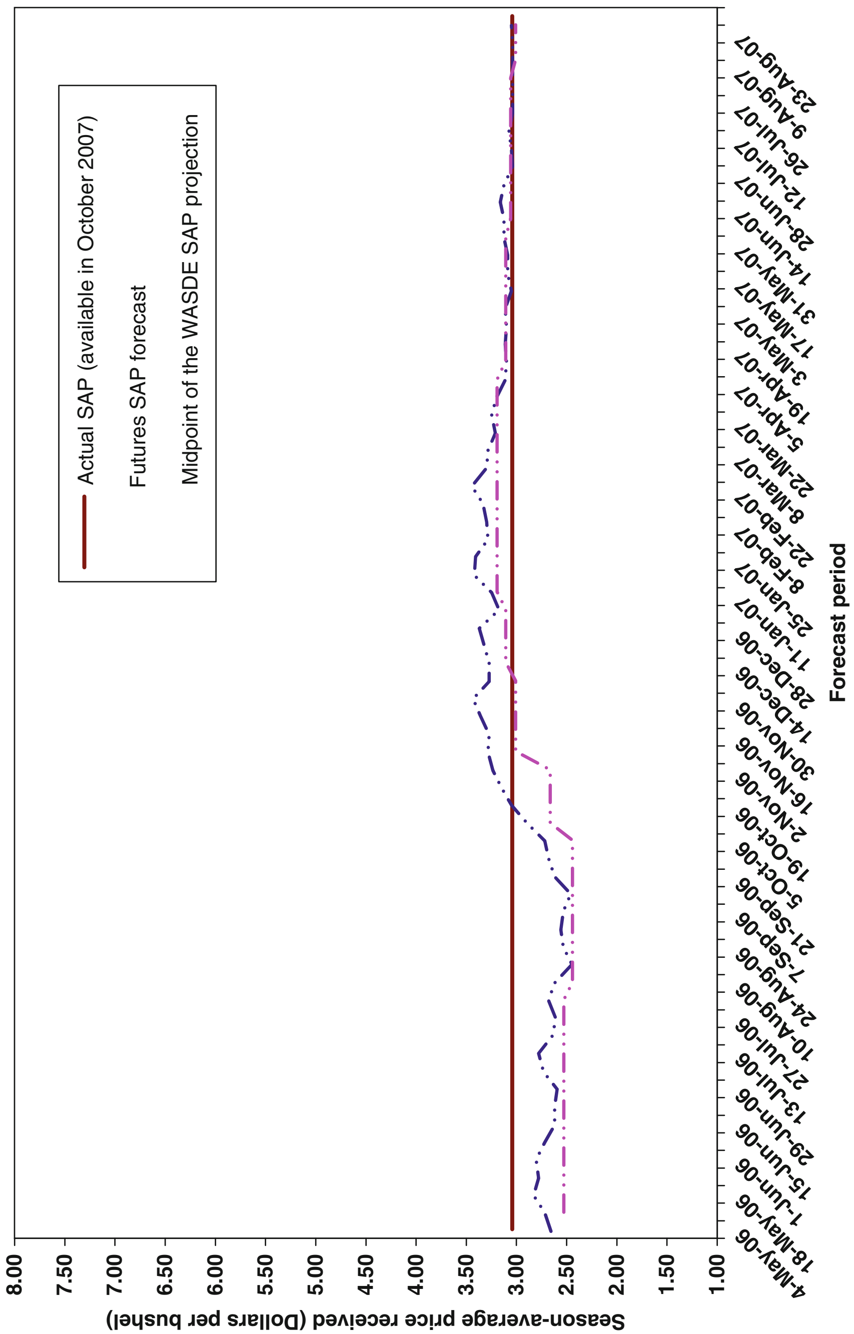

Fig. 7.4 Futures forecast of US corn producers' season-average price received (SAP), marketing year 2006–2007

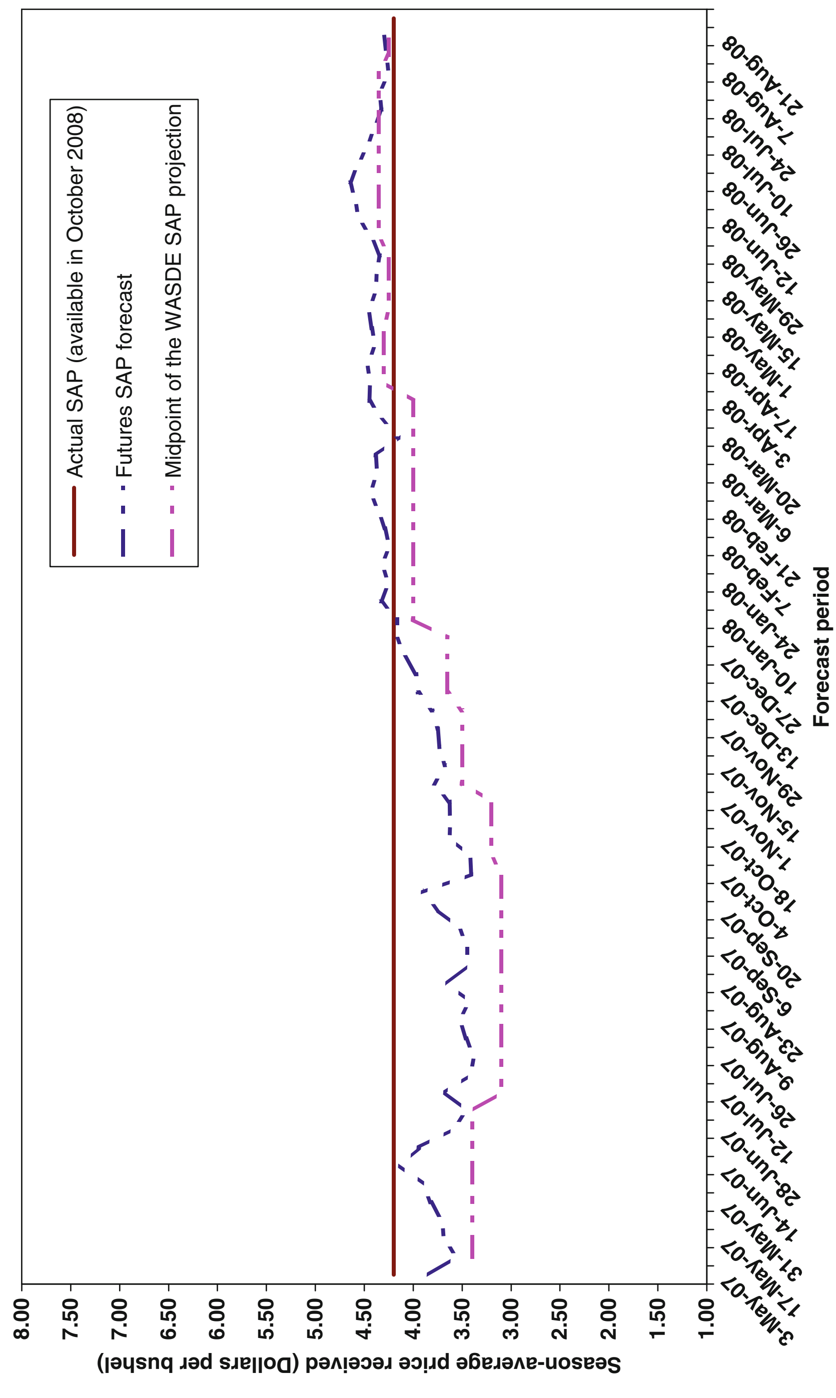

Fig. 7.5 Futures forecast of US corn producers' season-average price received (SAP), marketing year 2007–2008

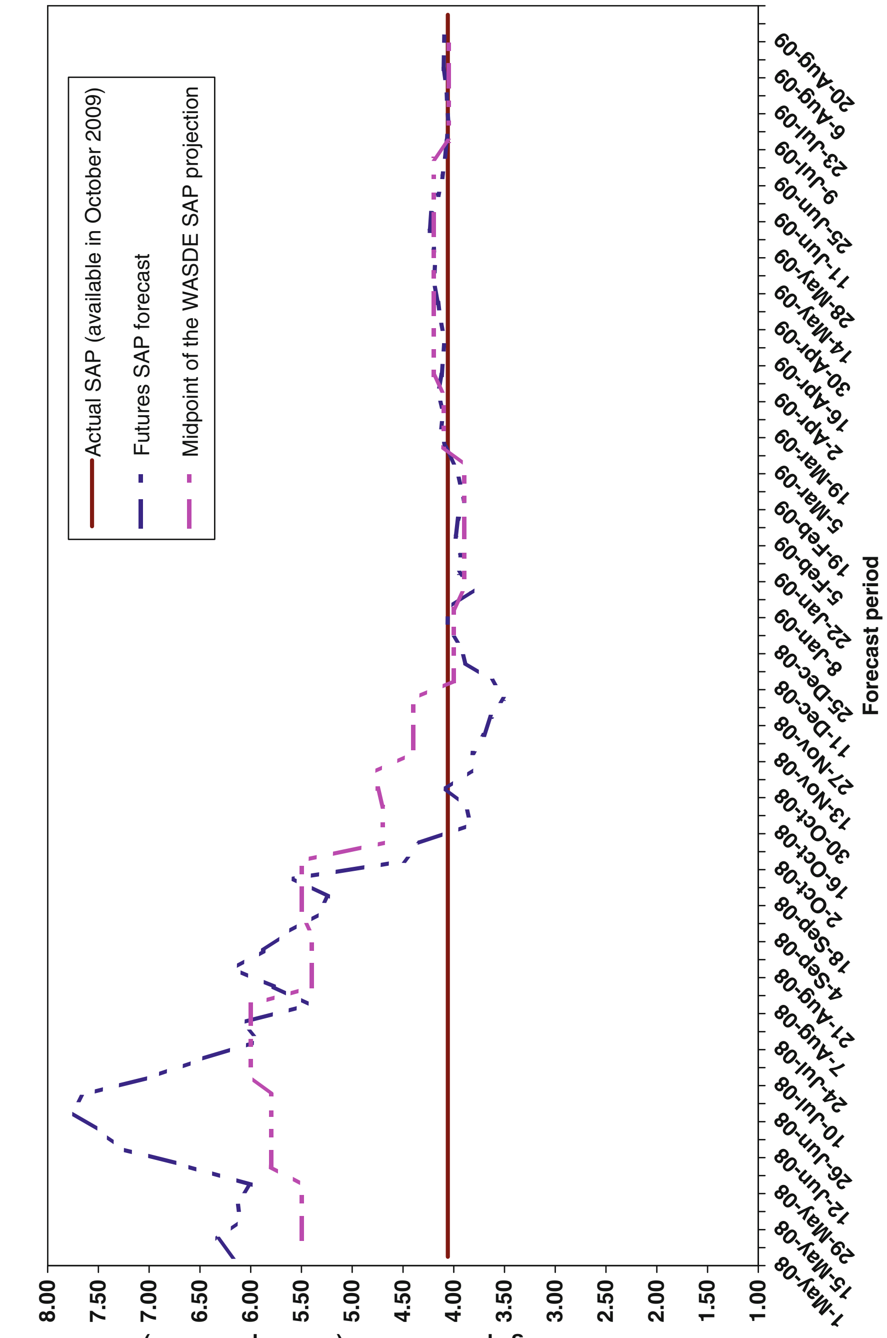

Fig. 7.6 Futures forecast of US corn producers' season-average price received (SAP), marketing year 2008–2009

7.9 Suggestions for Improving Price Forecasts During Periods of Increased Price Volatility

Forecasting during periods of increased price volatility requires one to incorporate additional information known by market analysts. For example, experiences with large volatility have been limited but the 1995–1996 price spike provides some information. The futures forecast model erred on the high side of the forecast during that price rise. Thus, for a year such as 2007–2008, a year of rapidly rising prices, perhaps it would be constructive to use basis levels that reflect a larger basis than the 5-year average. During the 2007–2008 crop year, basis levels were much wider than the 5-year average. Thus, selecting the basis from the earlier year, 2006–2007, which also had basis levels larger than the 5-year average might be a preferable basis selection. Since this period of price volatility was fairly shortlived, no permanent changes to the futures forecast model were made. However, this kind of adjustment can be made by the individual forecaster.[19]

Some potential suggestions for forecasting during periods of price volatility follow:

1. Examine alternative basis forecasting methods, one potential source of error for the model.
   - Are we in short (excess) crop forecasting period?
   - Are there periods in which prices rapidly increase or decrease?
   - What prior periods exhibited these characteristics?
   - Explore potential of using past basis levels for current forecasting periods.
   - Explore "Olympic average" based-5-year average, deleting high and low and change monthly basis levels based on the past months' observed difference between the actual basis and Olympic average.
2. How well is the forecast of the marketing weight doing? This variable can cause some error but usually not as much as the basis. Perhaps a better forecasting method can be derived for this variable other than a 5-year average.
3. Examine alternative forecasts of monthly cash price received. Regress average monthly cash price received on monthly average of daily nearby futures.

7.10 Conclusion

Commodity price forecasting requires in-depth knowledge of the commodity market and the tools capable of facilitating the forecast. Forecasting models can be complex or simple but need to be evaluated periodically. One also needs to be cognizant of the

[19]See http://www.ers.usda.gov/Data/PriceForecast/Data/Futmodcorn.xls change forecast tab on the spreadsheet.

resources available and required to maintain forecasting models. Forecasting models at USDA range from different econometric models to the futures forecast model. Some econometric models can be and are used for simulation or policy analysis. Opportunities for such analyses with the futures model are limited.

The futures forecast model provides timely forecasts of the season-average price received by US corn producers. The futures model forecast error declines throughout the monthly forecast cycle within a crop year as more information becomes available. The futures model forecast error is similar to the alternative forecast, WASDE projections. No statistical difference was found between the futures model forecasts and WASDE projections. Errors found in the futures model forecasts could possibly be reduced with more accurate forecasts of the basis or marketing weights. Futures forecasts were derived from a 5-year moving average of both the basis and marketing weights.

Price volatility was found to be much greater during the past 3 crop years, 2006–2007 to 2008–2009, compared to the prior more stable crop years, 2000–2001 to 2005–2006. This volatility provided new challenges for the futures price forecasting model. The basis tends to rise during periods of rapidly rising prices due to increased risk and uncertainty of larger margin payments for hedgers. Therefore, in periods of rising prices the futures forecast model tends to overestimate the season-average price because it uses a 5-year average basis. Incorporating a current basis during periods of rapidly rising prices, one that is wider than a 5-year average may provide more accurate forecasts.

Many markets appear to be in a period of structural change due, in part, to biofuels. This change may affect our forecasting models for some time. Consequently, our forecasts will face continuing challenges.

Appendix: Tables 7.1 to 7.5

Table 7.1 Futures model's forecast periods and derivation of monthly and season-average price forecast

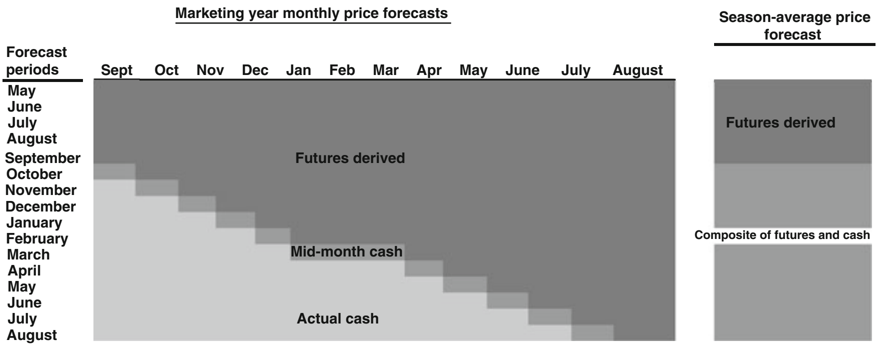

Table 7.2 Futures model forecast of US corn procedures' season-average price received, marketing year 2009/2010. Date of futures forecast: December 10, 2009

	Step # 1		Step # 2		Step # 3	Step # 4		
(Col. A) Marketing year month	(Col. B) Current futures price by trading contract	(Col. C) Futures price based on nearby contract	(Col. D) Basis (5-year US average)	(Col. E) Monthly farm price forecast	(Col. F) Actual monthly farm price, if available	(Col. G.) Composite monthly forecast actual/futures	(Col. H) Monthly marketing weights (5-year US average)	(Col. I) Monthly price weight
	——Dollars per bushel——						Percent	Dollars per bushel
September		3.77	−0.24	3.53	3.25	3.25	6.9	0.224
October		3.77	−0.13	3.64	3.61	3.61	12.2	0.439
November		3.77	−0.13	3.64	3.64	3.64	11.6	0.424
December	3.77	3.93	−0.22	3.71	0.00	3.71	8.4	0.312
January		3.93	−0.27	3.66	0.00	3.66	14.5	0.530
February		3.93	−0.26	3.66	0.00	3.66	7.2	0.265
March	3.93	4.04	−0.36	3.68	0.00	3.68	7.7	0.285
April		4.04	−0.27	3.76	0.00	3.76	5.8	0.217
May	4.04	4.13	−0.34	3.79	0.00	3.79	6.1	0.233
June		4.13	−0.47	3.67	0.00	3.67	6.8	0.251
July	4.13	4.19	−0.30	3.89	0.00	3.89	6.8	0.265
August		4.19	−0.13	4.07	0.00	4.07	5.9	0.238
September	4.19					Sum of weights =	100.0	
Forecast of season-average price received:								
Step #5 Futures model forecast of the season-average price received (weighted average ($/bu.) =								3.689

Table 7.3 Comparison of error statistics for the futures model forecast and WASDE projections of the season-average price received for US corn, crop years 1980 through 2005

Forecast periods	Mean absolute error		Mean absolute percentage error		Statistical difference between means of forecast methods[a]
	Forecast methods		Forecast methods		
	Futures	WASDE	Futures	WASDE	Modified Diebold–Mariano Test
	Dollars per bushel		Percent		Test statistic
May	0.33	0.32	15	14	0.69
June	0.32	0.31	14	13	0.54
July	0.28	0.27	12	11	1.16
August	0.21	0.21	9	9	0.47
September	0.19	0.19	8	8	0.21
October	0.15	0.17	6	7	−0.31
November	0.11	0.15	5	6	−1.27
December	0.10	0.12	4	5	−1.44
January	0.09	0.09	4	4	−0.45
February	0.07	0.08	3	3	−0.59
March	0.08	0.06	3	3	0.51
April	0.06	0.06	3	2	0.36
May	0.06	0.05	3	2	0.61
June	0.04	0.04	2	2	−0.38
July	0.03	0.03	1	1	0.15
August	0.02	0.02	1	1	−0.40

[a]The monthly differences between forecasts from each method are not statistically different from each other based on Modified Diebold–Marion (MDM) test. Reject null hypothesis at the 5% (critical $t = 2.06$) significance level.

Table 7.4 Average absolute daily price volatility for the nearby corn futures contract by crop year

	Average absolute price change/crop year	Average absolute price change/specified crop years	Statistical test for means comparison	
Crop year	Percent	Percent	*t*-test	*P*-value[a]
2000/2001	1.10		−24.62	0.00
2001/2002	1.01			
2002/2003	0.90			
2003/2004	1.28			
2004/2005	1.21			
2005/2006	1.20	1.12 (2000/2001–2005/2006 crop year average)		
2006/2007	1.74			
2007/2008	1.66			
2008/2009	2.05	1.82 (2006/2007–2008/2009 crop year average)		

[a]The average absolute price change increased from 2000/2001–2005/2006 vs. 2006/2007–2008/2009, and the means are statistically different from each other at the 0% level.
Source: CME Group, http://www.cmegroup.com/market-data/datamine-historical-data/datamine.html

Table 7.5 Comparison of average error statistics for the futures model forecast, crop years 2000/2001–2005/2005 vs 2006/2007–2008/09

	Mean absolute error		Mean absolute percentage error	
	Average of 2000/2001–2005/2006	Average of 2006/2007–2008/2009	Average of 2000/2001–2005/2006	Average of 2006/2007–2008/2009
Forecast months	Dollars per bushel		Percent	
May	0.32	0.94	16	24
June	0.30	1.22	15	31
July	0.26	1.05	12	26
August	0.19	1.02	9	27
September	0.16	0.83	7	22
October	0.11	0.39	5	10
November	0.09	0.35	4	9
December	0.07	0.31	3	8
January	0.05	0.25	2	7
February	0.05	0.17	2	5
March	0.06	0.16	3	5
April	0.07	0.14	3	4
May	0.04	0.12	2	3
June	0.03	0.22	1	6
July	0.04	0.09	2	2
August	0.02	0.04	1	1

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Chapter 8
Approaches to Assess Higher Dimensional Price Volatility Co-movements

Jochen Schmitz and Oliver von Ledebur

Abstract In this chapter two different multivariate GARCH models are used to analyse how volatility changes over time and markets. Multiple time series properties for agricultural commodities futures are analysed and non-linearity in the variance of each series is taken into account. Both implemented models are discussed in light of viability of estimation of higher dimensional time series systems. We identified patterns in volatility transmission that are of particular importance for volatility analysis and for market participants.

8.1 Introduction

Modelling and forecasting volatility has been a major research area for years. Progressive integration of markets has generated interest to analyse the transmission of price shocks across markets. The idea that volatility in one market spills over to another market is not new. The transmission of volatility across financial markets in particular has been extensively examined. Among others, Hamao et al. (1990), Kroner and Ng (1998), Bekaert and Harvey (1995) and Bollerslev et al. (1988) dedicated effort in that research area. Transmission of volatility between different energy markets is also becoming a focal area of interest. Recent contributions are Ewing et al. (2002), Sadorsky (2006) and Agnolucci (2009). Research on the agricultural sector has focused so far on univariate models, e.g. Crain and Lee (1996), Goodwin and Schnepf (2000). The question emerges as to how markets in the agricultural sector are linked to each other. For market participants it is increasingly important to understand the underlying mechanisms. Likewise it is important for producers and traders in order to improve their portfolio allocation decision and for governments to act in a more coherent way to minimise the negative impact of rapid food and feed price changes on vulnerable population groups.

J. Schmitz (✉)
Johann Heinrich von Thünen Institute (vTI), Braunschweig, Germany
e-mail: jochen.schmitz@vti.bund.de

O. von Ledebur
Johann Heinrich von Thünen Institute (vTI), Braunschweig, Germany
e-mail: oliver.ledebur@vti.bund.de

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Here we focus on two methods to assess price volatility co-movements. Price and return behaviour of different agricultural commodities are investigated. Further differentiation will be made between the "long-run" and "short-run" price behaviour. It will be shown that (price) information in the short-run is swapped for a long-run perspective. This has implications for the partition of markets. Results show that contrary to the long-run perspective, in the short-run markets are not always linked together and as a consequence an independent pricing of the same agricultural commodity on different markets can evolve. Additionally, this chapter shows how different concepts to model volatility co-movement can be used to incorporate a large number of time series. Two model settings are implemented to study possible spillover effects. The main difference between these models is the number of time series taken into account. While the first model allows for a very flexible modelling of the variance, it permits only a small number of time series to be regarded for. Larger systems of time series can be represented by the second modelling approach. Contrary to the flexibility of the first approach, this set-up allows a restricted volatility co-movement modelling via the correlation coefficients. Both models are discussed in detail in the next section. Section 8.3 presents the main results of the implementation of the modelling approaches and discusses the implications. The last section concludes and gives an outlook of a possible future research agenda.

8.2 Methods and Models

Multivariate extensions to univariate volatility models became a promising research field in the mid-1990s. Often the term "stochastic volatility" is used for different sets of volatility models with different scopes. A precise differentiation between time discrete models and time continuous models is needed. Applications of these models range from describing volatility, calculating hedge ratios to pricing options. Having these applications in mind it will become clear how and why models describe volatility in different ways. A brief introduction of the most well-known multivariate stochastic volatility concepts will follow.

The first multivariate approach was the VEC model (Bollerslev et al., 1992). The successor and more widely applied model was the BEKK model (Engle and Kroner, 1995). Here a quadratic form setup was used to model the time varying conditional variances and covariances. Due to this approach, a huge flexibility is archived. Direct volatility links among time series can theoretically be easily modelled. A second different modelling approach led to the Constant Conditional Correlation (CCC) model (Bollerslev, 1990). In this case a correlation matrix of the time series of interest is estimated to combine (univariate) GARCH models. The central assumption of this model is a time-invariant correlation matrix. The Dynamic Conditional Correlation (DCC) model proposed by Engle (2002) eases this restriction and allows for time varying correlations. So far these models focus on the description of volatility.

The idea that co-movements in returns are driven by common underlying variables, which are called factors, has been put forward by Robert Engle and Tim

Bollerslev in two papers (Engle et al., 1990; Bollerslev and Engle, 1993). Hence, the name "factor models". Leverage effects are taken into account by the Asymmetric Dynamic Covariance (ADC) model (Kroner and Ng, 1998). Also, in the univariate case of the EGARCH (Nelson, 1991) or the GJR-model proposed by Glosten et al. (1993) where the sign of the innovations plays a central role. So, negative innovations lead to a higher volatility than positive innovations of the same magnitude. Finally, one alternative approach to analyse volatility on a multivariate framework should be mentioned here. The stochastic volatility model of Harvey et al. (1994) specifies the conditional variance as dependent on some unobserved stochastic process rather than on past observations. It should be mentioned that this model is a complete time discrete model.

Time continuous stochastic volatility models (as in Heston, 1993), have the same intention, to describe time variant volatility, but the purpose differs. These models are used for pricing options.

Here the BEKK and the CCC models are the most important to mention. These models are widely used in empirical modelling of volatility transmission, see Ewing et al. (2002) or Bekaert and Harvey (1995). A complete description of all possible multivariate GARCH models is beyond the scope of this text. For an extensive survey of multivariate GARCH models, see Bauwens et al. (2006).

One further issue should be described before the two models are discussed in more detail. Their specification assumes a normal distribution for the innovation process. This specification is contrary to the empirical findings. Financial market returns show a clear non-normal behaviour. Stylised facts of returns clearly show an excess kurtosis and fat tails (Taylor, 2005, pp. 51–95). Due to this discrepancy between theoretical model setup and empirical finding, one might question the appropriateness of the normal distribution assumption. One may furthermore conclude that a better distribution, with more probability mass in the tails, e.g. *t*-distribution, might lead to an improvement in modelling financial data. Lunde and Hansen (2005) tried to clarify this issue. They estimate 350 different GARCH specifications including different distribution assumptions. A detailed in-sample and out-of-sample comparison showed that the standard GARCH(1,1) model with normal distribution is to be favoured. It is worth remembering that the choice of a seemingly more appropriate distribution is of much less importance than the choice of an adequate set of model assumptions (and restrictions) that allows for its empirical implementation. Keeping this in mind a standard normal distribution assumption is also used here.

8.2.1 BEKK Model

With the approach of Engle (1982), it is possible to model the (unobserved) second moment that means the variance. The resulting variance is dependent on the amount of currently available information. This type of model can be characterised with two central expressions. The first one is Eq. (8.1) that describes the mean equation, depicting the first moment of the process. In this specification only a long-term trend component μ is assumed.[1] Price returns are used for estimation. Those returns are best characterised by a long-term trend component:

$$r_t = \mu + \varepsilon_t \tag{8.1}$$

where the error term is

$$\varepsilon_t = \sqrt{h_t} z_t \tag{8.2}$$

with

$$\varepsilon_t | I_{t-1} \sim N(0,h) \tag{8.3}$$

The second central equation describes the variance equation. It serves as the second moment of the process (Eq. (8.4)). In an ARCH(p) process this is the total p delayed information. The known information I_{t-1} set is generated from the returns up to the time point t–1. The returns are calculated as $r_t = \log(F_t/F_{t-1})$, while F_t is the futures price at time t, and r_t corresponds to the returns at time t.

The resulting variance of r_t yields the generalisation of the model by Bollerslev (1986). It permits the inclusion of past variances in addition to the consideration of past innovations. This leads to the general univariate GARCH(p,q) model:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_p \varepsilon_{t-p}^2 + \beta_1 h_{t-1} + \cdots + \beta_q h_{t-q} \tag{8.4}$$

The transfer into a multivariate GARCH model takes place with a generalisation of the resulting variance matrix H_t.

$$H_t = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix} \tag{8.5}$$

Each element of H_t depends on p delayed values of the squared ε_t, the cross product of ε_t and on q delayed values of the elements from H_t. We do not make use of the possibility to draw exogenous factors into the resulting variance equation. In general, a multivariate GARCH(1,1) model without exogenous factors can be presented as follows (Eq. (8.6)) as a diagonal BEKK model (Engle and Kroner, 1995). For reasons of clarity time indicators are not included in the presentation. A model with the time delay of only one lag (t–1) was modelled.

$$H_t = C_0' C_0 + \cdots$$

[1] This way of modelling is chosen as a standard approach. For a discussion and analysis of the variability of trends of prices and volatility, see Gilbert (2006) and Gilbert and Morgan (2010).

$$\cdots + \begin{pmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{pmatrix} \begin{pmatrix} \varepsilon_1^2 & \varepsilon_1\varepsilon_2 & \varepsilon_1\varepsilon_3 \\ \varepsilon_2\varepsilon_1 & \varepsilon_2^2 & \varepsilon_2\varepsilon_3 \\ \varepsilon_3\varepsilon_1 & \varepsilon_3\varepsilon_2 & \varepsilon_3^2 \end{pmatrix} \begin{pmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{pmatrix} + \cdots$$

$$\cdots + \begin{pmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{pmatrix} \begin{pmatrix} h_1^2 & h_1h_2 & h_1h_3 \\ h_2h_1 & h_2^2 & h_2h_3 \\ h_3h_1 & h_3h_2 & h_3^2 \end{pmatrix} \begin{pmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{pmatrix}' \tag{8.6}$$

Through the model construction via the quadratic form it is possible to positively define the resulting variance–covariance matrix H_t. This ensures that all variances and covariances are always positive. In compact form, the above equation can also be written as Eq. (8.7):

$$H_t = C_0' C_0 + A' \varepsilon_{t-1} \varepsilon'_{t-1} A + B' H_{t-1} B \tag{8.7}$$

The matrices A, C_0 and B possess the dimension $(n \times n)$. C_0 is a (lower) triangular matrix. In the model assumed here, we are dealing with the matrices A and B as diagonal matrices. A generalisation of the model, by assuming A and B as full matrices, is possible. All possible interactions are then implemented. The result is a much more complex matrix H_t as in the diagonal BEKK model.

Apart from the achievement of a positive definite matrix H_t there is another advantage of the BEKK specification. Due to the diagonal BEKK model assumed here, a checking of the stationary nature of the process is determined solely through the diagonal elements of matrices A and B. The diagonal BEKK model is stationary if $\sum (a_{ii,k}^2 + b_{ii,k}^2) < 1 \; \forall i$ (Engle and Kroner, 1995, p. 133). Due to this type of model setup, only small scale systems can be estimated. Therefore, we are focusing our analysis on only three time series. Furthermore, as described above, only a single period time lag was included. The resulting variance and covariance equations are as follows:

$$h_{11} = c_{01} + a_{11}^2 \varepsilon_1^2 + b_{11}^2 h_1^2 \tag{8.8}$$

$$h_{21} = c_{02} + a_{11} a_{22} \varepsilon_2 \varepsilon_1 + b_{11} b_{22} h_{21} \tag{8.9}$$

$$h_{31} = c_{03} + a_{11} a_{33} \varepsilon_3 \varepsilon_1 + b_{11} b_{33} h_{31} \tag{8.10}$$

$$h_{22} = c_{04} + a_{22}^2 \varepsilon_2^2 + b_{22}^2 h_2^2 \tag{8.11}$$

$$h_{32} = c_{05} + a_{22} a_{33} \varepsilon_3 \varepsilon_2 + b_{22} b_{33} h_{32} \tag{8.12}$$

$$h_{33} = c_{06} + a_{33}^2 \varepsilon_3^2 + b_{33}^2 h_3^2 \tag{8.13}$$

Thus no distinction is made between h_{21}/h_{12}, h_{31}/h_{13} or h_{32}/h_{23}. The empirically estimated BEKK-GARCH model is thus based on a multivariate version of Eq. (8.4) and Eqs. (8.8), (8.9), (8.10), (8.11), (8.12), and (8.13) (derived from Eq. (8.6)).

8.2.2 CCC Model

The core modelling issue in a multivariate GARCH model is how to build the conditional variance–covariance matrix H_t. A relatively flexible approach is the CCC model by Bollerslev (1990). It allows for a combination of univariate GARCH models. In this model class the conditional correlations are constant and thus the conditional covariances are proportional to the product of the corresponding conditional standard deviations. This restriction strongly reduces the number of unknown parameters and thus simplifies the estimation.

Let r_t denote the $N \times 1$ time series vector (e.g. returns) (Eq. 8.14) with time varying conditional covariance matrix H_t (Eq. 8.15). The CCC model is defined as:

$$r_t = \mu + \varepsilon_t \tag{8.14}$$

with $\mathrm{Var}\,(\varepsilon_t|I_{t-1}) = H_t$

$$H_t = D_t R D_t = \rho_{ij}\sqrt{h_{iit}h_{jjt}} \tag{8.15}$$

where

$$D_t = \mathrm{diag}(h_{11t}^{1/2} \cdots h_{NNt}^{1/2}) \tag{8.16}$$

h_{iit} can be defined as any univariate GARCH model, and

$$R = (\rho_{ij}) \tag{8.17}$$

is a symmetric positive definite matrix with $\rho_{ii} = 1, \forall i$. R is a matrix containing the constant conditional correlations ρ_{ij}. The univariate GARCH(1,1) specification used here for each conditional variance in D_t is:

$$h_{iit} = \omega_i + \alpha_{1i}\varepsilon_{i,t-1}^2 + \beta_{1i}h_{ii,t-1},\, i = 1, \ldots, N \tag{8.18}$$

As in the BEKK model the innovations are normally distributed. Due to this standard (univariate) assumption set the usual restrictions for a stationary process and a positive definite variance ($\omega_i > 0,\ \alpha_{1i} \geq 0,\ \beta_{1i} \geq 0,\ \sum \alpha_{1i} + \beta_{1i} < 1\ \forall i$) apply.[2]

Due to their non-linear specification, the unconditional covariances are difficult to calculate (Bauwens et al., 2006, p. 89). To ensure that all (conditional) variances are positive, the variance-covariance matrix H_t must be positive definite. The conditions for this are easy to impose and to verify. The matrix H_t is positive definite if all N conditional variances are positive and the correlation matrix R must be positive definite (Bollerslev, 1990, p. 499).[3] To ensure stationary of the covariances only one

[2] These restrictions are the same as in the univariate GARCH model, see Bollerslev (1986).

[3] See footnote 2 for the restrictions of the variances to be positive.

restriction needs to be fulfilled. The sum of the parameters α_{1i} and β_{1i} needs to be smaller than one for all i.

We can now go on to the core building block, the conditional variance–covariance matrix H_t. From Eq. (8.2) it is clear that the covariance equation h_{iit} is the product of the conditional standard deviations multiplied by the corresponding correlation coefficient ρ_{ij}. So the resulting matrix H_t is

$$H_t = \begin{pmatrix} h_{11t} & h_{12t} & h_{13t} \\ h_{21t} & h_{22t} & h_{23t} \\ h_{31t} & h_{32t} & h_{33t} \end{pmatrix} \dots$$

$$\dots = \begin{pmatrix} h_{11t} & \rho_{12}\sqrt{h_{11t}h_{22t}} & \rho_{13}\sqrt{h_{11t}h_{33t}} \\ \rho_{21}\sqrt{h_{22t}h_{11t}} & h_{22t} & \rho_{23}\sqrt{h_{22t}h_{33t}} \\ \rho_{31}\sqrt{h_{33t}h_{11t}} & \rho_{32}\sqrt{h_{33t}h_{22t}} & h_{33t} \end{pmatrix} \tag{8.19}$$

As one can see, the conditional covariances are mainly driven by the conditional variances h_{ii}. The mechanism of linking two or more time series together is easy and straightforward. The conditional correlation matrix R is used to link the markets and build the conditional covariances. By construction the correlation between market A and market B is the same as market B and market A. A clear identification of the direction of volatility transmission is therefore not possible. So this approach allows one to identify if, and to what extent, volatility transmission is apparent.

To summarise the advantages and disadvantages of both models, the BEKK model is a modification of the VEC specification. Due to the quadratic form setup, it nested all positive definite diagonal VEC specifications. A more detailed depiction of interactions between markets can theoretically be achieved. This flexibility nevertheless has its price. A great number of parameters must be estimated, which makes it more complicated to achieve convergence for the mathematical solution. Even the less flexible diagonal BEKK approach is, in its empirical implementation, only suitable for small systems.

The CCC model overcomes this convergence problem for larger systems. This model is especially useful when one has to model a large set of series. Elements of the main diagonal can be freely chosen. That means that any (univariate) GARCH model, including different distribution assumptions, can be selected. This is a clear improvement and advantage of this model class. But again, this flexibility comes at a price. Due to this special combination of univariate GARCH models via the correlation matrix, no differentiation among secondary diagonal elements can be made, comparable to the diagonal BEKK setting.

The implementation of these models is closely related to more or less restrictive assumptions regarding the structure of the volatility change over time with the invariability of the correlation over time as the most important.

8.3 Empirical Data Issues

This section focuses on sample characteristics of two different time spans to show that differences between a "short-run" and a "long-run" consideration might exist. Stylised facts for returns exhibit skewness, higher kurtosis and, therefore, a non-normal distribution of the returns. A standard fundamental assumption in the financial literature when modelling a market is the normal distribution assumption of returns. Based on this we should expect a skewness of zero and a kurtosis of 3. An important question for this analysis is whether returns of agricultural futures exhibit these characteristics.

The first time period ranges from July 1996 to November 2009. In Figs. 8.1 and 8.2 the futures notations (levels) of wheat at Chicago Board of Trade (CBOT) and Marché à Terme d'Instruments Financiers (MATIF), corn at CBOT and rapeseed at MATIF are displayed. Price quotations are given in US Dollars. Each Future contract is based on a different amount of product quantity. At MATIF one rapeseed contract stands for 50 t while the wheat contract stands for 100 hundreds of tonnes. At CBOT the unit per contract is 5,000 bushels, equivalent to 127 t corn and 136 t wheat.

The following figures show clearly the well-known commodity price pattern that culminated with the price spike in 2008. Table 8.1 shows the summary statistics of the returns, i.e. changes of the log prices. The skewness of all series is small but not zero. Three of the series show a positive skewness which indicates a right skewed distribution. All series show kurtosis values higher than 3.

The Jarque–Bera test for the series under consideration indicates a clear non-normal distribution of returns. These results are in line with the empirical findings in finance literature.

The second time period ranges from 27/03/2007 to 05/03/2008. Again daily futures notations are considered. In Fig. 8.3 the futures notations (levels) of maize at MATIF, Bolsa Mercantil e de Futuros (BRAZ) and CBOT are displayed. Price quotations are given in US Dollars. Each futures contract is based on a different amount of corn quantity. One contract in Europe stands for 50 t of corn.

In Brazil, 450 units of 60 kg bags are traded by one contract. This is equivalent to 27 t. In the United States, the unit per contract is 5,000 bushels. This is equivalent to 127 t. Again these different units of measurement explain the observed price levels per unit of weight on these markets.

Contrary to the findings above, the results for the short-run perspective look different. Table 8.2 shows the summary statistics in the short run.

Again all three series show negative skewness. The surprising difference can be found in the kurtosis values. The values for MATIF and BRAZ are, as expected, higher than 3. The CBOT data behaves differently. Here the kurtosis is close to 3. Due to this, the Jarque–Bera statistic indicates a normal distribution of the returns for CBOT. It seems that short-run price movements are overlaid by the large amount of data in the long run. In other words, in the long run the importance of short-run "unnatural" price behaviour declines.

These returns characteristics for both time periods have a direct impact on the estimation results. The long-run data sample generates standard estimation results, as can be verified in Tables 8.3 and 8.4.

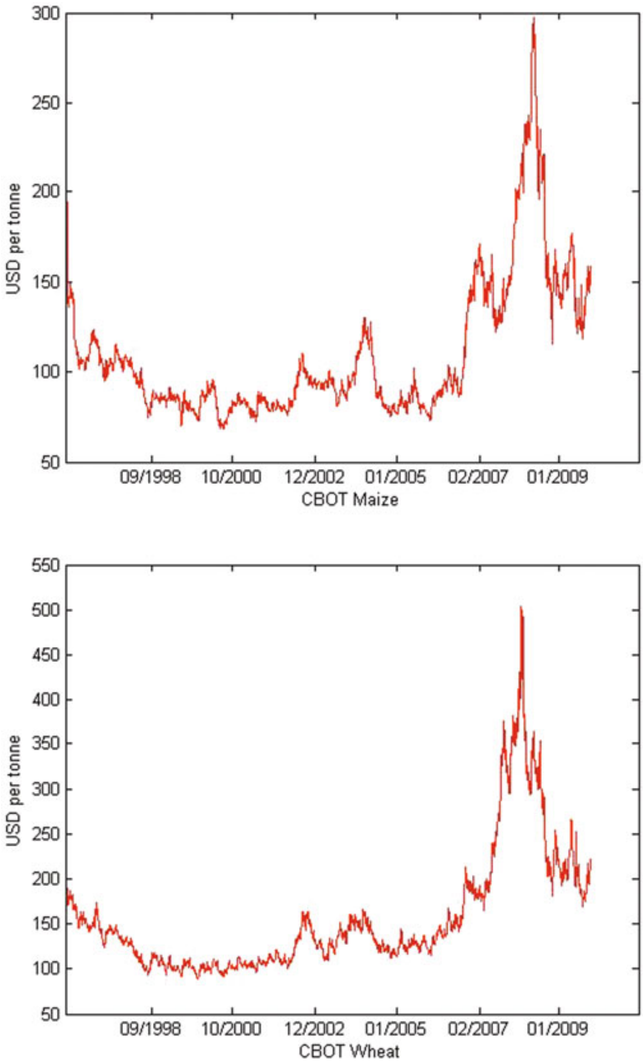

Fig. 8.1 Nearby futures prices for maize and wheat at CBOT (US$ per tonne), 07/1996–11/2009. Source: AMI (2009)

Table 8.3 shows the estimation results of GARCH models for an expanded commodity futures range including soybeans at CBOT, crude oil at the International Petroleum Exchange (IPE) in London, palm oil at Kuala Lumpur (KL) and wheat at MATIF.

All (univariate) GARCH models fulfil the condition for a stable evolution of the volatility. The sum of the coefficients alpha and beta are all smaller than 1. As usual in GARCH estimates, the past volatility (beta) has a greater influence on actual

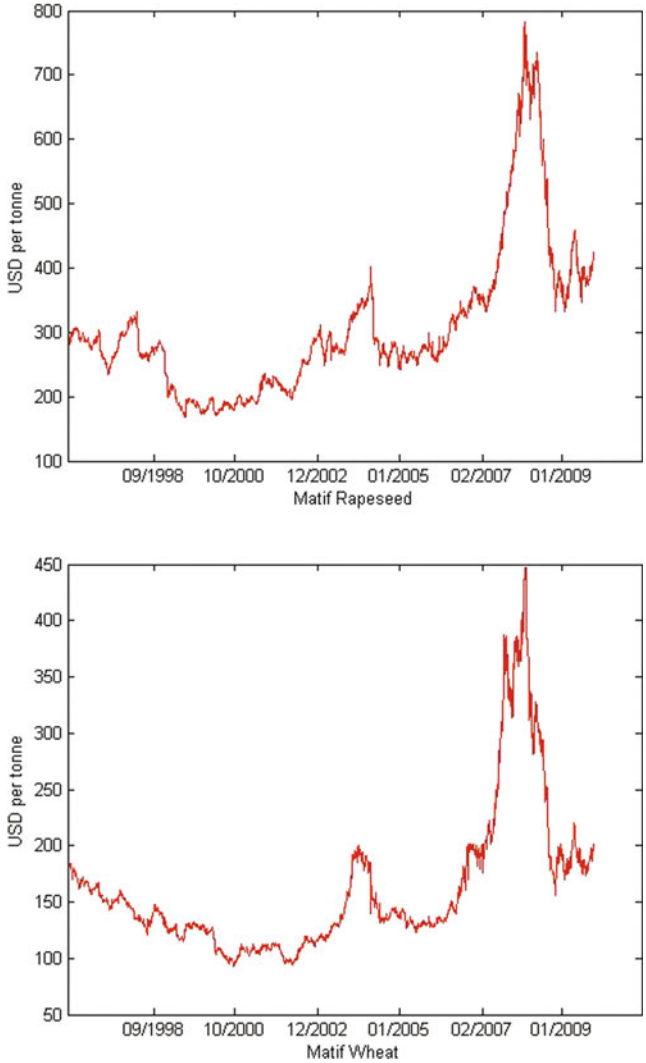

Fig. 8.2 Nearby futures prices for rapeseed and wheat at MATIF (US$ per tonne), 07/1996–11/2009. Source: AMI (2009)

volatility than past innovations. The coefficient for beta has a larger magnitude than alpha.

Table 8.4 shows the corresponding estimated correlation matrix. These correlations can be interpreted as the long-run dependence between the corresponding time series. A full analysis of all dependencies is beyond the scope of this study and we focus only on the main findings. We observe a higher correlation between futures of commodities at the same market. The relationship between wheat, maize

Table 8.1 Summary statistics of returns 07/1996–11/2009

	CBOT maize	CBOT wheat	MATIF rapeseed	MATIF wheat
Mean	–0.000090	0.000048	0.000116	0.000022
Std. Dev.	0.019712	0.020781	0.014216	0.015438
Skewness	–0.97355	0.0701	0.0457	0.0701
Kurtosis	22.10484	18.18005	25.156	40.02184
Jarque–Bera	49310.19	30852.32	66369.53	183810.50
p-value	0.000000	0.000000	0.000000	0.000000
Nobs	3209	3209	3209	3209

Source: Own calculations

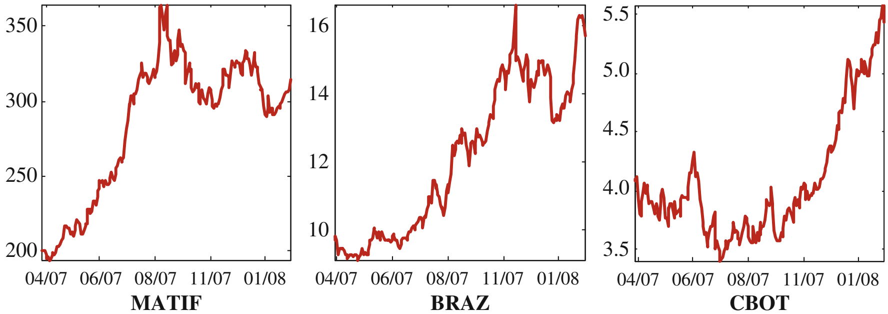

Fig. 8.3 Nearby futures prices for corn at MATIF, BRAZ and CBOT, (US$ per futures contract quantity) 27/03/2007–05/03/2008. Source: ZMP (2009)

Table 8.2 Summary statistics of returns 03/2007–03/2008

	MATIF maize	BRAZ maize	CBOT maize
Mean	0.0020	0.0020	0.0014
Std. Dev.	0.0167	0.0182	0.0185
Skewness	–0.02844	–0.0094	–0.2595
Kurtosis	5.0355	5.4022	3.2843
Jarque–Bera	41.6920	53.8667	3.2682
p-Value	0.0000	0.0000	0.1952
Nobs	225	225	225

Source: Own calculations

and soybean at CBOT is quite strong. The correlation coefficients are all larger than 0.37 with wheat and maize at the top. The correlation between rapeseed and wheat at MATIF is 0.33, smaller compared with CBOT but still higher than any other correlation coefficient.

A second observation is that the long-run correlation between similar commodity markets at different marketplaces is relatively small, only 0.18 in the case of wheat (CBOT-MATIF). For oilseeds (CBOT-MATIF) the coefficient is 0.29, while

Table 8.3 Estimation results of GARCH model, 07/1996–11/2009 (p-values in parentheses)

	μ_i	ω_i	α_{1i}	β_{1i}
CBOT maize	0.0003	5.14E-06	0.0624	0.9250
	(0.1024)	(0.0000)	(0.0000)	(0.0000)
CBOT soybean	0.0002	5.60E-06	0.0932	0.8956
	(0.1375)	(0.0000)	(0.0000)	(0.0000)
CBOT wheat	0.0003	2.94E-07	0.0234	0.9752
	(0.1818)	(0.0024)	(0.0000)	(0.0000)
IPE oil*	0.0008	1.47E-06	0.0469	0.9392
	(0.0070)	(0.0000)	(0.0000)	(0.0000)
KL palmoil**	0.0000	1.63E-07	0.0652	0.9392
	(0.5919)	(0.0000)	(0.0000)	(0.0000)
MATIF rapeseed	0.0003	6.41E-06	0.1270	0.3267
	(0.0384)	(0.0000)	(0.0000)	(0.0000)
MATIF wheat	0.0002	3.74E-07	0.1388	0.8539
	(0.4802)	(0.0000)	(0.0000)	(0.0000)

Notes: *IPE: International Petroleum Exchange; **KL: Kuala Lumpur
Source: Own calculations

the coefficient for palm oil and soybeans is 0.15 and for rapeseed 0.23. The lower correlation between palm oil and soybeans is due to the different stage of processing of the oilseed as well as the influence of the soy meal market on the soy oil and soybeans price formation.

This outcome seems to indicate that although the markets are internationally linked, the regional market reflects more visibly regional aspects like the competition for production factors or the substitutability among feedstocks. This example also shows that in the long run no unexpected data characteristics arise and, therefore, the estimation results are straightforward.

Contrary to the previous model, the short-run sample model estimation results produce a non-standard picture. Due to the quadratic form of the conditional variance and covariance matrix (H) in the BEKK model, a direct interpretation of the estimated coefficients is difficult. It is nevertheless clear that the prob-value will indicate if a link between markets based on innovations (ε) exists or not.

The parameters shown in Table 8.5 correspond to a BEKK model as derived in Section 8.2. The estimated coefficients correspond to the parameters in Eqs. (8.1) and (8.8), (8.9), (8.10), (8.11), (8.12) and (8.13).

Due to this result, the term related to the innovations of the following model Eqs. (8.8), (8.9) and (8.10) collapses:

$$h_{11} = c_{01} + a_{11}^2 \varepsilon_1^2 + b_{11}^2 h_1^2 \tag{8.20}$$

$$h_{21} = c_{02} + a_{11} a_{22} \varepsilon_2 \varepsilon_1 + b_{11} b_{22} h_{21} \tag{8.21}$$

$$h_{31} = c_{03} + a_{11} a_{33} \varepsilon_3 \varepsilon_1 + b_{11} b_{33} h_{31} \tag{8.22}$$

Table 8.4 Estimation result of correlation matrix 07/1996–11/2009 (*p*-value in parentheses)

	CBOT maize	CBOT soybean	CBOT wheat	IPE oil	KL palmoil	MATIF rapeseed	MATIF wheat
CBOT maize	1	0.5286 (0.0000)	0.5586 (0.0000)	0.1372 (0.0000)	0.0970 (0.0000)	0.2141 (0.0000)	0.1226 (0.0000)
CBOT soybean	.	1	0.3673 (0.0000)	0.1472 (0.0000)	0.1497 (0.0000)	0.2956 (0.0000)	0.1152 (0.0000)
CBOT wheat	.	.	1	0.1120 (0.0000)	0.0710 (0.0000)	0.1710 (0.0000)	0.1825 (0.0000)
IPE oil	.	.	.	1	0.0146 (0.4229)	0.1288 (0.0000)	0.0792 (0.0001)
KL palmoil	.	.	.	.	1	0.2283 (0.0000)	0.0630 (0.0029
MATIF rapeseed	.	.	.	.	.	1	0.3301 (0.0000)
MATIF wheat	.	.	.	.	.	.	1

Source: Own calculations

Table 8.5 Estimated BEKK parameters, 03/2007–03/2008

	Coefficient	Prob. value
μ_1	0.0012	0.2850
μ_2	0.0024	0.0475
μ_3	0.0026	0.0210
c_{01}	0.0026	0.6539
c_{02}	0.0018	0.5760
c_{03}	0.0037	0.5903
c_{04}	0.0047	0.0093
c_{05}	–0.0005	0.9102
c_{06}	0.0000	1.0000
a_{11}	–0.0700	0.4179
a_{22}	0.2332	0.0002
a_{33}	0.4709	0.0000
b_{11}	0.9855	0.0000
b_{22}	0.9216	0.0000
b_{33}	0.8745	0.0000

Source: Own calculations

Parameters a_{11} and c_{01} in Eq. (8.8) that stands for the CBOT Market are not statistically significant at the 5% level. This means first that the according variance equation (Eq. (8.8)) is partially void. The returns at CBOT were not marked by conditional heteroscedasticity in the time period considered. The conditional variance of prices at CBOT is characterised only by its own lagged variance. As the estimated parameter a_{11} is insignificant (Table 8.5), information shocks are not accounted for. This finding again highlights the peculiarity of this exchange at this time (03/2007–03/2008).

This estimation result has a broad-reaching meaning since the ARCH-terms described by parameters $a_{11}a_{22}$ and $a_{11}a_{33}$ are null in Eqs. (8.9) and (8.10). These equations illustrate the spillover effects of the Chicago Market on MATIF and Brazil. Thus, in the time period considered, no spillover of price or information shocks from Chicago (e.g. updated harvest forecast in the USA) took place on the development of prices to MATIF and to Brazil. The results nevertheless indicate that the other two markets considered were influenced via the covariance as the GARCH-term, described by the parameters $b_{11}b_{22}$ and $b_{11}b_{33}$ hold as these parameters are different from zero.

The estimation results indicate that during the analysed period (of rising energy prices) the politically induced maize market development, that boosted the US corn-based biofuels sector, caused a partial decoupling of the US market from the other markets analysed. The results also show that during the period analysed only the lagged conditional variance of CBOT influences the covariance. The importance of the futures exchange at CBOT for the global maize market can be recognised as it nevertheless had a noticeable influence on the other marketplaces via the covariance during the period analysed here.

As mentioned above, the main aim of this chapter is to present some aspects related to the application of two methods that allow us to handle simultaneously large-scale time series problems for empirical volatility analysis. A detailed analysis of the appropriateness of BEKK or the CCC model is beyond the scope of this chapter. The assumption of constant correlation is, therefore, not tested. Here some constraints remain in place but this is a field of research that recently attracted new attention. Bera (2002) proposed a test that could be implemented for the bivariate case. The development of an appropriate test that allows the testing of the assumption of constant correlation in higher dimensions is still needed and remains an open field of research.

8.4 Conclusion

Analysing the existence of volatility spillover effects across regions and markets requires special attention to the data. We showed that swapping of information comprised in commodity futures data for time periods longer than one contract can occur. Marketplaces are not continuously linked together in the same manner. With the example of three simultaneous corn futures contracts at different trading centres, it could be shown that single futures contracts of the same commodity can exhibit distinct price patterns in the short run. As a result, volatility transmission can be interrupted or disrupted in the short-run. In the long-run, however, such occasional interruptions are not observable and do not play a relevant role with regard to the underlying long-run commodity market architecture and the signalling function of the price. For the long-run perspective volatility transmission could be identified among the considered commodities even at the different marketplaces.

Whether the constant correlation assumption can be validated is still an open question. Therefore, further research needed to test the hypothesis of time-invariant correlation. For systems of higher dimensions this can be a difficult task. Most tests were developed for the low dimension case, e.g. bivariate GARCH models.

Finally more efforts should be directed to the identification of the real sources of volatility. GARCH models only describe, very successfully, time evolving volatility pattern of economic series and to a certain extent cross effects among these series. One starting point might be theoretical models concerning the non-normal distribution of returns. In particular, the mixture of distribution hypothesis (MDH), the stable distribution theory and the theory of storage should be tested for different agricultural commodities and seem to be a promising field of future research.

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Chapter 9
Price Co-movements in International Markets and Their Impacts on Price Dynamics

Hadj Saadi

Abstract The upsurges of international primary commodity prices of 1973 and 1979, the fall of the 1980s, the price recovery of the early 1990s, the drop of the end of the 1990s and the high rise of the 2000s reflect a cyclical evolution over several decades and one which stems from endogenous mechanisms. This chapter aims to review the literature regarding similarity phenomena and analyses price evolution over the last three decades. The impact of macroeconomic factors brings about co-movements of primary commodity prices. Numerous econometric tests of causality and cointegration are run to check interactions and co-movements between prices. In addition, some economic comments are suggested.

9.1 Introduction

An examination of primary commodity price series over several decades shows that the evolution of the international prices of the major primary commodities follows a parallel movement upwards and downwards. This is reflected by simultaneous and alternating phases of rising and falling commodity prices, often affecting the economies of producing countries and leading to significant macroeconomic imbalances. When commodity prices increase, producers are encouraged to invest in production capacity and to launch comprehensive development programs while consuming countries are forced to reduce their consumption of primary commodities by looking for alternative products or transformation of production technology. In periods of falling prices, producing countries generally need to use external borrowing to cover the recurrent costs of their investments and meet their budget deficit.

This leads to questions about the interdependence of international markets of primary commodities and the mechanisms that generate them. This chapter examines the international price dynamics of primary commodities over a long period to show the interdependence of markets through the interactions between prices. In this context, interaction is a phenomenon of reciprocal influences whose mechanisms are based in particular on decisions related to the complementarities or substitutions between products. This chapter also seeks to update the debate on

H. Saadi (✉)
Université Pierre Mendès France, Grenoble, France
e-mail: hadj.saadi@upmf-grenoble.fr

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international price co-movements of primary commodities which produced an abundant literature. However, most studies have relied most often on the analysis of stock prices that have more short-term phenomena, so that understanding the mechanisms of endogenous commodity markets cannot be understood without analysing the medium-long-term dynamics. Indeed, in the mid and long term, interactions exist between the prices of primary commodities due to phenomena of substitutions and complementarities between products. When the price is increasing, consumers try to use substitute products and save the quantity of primary commodity used thanks to new production technology. Complementarities between products are reflected in their use and preferences of users to choose a particular product based on its qualities. Substitution effects and complementarities encourage with delayed reactions, movements of synchronisation of primary commodity prices and coincidences of the markets dynamics. In the mid and long term, macroeconomic factors also influence the dynamics of primary commodities markets.

Section 9.1 examines price co-movements that support interactions between commodities' markets. These co-movements are defined by the joint influence of common global factors on the markets dynamics. Our analysis is based on monthly data series of prices of 10 significant primary commodities (6 minerals: copper, aluminium, lead, nickel, tin and zinc; 4 agricultural products: coffee, cocoa, rubber and cotton). These primary commodities play a decisive role in world trade and the analysis of their market dynamics is useful to understand the functioning of their endogenous mechanisms. Interactions between prices may be revealed by tests of causality and cointegration which show that many commodity markets are interdependent. These tests presented in Section 9.2 can show interactions between primary commodity prices in the mid and long term. They can also test for the existence of similarities in their movements.

9.2 Similarities of Price Movements in International Primary Commodity Markets

Interactions between commodity markets are reflected in price co-movements caused by common macroeconomic factors such as changes in aggregate demand, inflation, exchange rates and interest rates. These interactions lead to coincidences in the evolution of primary commodity prices and financial markets. In addition, excessive joint movements can be triggered by expectation and speculation phenomena on stock markets.

9.2.1 Price Co-movements on International Primary Commodity Markets

Many interactions exist between many primary commodities' prices and between them and the financial markets. These interactions influence the primary commodity price dynamics, particularly since the 1970s. They result from interventions of hedge funds on stock markets affecting many products such as cocoa, coffee, rubber, copper, lead, tin and zinc. American hedge funds have engaged, since the early 1990s, significant financial investments in futures markets of primary commodities (coffee, nickel, tin, aluminium). Since the 1980s, the amount of these hedge funds has grown significantly and their interventions in the financial markets have increased.

The growing market for financial transactions is a good example: the contract amount increased from US$65 billion in 1970 to US$255 billion in 1975, US$1450 billion in 1986 (Maizels, 1992) and US$5.669 trillion in 1998 (Albagli, 1999). A high instability on commodity markets has facilitated large interventions of funds for hedging or for speculative purposes (Labys and Thomas, 1975). The financial amount involved in international primary commodities markets skyrocketed in 2007 when the financial crisis occurred.

In addition, the evolution of international primary commodities prices over several decades indicates that these prices tend to fluctuate at the same time and this phenomenon is a co-movement which was first observed empirically by Pindyck and Rotemberg (1990). These authors show that traders consider on some occasions that the price of a product will rise because the prices of other commodities have increased. While it appears that speculative behaviour, particularly on stock markets, could lead to high volatility, speculation does play an ambiguous role in the variation of primary commodity prices (Netz, 1995; Zulanf and Irvin, 1998; Carter, 1999; Chatrath and Song, 1999, Swaray, 2007).

Moreover, changes in commodity prices can also register a common trend due to the influence of exogenous factors such as macroeconomic aggregate demand, inflation, exchange rates and interest rates that are common determinants (Baffes and Haniotis, 2009; Vansteenkiste, 2009). These macroeconomic factors cause price co-movements which are defined by the trend that led prices to evolve at the same time, upwards or downwards, under the combined influence of traders' expectations on stock markets and macroeconomic factors (Pindyck and Rotemberg, 1990; Palaska and Varangis, 1991; Leybourne et al., 1994; Frankel, 2005; Ai et al., 2006; Blanchard and Gali, 2007).

Analyzing co-movement phenomenon, Pindyck and Rotemberg (1990) found that, even taking into account the macroeconomic effects, primary commodities prices that have no apparent connection continue to follow a common trend and lead to a phenomenon of price overshooting or excess co-movement. The results of Pindyck and Rotemberg have been questioned by Palaska and Varangis (1991) showing that excess co-movement is more the exception than the rule in the evolution of uncorrelated prices of primary commodities. Similarly, Deb et al. (1996) have also shown that the results of Palaska and Varangis are sensitive to the 1970s structural changes and to the checking of heteroscedasticity of price data.

However, the position of Leybourne et al. (1994) leads to a consensus between the Pindyck and Rotemberg version and that of Palaska and Varangis. Excess co-movement comes from two main sources: the herding behaviour and the capital movement's effects. The herd behaviour and "sympathetic" speculative buying behaviour occurs if traders execute the information more or less in the same way on all primary commodity markets. Hence, traders conduct an up or down on all primary commodity markets reflecting a subjective consensus of trust or distrust.

However, traders can take time to check the impact of information on prices and thus react in a similar manner on all markets (Truong, 1995). They adapt their behaviour with a delay taking into account specific information. The herd behaviour results in automated trading strategies which are reflected in decisions depending particularly on exchange rates. The behaviour on the market and the adoption of automated trading strategies may involve an attitude without apparent logic, that is to say behaviour triggered by reasons unrelated to market fundamentals, in other words, the actual availability of product. In fact, the stock market phenomena that occur in the short term reflect the mid- and long-term dynamics of primary commodity markets (Calabre, 1985).

Nevertheless, monetary policy and exchange rate variations can have effects as large as variations of primary commodity prices on the behaviour of a consumer. Frankel (2006) explains that higher interest rates in the short term lead to increased supply of primary commodities and reduce the demand for storable commodities whose prices are falling. More expansionary policy, more interest rates are low and primary commodity prices are high.

Liquidity constraints also introduce interactions between primary commodities prices that are not correlated. When a primary commodity price falls, it leads to falling prices of other primary commodities because it causes a reduction in funds available for reinvestment of speculators, who are buyers, that is to say holders of contracts on many primary commodities markets. But beyond the short-term fluctuations, the interactions between primary commodity prices and financial markets depend mainly on the real level of market supply resulting from mid and long dynamics.

9.2.2 Excess Co-movements of International Primary Commodity Prices

To test steady relationships between primary commodity prices and macroeconomic variables, Palaskas and Varangis (1991) use the cointegration method and error correction models. They hypothesise that all series are non stationary and integrated at first order.

Incorporating a macroeconomic variable such as industrial production index (*IPI*) or consumer price index (*CPI*), Palaskas and Varangis build the following equation:

$$\Delta P_{it} = \lambda z_{t-1} + b\Delta P_{jt} + c\Delta X_t + \mu_{it} \tag{9.1}$$

where P_{it} and P_{jt} are respectively the prices of products i and j; $z_t = P_{it} - \lambda P_{jt}$ with λ as the regression parameter of cointegration.

To detect excess co-movement, only series P_{it} and P_{jt} which have common trend could be accepted. According to Granger (1986), cointegration of two integrated variables with the same order implies that ΔP_{jt} explains significantly ΔP_{it}. In addition to the explanatory power of ΔP_{jt}, ΔP_{it} can be in part described by macroeconomic variables (ΔX_t) in Eq. (9.1).

With Eq. (9.1), Palaskas and Varangis (1991) show that the OLS estimator of the coefficient b is not significant, and X_t explains common relationships between prices of two primary commodities. An excess co-movement means that there is a situation where the estimator of b is significantly different from zero when ΔX_t is part of that equation. Even if the traders' behaviour is likely, the Palaskas and Varangis analysis has raised some doubt on these results' validity by demonstrating that excess co-movements are more the exception than the rule in the dynamics of primary commodities prices. Testing 21 pairs of prices, Palaskas and Varangis found that only 4 of them reject the null hypothesis of no excess co-movement at 5% with annual data and 7 with monthly data (wheat, cotton, copper, gold, crude oil, timber and cocoa). In addition, analysing the interactions between financial markets and primary commodity markets, Palaskas obtained the opposite results and found that there is an excess co-movement between these two markets (Palaskas, 1996).

While Pindyck and Rotemberg believe that excess co-movements may affect all markets, Palaskas and Varangis introduce exceptions by showing that excess co-movements affect only a few markets. In addition, Leybourne et al. (1994) synthesise the two versions by noting that, finally, there is no formal and satisfactory definition of these excess co-movements which may ease the understanding of this phenomenon. Indeed, the definition of the previous analysis may seem blurred and can lead to confusion in interpreting test results. In the study of Pindyck and Rotemberg, the question that arises is whether a co-movement is a trigger of an excess co-movement. If the answer is negative, the estimate in first differences will be the best method providing the main economic variables are taken into account. It avoids mistakes of regressions and loss of information. If the answer is positive, then their equations are not correctly specified since they do not take into account these price co-movements with a common trend.

Leybourne et al. (1994) consider that excess co-movements can make economic sense only if there is a correlation of primary commodity prices which can be explained by the effects of macroeconomic variables and implying that traders react routinely to "uneconomic" information. Provided that the influence of macroeconomic variables has been taken into account in the price regressions, excess co-movements can be easily detected by correlations between residues from Eq. (9.1). Hence, co-movements may stem from oversight of important macroeconomic variables in the price equations.

Under these conditions, excess co-movements are an artefact of poor econometric specification and can therefore be described as "false excess co-movements" (*spurious excess co-movement*). This result is confirmed by other studies, such as that of Malliaris and Urritia (1996), using cointegration to reject the independence of six long-term series of stock prices of primary commodities. Unfortunately, these studies use stock market price series fundamentally based on short-term dynamics and which could, therefore, not explain the endogenous market mechanisms.

Such is the case for Cashin et al. (1999), and Cashin and McDermott (2002), who based their works on a statistical definition of cycles of primary commodity prices and of time series characteristics and neglected the underlying economic fundamentals. These authors used non-parametric co-movements suggested by Pagan (1999) and found synchronicity in the turning points of primary commodity prices of 7 products over the same period as that of Pyndick and Rotemberg (1990). Kellar and Wohar (2006) used the same methodology and focused their analysis on cycle characteristics of the primary commodity prices, although the endogenous mechanisms are crucial to understand the price dynamics and their economic impacts.

The results of Ai et al. (2006) suggest that co-movements are not excessive. In addition, most co-movements are generated by the common trends of demand and supply factors. Ai et al. used a partial equilibrium model to check correlations of factors that were not taken into account by Pyndick and Rotemberg (1990). The empirical model explains most of the price co-movements of primary commodities by a high level of price correlations.

Taking into account all these studies, it seems to be that the hypothesis of excess co-movements is an artefact of econometric modelling and if the right econometric model was found, evidence of co-movements would disappear. Therefore, research on the assumption of excess co-movements focused more on the nature of excess co-movements than on the causes themselves (Calabre, 2003).

Cointegration of two variables is necessary but not sufficient to show an excess co-movement. Co-movements are important as the economic variables are themselves cointegrated. Therefore, excess co-movements are only justified by the existence of significant macroeconomic variables and by the correlations of the equations' residues. Furthermore, Leybourne et al. make a distinction between "strong excess co-movements" where commodity prices have a common trend and "weak excessive joint movements" without common trend. Indeed, the existence of excess co-movements between prices of two commodities assumes the existence of a "not excess" co-movement but it is not a prerequisite for the existence of significant correlation between residues of correctly specified price equations. In other words, there are excess co-movements when residues price equations are correlated.

P_{1t} and P_{2t} are prices of two primary commodities, X_{1t} and X_{2t} are macroeconomic variables and δ_{1t}, and δ_{2t} are proxies in the following equations:

$$\begin{Bmatrix} P_{1t} = X_{1t} + 2X_{2t} + \mu_{1t} \\ P_{2t} = -X_{1t} + X_{2t} + \mu_{2t} \end{Bmatrix} \tag{9.2}$$

where

$$\begin{Bmatrix} \mu_{1t} = \alpha_3 N_t + \delta_{1t} \\ \mu_{2t} = \beta_3 N_t + \delta_{2t} \end{Bmatrix} \tag{9.3}$$

N_t is a variable incorporating the information that is probably common to the two prices and that is easily identified as the source of the possible excess co-movement when $\alpha_3 \neq 0$ and $\beta_3 \neq 0$ and the partial derivatives of P_{1t} and P_{2t} according to X_{2t} have the same sign.

Whereas primary commodity prices are linked to the same macroeconomic variables, they are not cointegrated and do not have the same common trend. There is a weak excess co-movement, that is to say commodity prices do not have a common trend.

Let us consider the following model:

$$\begin{Bmatrix} P_{1t} = X_{1t} + 2X_{2t} + \mu_{1t} \\ P_{2t} = X_{1t} - 2X_{2t} + \mu_{2t} \end{Bmatrix} \tag{9.4}$$

where μ_{1t} and μ_{2t} are defined as earlier. Prices will be cointegrated but as the partial derivatives of P_{1t}, and P_{2t} according to X_{2t} have opposite signs, there is also co-movement. A strong excess co-movement will occur if $\alpha_3 \neq 0$ and $\beta_3 \neq 0$.

Finally, co-movement is verified when residues of price equations are correlated. There is a weak excess co-movement when primary commodity prices do not move in parallel and a strong excess co-movement in the contrary case. Price co-movement means that prices move in parallel when they are cointegrated and that such movement is linked to a "long-term" common behaviour while the excess co-movement refers to a "short-term" common behaviour.

Cointegration tests aim to check if prices of 10 pairs of primary commodities (aluminium, copper, tin, nickel, lead, zinc, cocoa, coffee, cotton and rubber) have cointegrated relationships and reflect co-movement. Cointegration procedure was applied by using a stationarity errors test and the Durbin Watson test. The existence of a cointegrated relationship is found using the CRDW with critical values provided by Engle and Granger (1987). These tests were applied to each pair of prices with some time lags ($p = 1$ and $p = 2$).

This chapter revisits an analytical framework and data used in an earlier work (Saadi, 2001). Hence, this study focuses on 344 monthly price data in constant dollars over a period spanning from January 1970 to December 1998 (UNCTAD). It involves 10 major primary commodities (aluminium, copper, tin, nickel, lead, zinc, coffee, cocoa, rubber and cotton) whose characteristics are generally those of all primary commodities and markets in terms of actors' behaviour and price dynamics. The resulting analysis of these major primary commodities can help to understand the endogenous market mechanisms that serve as an interpretative framework for the functioning of all markets.

The period chosen covers the soaring prices of the 1970s, the falling prices of the 1980s and the recovery of most prices in the 1990s. Then, prices have risen sharply to the systemic financial crunches of 2007. After declining between 2007 and 2009, prices started to increase, driven in particular by a dynamic South–South trade through the strong growth rate of emerging countries offsetting the decline in demand from developed countries. This period is characterised by movements of parallelism in the evolution of primary commodity prices which are reflected in cyclical dynamics (Saadi and Truong, 1995).

The methodology used is to perform causality and cointegration tests to show interactions between prices in the short and medium term, interdependence of markets and similarities in the market dynamics.

The results in Tables 9.1 and 9.2 show that cointegration hypothesis is accepted for most couples of prices except prices of cocoa and rubber. In addition, cointegration hypothesis is accepted for couples of mineral commodity prices on the one hand and those of other agricultural products on the other.

The resulting interactions raise questions about potential links between endogenous cycles of primary commodity markets and exogenous cycles of overall economic activity. However, many studies seem to overlook the distinction between endogenous factors and the impact of exogenous shocks and are sceptical regarding the still obvious relationships between economic activity and prices of primary commodities.

Table 9.1 Long-term relationships of monthly prices of mineral products

Variable $P_i \Rightarrow$ Variable $P_j \Downarrow$	Copper	Tin	Nickel	Zinc	Lead
Aluminium	7.42* (2.00)	8.44* (1.99)	7.58* (1.99)	7.54* (1.99)	8.33* (1.98)
Copper		8.17* (2.00)	8.50* (2.00)	8.22* (2.00)	8.38* (2.00)
Tin			8.01* (1.99)	3.03** (2.00)	9.75* (2.01)
Nickel				7.05* (2.01)	7.71* (1.99)
Zinc					4.27* (2.01)

Notes: For each regression of cointegration, the indicated figures correspond respectively to the values of the DW test and of the *t* of Dickey and Fuller test (Engle and Yoo, 1987). Acceptance threshold or margin of error: (*) 1%, (**) 5%.

Table 9.2 Long-term relationships of monthly prices of agricultural products

Variable $P_i \Rightarrow$ Variable $P_j \Downarrow$	Cocoa	Rubber	Cotton
Coffee	4,62* (1,99)	3,19** (2,00)	3,63* (2,00)
Cocoa			3,01** (2,00)
Rubber			3,67* (1,99)

Notes: see notes of Table 9.1

Cyclical dynamics of primary commodity markets and those of the global economy overlap even if they are closely linked to separate mechanisms. Hence, the primary commodity markets' dynamics suffer from external shocks that can accelerate or slow down the process of these cyclical markets. But the exogenous shocks, particularly soaring energy prices, reflect the pace of overall economic activity and often lead to convergence in the dynamics of primary commodity markets.

Short-term factors such as monetary and stock market problems are combined with longer-term behaviour, such as the decision to produce and to consume, or the dynamics of political and social institutions or alternations of recessions, notably during the 1980s, and economic recovery (in the early 1990s). In the mid term, the combination of endogenous and exogenous shocks leads to turning points of markets for many commodities, marking simultaneity in their dynamics.

9.3 Impacts of Price Co-movements on Price Dynamics

Interactions exist between prices and primary commodity markets. They lead to convergence or divergence phenomena in primary commodity market dynamics (Saadi, 2005). The understanding of the price dynamics of a primary commodity needs a distinction between short- and mid-long term. This distinction identifies the fundamental factors of market dynamics of a primary commodity in the mid and long term. Indeed, the short term is too short to capture the impact of the relationship between production and consumption during the price dynamics. The mid and long term is long enough to understand the impact of the balance between production and consumption. Thus, mid and long term price dynamics stem from the endogenous mechanisms of the balance between production and consumption causing delayed reactions due to the behaviour of producers on the international markets in terms of investment in production capacity (Calabre, 1980, 1997). These endogenous mechanisms lead to similarities in the evolution of many primary commodity markets, but some products still have specific characteristics that lead them to move in different ways.

Moreover, the substitution and complementarity phenomena encourage interactions between prices of primary commodities bringing about interdependence between markets. Tests can generally show how price fluctuations of a primary commodity can influence the price of another primary commodity and what the potential explanatory factors are. But the resulting interactions cannot always be assimilated with causality because unprocessed data can lead to biased interactions. This study does not want to show simultaneous links due to common trends but characteristics of the mid- and long-term dynamics.

Analysis of these interactions must be based on transformed data, that is to say stationarised series that do not include inflationary trend and influence of macroeconomic variables such as interest rates. Therefore, data must undergo a stationarised procedure eliminating these influences. The stationarised series need to know its order of integration which can be determined from the unit root test of Dickey and Fuller (1981).

Causality tests applied to price series for each product can show on the one hand the causal relationships between them and, on the other, delayed reactions of one variable compared to another. The implementation of these tests aims to check the possible influence of a primary commodity price on another. This influence may reflect interdependence between markets of primary commodities.

However, all primary commodity markets do not react the same way and their specificities can lead to autonomous and divergent dynamics. Indeed, each primary commodity market has its own mechanisms associated with its nature, its specific production and consumption, that is to say its "economy", and its market regulating forms. Market regulation of a primary commodity is defined by the mechanisms that tend gradually year by year to promote the balance between production and consumption. It also stems from the market structure, the behaviour of producers and consumers in the international market, the impact of exogenous shocks and political and social situations. Organisational forms depend on the development of tools tailored to ensure the balance between production and consumption, to limit a high variability of prices in the short or mid term, to contingent exports etc.

However, real prices of primary commodities have generally declined since the early 1980s. After a slight recovery in 1984, they fell overall by almost 45% leading to a sharp deterioration of terms of trade for many primary commodity exporting countries.[1] Between 1980 and 1986, according to data from the World Bank, they fell sharply due to slowing economic growth in major consumer countries and lower demand for primary commodities was enhanced by improving production technology and, in some cases, environmental constraints.

In developing countries, the sharp rise in commodity prices of the 1970s encouraged extensive outreach programs designed to increase production capacity and export earnings and to finance development. Borensztein and Reinhart (1994a) showed that prices of primary commodities, compared to those of manufactured goods, reached their lowest level during a period of 90 years (1900–1990). Therefore, a quick analysis of real commodity price dynamics seems to confirm the Prebisch–Singer hypothesis. Indeed, the long-term primary commodity prices compared to those of manufactured products are characterised by a downward trend. Empirical verification of this hypothesis is difficult, as noted by many studies (Powell, 1991; Ardeni and Wright, 1992).

However, Borensztein and Reinhart (1994b) explain that the supply conditions have also played an important role in the weakness of primary commodity prices,

[1] According to the Prebish–Singer Hypothesis, primary commodities are sold at decreasing prices compared to manufactured products. To measure relative prices or terms of trade, let T_n be two index ratios P_x and P_m. P_x is the average price of exports of a country whose amount can be obtained by dividing the volume index of exports with the export earnings index. P_m is the average price index of imports which is determined in the same way as P_x. Terms of trade T_n increase if price exports increase according to price imports.

especially since the mid-1980s. The causes of the supply response of primary commodities during the 1980s can be found, in part, in the debt crisis and the need for adjustment measures which, inter alia, aim to increase export earnings by increasing the quantities exported. However, other factors such as technological progress, improved communication techniques and the increasing productivity of production factors contribute to the accumulation of the global supply of primary commodities.

The Granger causality test is only implemented on price series that have undergone a stationarity procedure. A high correlation with delay variables may reflect multicollinearity which can be avoided by introducing into the model a delay variable stemmed from the dependent variable (Y_t). The estimated model becomes:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{k} a_i \Delta Y_{t-i} + \sum_{j=1}^{l} b_j \Delta X_{t-j} + \varepsilon_{1t} \quad (9.5)$$

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{m} c_i \Delta Y_{t-i} + \sum_{j=0}^{n} d_j \Delta X_{t-j} + \varepsilon_{2t} \quad (9.6)$$

The coefficients' significance and the estimated models are assessed by using the Student t test and F test of Fisher–Snedecor. If the null hypothesis of the coefficients b_j associated with X_t in Eq. (9.5) is rejected, then x "cause" y and it is the same for Y_t in Eq. (9.6).

The results of the causality test show that interactions exist between prices of the primary commodities but the direction of causality is not reciprocal for all products (Table 9.3). Application of the Fisher test on price series determines the number of lags of the explanatory variable for each pair of variables.

For most primary commodities analysed, tests have identified causal relationships. There are many primary commodities whose prices have reciprocal causality, such as aluminium and tin, aluminium and lead, tin and lead, coffee and cocoa, cotton and aluminium. These interactions are reflected in substitutions and complementarities influencing consumer behaviour in the use of primary commodities. When prices increase, consumers tend to reduce their demand and look for substitutes.

Reciprocal causality between prices of coffee and cocoa shows that both products are perennials with many common characteristics. There is also a reciprocal causality from coffee to rubber and from cotton to cocoa. Interactions between prices of most mineral products except that of copper with other products reflect both complementarities of these products and competitive situations of each product vis-à-vis the users.

The test results show non-reciprocal causality from tin to zinc, from rubber to cotton to zinc, from cotton to cocoa, lead to zinc, aluminium to cocoa, cotton to lead, from nickel to tin and zinc and from zinc to lead. However, test results show no causality between prices of copper and other primary commodities except those of

Table 9.3 Fisher tests of lagged causality

Products	Coffee	Cocoa	Rubber	Cotton	Tin	Lead	Zinc
Aluminium		⇒4,09**(1)		⇓5,44*(2) ⇒3,95**(1)	⇒3,77**(1) ⇓5,67*(2)	⇒26,18* (1) ⇓11,25*(2)	⇓1,88**(8)
Coffee			⇒2,00**(8)				
Cocoa	⇓6,03*(2) ⇒3,49**(2)			⇓2,86**(3)			
Cotton			⇓7,46*(2)		⇓2,26**(7) ⇒4,66**(1)	⇒20,03*(1)	
Copper				⇒4,19**(1)			
Tin						⇓3,11**(4) ⇒4,73*(7)	
Nickel					⇒2,88*(10)	⇓2,19**(7)	⇒2,77*(7)
Lead			⇒3,42*(8)				
Zinc			⇓3,41**(2)	⇓6,50*(2)	⇓3,28**(2)	⇒2,59*(7)	

Notes: Acceptance threshold or margin of error: (*) 1%, (**) 5%. The first figure corresponds to the result of F test of Fisher. The arrow shows the direction of causality. Figures in parentheses indicate the number of months of delayed reaction. Empty boxes mean that there is no causality cotton. These negative results cannot check interactions that may exist between markets for these products. But the causality tests have led to important results regarding major products and lagged responses are from 1 to 3 months for most products.

9.4 Conclusion

The dynamics of primary commodity prices over the past three decades are characterised by parallel movements of rise and fall occurring in a mid and long term. This situation stems first from endogenous mechanisms acting in mid and long term. The market dynamics show similarities resulting also from the impact of exogenous shocks and interactions between prices.

Then, price co-movements are caused by the impact of macroeconomic factors such as aggregate demand, inflation, exchange rates and interest rates. Moreover, when speculation occurs, these co-movements can cause excess co-movement. Co-movements are combined with interactions between prices and markets for many primary commodities. These interactions are favoured by substitution effects and complementarities between products both in mining and agricultural markets. It also stems from specific phenomena of imitation or contagion arising from the traders' behaviour of speculation on stock markets. Substitution effects depend on price levels between competing products such as aluminium and lead, lead and tin and zinc and tin.

Complementarities between mining products depend on their usage and users' preferences to choose a particular product according to its characteristics. Substitution effects, complementarities and price co-movements favour, with lagged responses and in a mid and long term, synchronisation of all price movements and lead to coincidences in dynamics of international primary commodity markets.

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Chapter 10
Price Transmission and Volatility Spillovers in Food Markets of Developing Countries

George Rapsomanikis and Harriet Mugera

Abstract We use a bivariate Vector Error Correction model to assess the transmission of price signals from selected international food markets to developing countries. We introduce a Generalized Conditional Autoregressive Heteroscedasticity (GARCH) effect for the model's innovations in order to assess volatility spillover between the world and domestic food markets of Ethiopia, India and Malawi. Our results point out that short-run adjustment to world price changes is incomplete in Ethiopia and Malawi, while volatility spillovers are significant only during periods of extreme world market volatility. The problem in these countries is one of extreme volatility due to domestic, rather than world market shocks. In India, the analysis supports relatively rapid adjustment and dampened volatility spillovers which are by large determined by domestic policies.

10.1 Introduction

Between 2007 and 2008, the world experienced a dramatic swing in commodity prices. Agricultural commodity prices also increased substantially with the FAO food price index rising by 63% between January 2007 and June 2008, as compared with an annual increase rate of 9% in 2006. During the same period, the international prices of traditional staple foods such as maize and rice increased by 74 and 166%, respectively, reaching their highest level in nearly 30 years. After its peak in June 2008, the food price surge decelerated and in the autumn, international food prices decreased sharply as expectations for an economic recession set in. Between June 2008 and January 2009, with the demand for commodities weakening due to the global economic slowdown in conjunction with improved food crop supply, the FAO food index decreased by 33%.

Disclaimer: The views expressed in this chapter are those of the authors and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

G. Rapsomanikis (✉)
Trade and Markets Division, Food and Agricultural Organization of the United Nations, Rome, Italy
e-mail: george.rapsomanikis@fao.org

H. Mugera
University of Trento, Trento, Italy
e-mail: harriet.mugera@unitn.it

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The sudden and unexpected rise in world food prices strengthened the attention of policy makers to agriculture and fuelled the debate about the future reliability of world markets as a source for food. The possibility for further spells of volatility in food prices has instigated renewed efforts in designing and proposing price stabilising mechanisms at both the national and international levels. There is widespread recognition that beyond market fundamentals, a new set of forces drive food prices. These forces emerge from linkages between the agricultural and the energy markets, the role of financial and currency markets, together with the wider macroeconomy, which together, render agricultural markets much more vulnerable to shocks. During the 2007–2008 period, the concurrence of so many drivers, in conjunction with crop production decreases around the world, gave rise not only to an unprecedented price surge, but also to significant volatility. Indeed, there is the perception that volatility for many of the major internationally traded food commodities has been steadily increasing over the past decade, becoming more and more persistent and a permanent feature of the food markets.

The recent price surge in the food markets and the perceptions on increased volatility have renewed interest in analysing the interactions of food markets. This chapter focuses on assessing the persistence of food price volatility, as well as examining the mean and volatility spillover between world food markets and the domestic markets of developing countries. Spillover in the mean denotes the transmission of price changes from the world to domestic prices and vice versa (in terms of levels), while volatility spillover reflects the co-movement of the price variances in these markets. A better understanding of the price mean and variance relationships between the world market and the markets of developing countries can assist policy formulation. Increases in food price volatility have important negative implications for economic welfare in developing countries where agricultural commodities form the basis for household income and food consumption.

Commodity prices, both at the world and the domestic markets, tend to be non-stationary processes that are integrated of order one. Often, their first differences tend to be leptokurtic. Non-stationarity implies that shocks to the series are permanent, rendering the mean dependent on time. However, in the first differences, shocks have a transitory impact resulting in volatility clustering. This suggests that the conditional variance of the first differences may be also time variant. Consequently, we model price transmission, or mean spillover, within a Vector Error Correction (VEC) framework. This allows us to reveal the dynamics of adjustment of prices to their long-run equilibrium path. The analysis of volatility spillover is based on the application of multivariate Generalised Autoregressive Heteroscedasticity (GARCH) on the innovations of the VEC model. GARCH models were introduced by Engle (1982) and generalised by Bollerslev (1986) and take into account that variances vary over time. Although there are many applications of vector autoregressions and GARCH models in the finance literature (see, for example, De Goeij and Marquering, 2004; Hassan and Malik, 2007; Qiao et al., 2008; Alizadeh et al., 2008), such analyses are uncommon in agricultural economics.

We study food markets in three different developing countries, namely wheat in Ethiopia, rice in India and maize in Malawi. In Ethiopia, wheat is a major staple food mainly consumed in urban areas. In 2003–2005, wheat and wheat products accounted for 16% of the total dietary energy supply while the country's self-sufficiency ratio of wheat and wheat products was 76%. India is a major producer and exporter of rice. It is fully self-sufficient in rice which is the main staple food throughout the country. Rice accounted for 30% of the total dietary energy supply in 2003–2005. In Malawi, maize is the main staple food produced and consumed throughout the country. Maize and maize products accounted for 52% of the total dietary energy supply in 2003–2005. On average in 2004–2008, per capita annual consumption of maize was 127 kg. The self-sufficiency ratio of maize was 97%.

The chapter is organised as follows. The next section discusses the modelling framework. Section 10.3 presents the empirical results and Section 10.4 discusses policy implications and concludes.

10.2 The Model

Given prices for a commodity in two spatially separated markets p_{1t} and p_{2t}, the Law of One Price and the Enke–Samuelson–Takayama–Judge model (Enke, 1951; Samuelson, 1952; Takayama and Judge, 1971) postulate that at all points of time, allowing for transfer costs m, for transporting the commodity from one market to another, the relationship between the prices is as follows:

$$p_{1t} = p_{2t} + m \tag{10.1}$$

If a relationship between two prices, such as Eq. (10.1), holds, the markets can be said to be integrated. However, this extreme case may be unlikely to occur, especially in the short run. At the other end of the spectrum, if the joint distribution of two prices were found to be completely independent, then one might feel comfortable saying that there is no market integration and no price transmission. In general, spatial arbitrage is expected to ensure that prices of a commodity will differ by an amount that is at most equal to the transfer costs with the relationship between the prices being identified as the following inequality:

$$p_{2t} - p_{1t} \leq m \tag{10.2}$$

Fackler and Goodwin (2002) refer to the above relationship as the spatial arbitrage condition and postulate that it identifies a weak form of the Law of One Price, the strong form being represented by equality in Eq. (10.1). They also emphasise that relationship in Eq. (10.2) represents an equilibrium condition. Observed prices may diverge from relationship in Eq. (10.1), but spatial arbitrage will cause the difference between the two prices to move towards the transfer cost. The condition encompasses price relationships that lie between the two extreme cases of the strong form of the Law of One Price and the absence of market integration. Depending on market characteristics, or the distortions to which markets are subject, the two price series may behave in a plethora of ways, having quite complex relationships with prices adjusting less than completely, or slowly rather than instantaneously and according to various dynamic structures or being related in a non-linear manner.

Within this context, complete price transmission between two spatially separated markets is defined as a situation where changes in one price are completely and instantaneously transmitted to the other price, as postulated by the Law of One Price presented by relationship in Eq. (10.1). In this case, spatially separated markets are integrated. In addition, this definition implies that if price changes are not passed-through instantaneously, but after some time, price transmission is incomplete in the short run, but complete in the long run, as implied by the spatial arbitrage condition. The distinction between short-run and long-run price transmission is important and the speed by which prices adjust to their long-run relationship is essential in understanding the extent to which markets are integrated in the short-run. Changes in the price at one market may need some time to be transmitted to other markets for various reasons, such as policies, the number of stages in marketing and the corresponding contractual arrangements between economic agents, storage and inventory holding, delays caused in transportation or processing, or "price-levelling" practices.

The spatial arbitrage condition implies that market integration lends itself to a cointegration interpretation with its presence being evaluated by means of non-cointegration tests. Cointegration can be thought of as the empirical counterpart of the theoretical notion of a long-run equilibrium relationship. If two prices in spatially separated markets p_{1t} and p_{2t}, contain stochastic trends and are integrated of the same order, say I(d), the prices are said to be cointegrated if

$$p_{1t} - \beta p_{2t} = u_t \tag{10.3}$$

where u_t is stationary and β is the cointegrating parameter. Evidence for cointegration reflects that prices are jointly determined. The concept of cointegration has an important implication, purported by the Granger Representation Theorem (Engle and Granger, 1987). According to this theorem, if two trending, say $I(1)$, variables are cointegrated, their relationship may be validly described by a Vector Error Correction (VEC) model, and vice versa. In the case that prices from two spatially separated markets are cointegrated, the VEC model representation is as follows:

$$\Delta \mathbf{p}_t = \boldsymbol{\mu} + \boldsymbol{\Pi}\mathbf{p}_{t-1} + \sum_{i=1}^{k} \boldsymbol{\Gamma}_i \Delta \mathbf{p}_{t-i} + \mathbf{v}_t \tag{10.4}$$

where $\mathbf{v}_t | \,\Omega_{t-1} \sim N(0, \mathbf{H}_t)$ are normally distributed disturbances conditional on past information with zero mean and a variance-covariance matrix denoted by $\mathbf{H}_t$, while the operator Δ denotes that the $I(1)$ variables have been differenced in order to achieve stationarity. $\boldsymbol{\Pi}\mathbf{p}_{t-1}$ states the long-run relationship while the matrix $\boldsymbol{\Pi}$ can be decomposed in $\boldsymbol{\Pi} = \alpha\beta'$ as follows:

$$\begin{pmatrix} \Delta p_{1t} \\ \Delta p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (p_{1t-1} - \beta p_{2t-1}) + \sum_{i=1}^{k} \boldsymbol{\Gamma}_i \begin{pmatrix} \Delta p_{1t-i} \\ \Delta p_{2t-i} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix} \tag{10.5}$$

The inclusion of the levels of the prices alongside their differenced terms is central to the concept of the VEC model. Parameters contained in matrices $\mathbf{\Gamma}$, measure the short-run effects, while β is the cointegrating parameter that characterises the long-run equilibrium relationship between the two prices. The levels of the variables enter the VEC model combined as the single entity $(p_{1t-1} - \beta p_{2t-1})$ which reflects the errors or any divergence from this equilibrium, and correspond to the lagged error term of Eq. (10.3). The vector $(\alpha_1\ \alpha_2)'$ contains parameters, commonly called "error correction coefficients", which measure the extent of corrections of the errors that the market initiates by adjusting the prices towards restoring the long-run equilibrium relationship. The speed with which the market returns to its equilibrium depends on the proximity of α_i to unity. Within this context, short-run adjustments are directed by, and consistent with, the long-run equilibrium relationship, allowing the researcher to assess the speed of adjustment that shapes the relationship between the two prices.

The model also allows testing for causality in the Granger sense, providing evidence on which direction price transmission is occurring, as well as the decomposition of the forecast error variance in parts that are due to international and domestic shocks respectively. The cointegration-VECM framework takes into account that prices are stochastic processes which have time dependent means, and replicates their systematic behaviour being essentially a description of the conditional process of realising the data.

While the VEC model provides the conditional expected means of the variables, in order to examine for higher moment relationships which reflect volatility spillovers, the VEC model's errors $\mathbf{v}_t$ are specified as a bivariate GARCH model (Bollersev, 1986). We employ the BEKK parametrisation by Engle and Kroner (1995) which incorporates quadratic forms in such a way so that the covariantce matrix is positive semi-definite, a requirement that is necessary for the estimated variances to be non-negative.

The BEKK parameterisation is given by

$$\mathbf{H}_{t+1} = \mathbf{C}'\mathbf{C} + \mathbf{B}'\mathbf{H}_t\mathbf{B} + \mathbf{A}'v_t v_t{}'\mathbf{A} \tag{10.6}$$

where $\mathbf{H}_{t+1}$ is the conditional variance matrix, $\mathbf{C}$ is a 2×2 lower triangular matrix with three parameters and $\mathbf{B}$ and $\mathbf{A}$ are 2×2 matrices of parameters restricted to be diagonal. In this parsimonious specification the conditional variances are a function of the lagged variances and error terms. Expanding Eq. (10.6) gives the variance–covariance equations:

$$\begin{aligned} h_{11t+1} &= c_{11} + b_{11}^2 h_{11t} + a_{11}^2 v_{1t}^2 \\ h_{22t+1} &= c_{22} + b_{22}^2 h_{22t} + a_{22}^2 v_{2t}^2 \\ h_{12t+1} &= c_{12} + b_{12}^2 h_{12t} + a_{12}^2 v_{1t} v_{2t} \end{aligned} \tag{10.7}$$

where $b_{12}^2 = b_{11}^2 b_{22}^2$ and $a_{12}^2 = a_{11}^2 a_{22}^2$.

The b_{ii}^2s measure the extent to which current levels of conditional variances are related to past conditional variances. The a_{ii}^2s assess the correlations between conditional variances and past squared errors reflecting the impact of shocks on volatility. This specification retains the intuition and interpretation of the univariate GARCH model with the variances and the covariance h_{t+1} being determined by "old" news, or past behaviour as reflected by the lagged h_t, as well as by "fresh" news, reflected by the lagged errors ν_t.

10.3 Empirical Results

10.3.1 Data and Preliminary Analysis

We use logarithmic transformations of monthly domestic prices measured in US$ per tonne from January 2000 to December 2009. We apply the VEC–BEKK model to investigate spillover between the world market and the wheat market in Ethiopia, the rice market in India and the maize market in Malawi. The data on domestic prices is collected from the FAO Global Information and Early Warning System. Data on the corresponding international market prices is collected from the IMF International Financial Statistics.

The order of integration of the price series is assessed by the Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979) and the $Z\rho$ test by Phillips and Perron (1988). All series were found to be non-stationary and integrated of order 1 (Table 10.1).

Table 10.2 presents a range of descriptive statistics for the differenced prices Δp_t. The sample moments for all differenced prices indicate non-normal distributions. Zero excess kurtosis is rejected for all series suggesting leptokurtic distributions with heavy tails. In general, the statistics indicate that the differenced prices exhibit time varying variance and volatility clustering with large changes being likely to be followed by further large changes.

Table 10.1 Food prices: tests for non-stationarity

	Augmented Dickey Fuller		Phillips–Perron	
	p_t	Δp_t	p_t	Δp_t
Ethiopia – wheat	−1.67	−8.55	−1.66	−8.55
India – rice	−0.48	−12.31	−0.12	−12.46
Malawi – maize	−3.08	−7.01	−2.23	−6.67
World market – wheat	−1.67	−8.56	−1.66	−8.58
World market – rice	−0.51	−6.77	−0.48	−6.32
World market – maize	−1.36	−8.42	−1.31	−8.42

Note: The 5 and 1% critical values for both tests are –2.88 and –3.48, respectively

Table 10.2 Differenced food prices: descriptive statistics

	Wheat		Rice		Maize	
	Ethiopia	World	India	World	Malawi	World
Mean	0.006	0.006	0.004	0.008	0.005	0.005
Median	0.002	0.002	0.004	0.003	0.013	0.004
Maximum	0.338	0.229	0.246	0.412	0.484	0.167
Minimum	−0.216	−0.219	−0.319	−0.190	−0.705	−0.246
St. deviation	0.070	0.065	0.055	0.068	0.177	0.063
Skewness	0.587	−0.048	−0.880	2.541	−0.773	−0.645
Kurtosis	7.850	4.913	14.380	16.706	5.483	5.106
Jarque–Bera	123.464	18.197	657.530	1059.564	42.427	30.256
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Ljung–Box lag=1	0.305	0.225	0.234	0.493	0.404	0.238
	0.001	*0.013*	*0.010*	*0.000*	*0.000*	*0.009*
Ljung–Box lag= 2	0.154	0.065	−0.004	0.075	0.034	0.049
	0.001	*0.035*	*0.032*	*0.000*	*0.000*	*0.027*

Note: Probabilities in italics

The Jacque–Bera test is used to test the hypothesis that the differenced prices are normally distributed. In all cases, the probability values are smaller than 0.01, rejecting the null hypothesis. We also calculated the sample autocorrelation functions, which provided evidence for autocorrelation at least for the first and the second lag.

10.3.2 Empirical Results

10.3.2.1 VEC models: Price Transmission or Mean Spillover

For each of the food markets, we test for cointegration between the domestic and world prices using the Full Information Maximum Likelihood method developed by Johansen (1995). This test is based on the rank of matrix $\mathbf{\Pi}$ in Eq. (10.4) and is the most commonly encountered in the price transmission literature. A rank equal to zero indicates non-cointegration. In our bivariate case, a rank of one would suggest cointegration between the domestic and world prices. For $n + 1$ variables, Johansen derived the distribution of two test statistics for the null of at most n cointegrating vectors referred to as the Trace and the Eigenvalue tests.

Table 10.3 presents the results of the non-cointegration tests for the food markets under consideration. In all cases, there is strong evidence that the domestic prices and the world prices are cointegrated, with the Johansen test rejecting the null hypothesis of no cointegration, but failing to reject the null hypothesis of one cointegrating vector. These results suggest that the domestic markets of these commodities are well-integrated with the world markets in the long run.

We formulate VEC models in order to assess the dynamics and the speed of adjustment and we also perform forecast error variance decomposition. The estimated VEC models are presented in Table 10.4. For the Ethiopian wheat market the

Table 10.3 Trace statistic

	Number of cointegrating vectors		Cointegrating vectors	
	0	1	Domestic price	World price
Ethiopia – wheat	16.03	2.47	1	–1.24
India – rice	18.50	0.03	1	–0.47
Malawi – maize	14.22	2.60	1	–0.81

Notes: In all cases the critical values for no cointegration and one cointegrating vector at the 5% level are 15.49 and 3.84, respectively. The appropriate lag length was chosen on the basis of the Schwartz–Bayes information criterion

Table 10.4 Domestic and international food prices: vector error correction models

	Ethiopia – wheat		India – rice		Malawi – maize	
	Δp_{dt}	Δp_{wt}	Δp_{dt}	Δp_{wt}	Δp_{dt}	Δp_{wt}
u_t	–0.069	0.0233	–0.163	0.172	–0.112	–0.008
	–3.548	*1.218*	*–2.574*	*2.547*	*–3.359*	*–0.654*
Δp_{dt-1}	0.278	0.102	–0.032	0.033	0.520	–0.056
	3.275	*1.217*	*–0.330*	*0.317*	*5.955*	*–1.563*
Δp_{dt-2}			0.047	–0.0372	–0.060	0.089
			0.489	*–0.362*	*–0.676*	*2.443*
Δp_{wt-1}	–0.075	0.258	–0.149	0.576	0.575	0.247
	–0.789	*2.752*	*–1.712*	*6.195*	*2.539*	*2.655*
Δp_{wt-2}			–0.056	–0.114	–0.663	0.009
			–0.611	*–1.170*	*–2.871*	*0.093*
c	0.004	0.003	0.005	0.004	0.0030	0.003
	0.784	*0.5556*	*1.174*	*0.928*	*0.217*	*0.551*

Note: The appropriate lag length was chosen on the basis of the Schwartz–Bayes information criterion

estimated VEC model suggests that the adjustment process of the domestic price to the world price is significantly slow. On average, over the 2000–2009 period, about 0.06% of the divergence of the domestic price from its notional long-run equilibrium with the world price is corrected each month. In addition, the short-run dynamics indicate that changes in the world market price are not transmitted to the Ethiopian wheat market in the short-run. The non-significant error correction coefficient in the world price VEC model suggests that the world price is weakly exogenous, identifying a causal relationship, in the Granger sense, which runs from the world to the Ethiopian market, as expected for a small player in the wheat market as Ethiopia.

High transaction costs and trade policies can result in discontinuities in trade which, within a time series modelling framework, give rise to slow speed of convergence to a long-run relationship. Such a slow adjustment to the world market prices suggests that the wheat market in Ethiopia may be characterised by high price volatility due to inadequate buffer capacity and a limited possibility to adjust domestic adverse shocks through trade. Indeed, 12 months ahead forecast variance decompositions, estimated by means of the VEC model, suggest that, on average, it is domestic shocks that give rise to volatility.[1] The estimates indicate that shocks in the domestic wheat market explain about 65% of the domestic price variability. On the other hand, slow adjustment indicates that world price surges may take some time to pass through to the domestic market, although there is the possibility of asymmetric response where increases in the world price are rapidly and more fully transmitted than decreases.

The statistical significance of both error correction coefficients in the Indian-world rice market VEC model suggests that both prices are endogenous, with the world price or rice influencing the Indian market price and vice versa. This is not surprising, given the importance of India in the world rice market. The results indicate that both the Indian and the world prices adjust to their long-run equilibrium relatively rapidly, correcting about 16% of the divergence each month.[2]

Maize is an important staple food in Malawi. The estimated VEC model suggests that the world maize price is the long-run driver of the price of maize in Malawi. The domestic maize price adjusts to changes in the world maize price quite slowly. About 11% of divergences from the long-run path are corrected during the period of 1 month. As in the case of Ethiopia, the slow transmission of changes in the world price to the Malawian maize market may lead to increased volatility. The 12 months ahead forecast variance decomposition suggests that, on average during the 2000–2009 period, domestic shocks explained about 85% of the maize price variance with the remainder being due to international shocks.

10.3.2.2 BEKK: Conditional Variances or Volatility Spillover

The estimation of the BEKK parameterisation of the multivariate GARCH is carried out by maximising the conditional non-linear log-likelihood function following Engle and Kroner (1995). The numerical maximisation method used was the Berndt, Hall, Hall and Hausman algorithm. The Schwartz–Bayes criterion was used to choose the appropriate lag length. The estimated parameters are shown in Table 10.5.

The estimated parameters capture the volatility spillovers between the domestic food markets under consideration and the world market. They quantify the effects of own lagged innovations (ARCH effects), as well as those of the lagged variances (GARCH effects) and thus reveal the persistence of volatility. On the whole, the parameters are significant indicating the presence of strong ARCH and GARCH effects. For the wheat and maize prices, the estimated GARCH parameters are considerably larger than the corresponding ARCH coefficients (ranging from 0.61 to

[1] Forecast error variance decomposition for the domestic price yields the contribution of the variance of international prices to the domestic prices and the part of the variance that is purely attributable to shocks in the domestic price.

[2] The bi-directional Granger causality between the Indian and world prices does not allow meaningful forecast error variance decomposition.

Table 10.5 Estimated multivariate GARCH model

	Ethiopia–World (wheat)	India–World (rice)	Malawi–World (maize)
c_{11}	0.001	0.000	0.007
	0.273	*0.118*	*0.344*
c_{22}	0.000	0.000	0.000
	0.554	*0.454*	*0.455*
v_{1t-1}^2	0.064	0.431	0.077
	0.010	*0.000*	*0.073*
h_{11t-1}	0.729	0.566	0.619
	0.000	*0.000*	*0.001*
c_{22}	0.000	0.000	0.000
	0.554	*0.454*	*0.455*
v_{2t-1}^2	0.109	0.358	0.125
	0.000	*0.000*	*0.000*
h_{22t-1}	0.848	0.517	0.824
	0.000	*0.000*	*0.000*
c_{12}	0.000	0.000	0.000
	0.314	*0.001*	*0.224*
$v_{1t-1}^2 v_{2t-1}^2$	0.083	0.393	0.098
h_{12t-1}	0.786	0.541	0.824

Note: Probabilities in italics

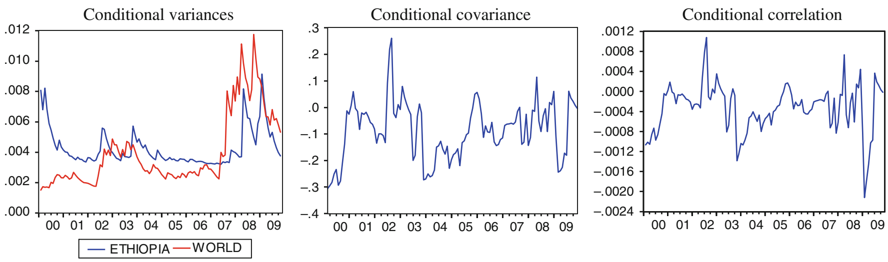
0.85, as compared with the lagged innovation parameter estimates of 0.06–0.11). This indicates that the variances of these prices are more influenced by their own lagged values, rather than by "fresh news" which are reflected by the lagged innovations. However, for the conditional variances of the Indian and the world rice prices past shocks also appear to be relatively important.

In all markets volatility, as reflected by the conditional variances, can be persistent. Higher levels of conditional volatility in the past are associated with higher conditional volatility in the current period. On the whole persistence as measured by sum of the ARCH and GARCH coefficients, $b_{ij}^2 + a_{ij}^2$ which is for all cases close to unity, is high. In all covariance equations the estimated parameters of the cross past innovations $v_{1t-1}^2\ v_{2t-1}^2$ are positive, suggesting that if shocks in the domestic and world markets have the same sign will affect the covariance in a positive manner reflecting the possibility for some indirect volatility spillover between the domestic and the world markets under consideration.

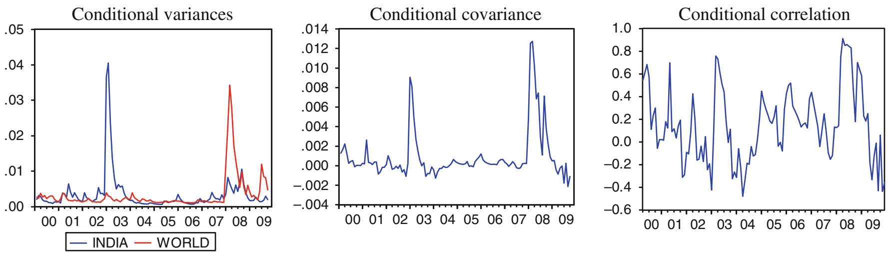
Rather than focusing on the parameters themselves, we discuss the time plots of the estimated conditional variances and covariances over the period 2000–2009. We also calculate the conditional correlation as follows:

$$\rho_{12t+1} = h_{12t+1} \Big/ \sqrt{h_{11t+1}}\sqrt{h_{22t+1}} \qquad (10.8)$$

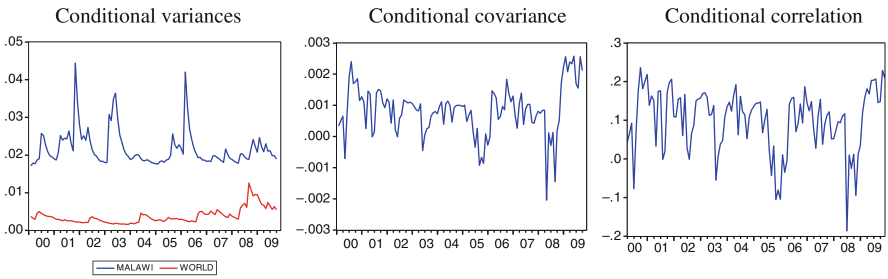
Panels 10.1, 10.2 and 10.3 present the conditional variances, covariances and correlations for the markets examined in Ethiopia, India and Malawi, respectively.



Panel 10.1 Ethiopian and world wheat prices: conditional variances and correlations



Panel 10.2 Indian and world rice prices: conditional variances and correlations



Panel 10.3 Malawian and world maize prices: conditional variances and correlations

The plots show that the conditional variances of the wheat and maize price pairs are not constant over time. For the wheat price pair volatilities tend to cluster during the 2008 price surge. The world maize price conditional variance also becomes significantly more volatile during the surge period. The maize price in Malawi is, during the whole period 2000–2009, extremely volatile. These findings are in line with the result of the previous section and the estimated VEC models. Very slow adjustment to world market prices points out a partly insulated market with limited buffer capacity to contain domestic shocks. The rice price pair variances appear to be relatively stable over the 2000–2007 period, with the exception of a high volatility incidence in the Indian market, while both series exhibit volatility clustering during the recent food price spike.

In general, the conditional variances of the world wheat and maize prices appear to follow a weak positive trend, suggesting that volatility in these markets has been increasing during the 2000–2009 period. We regressed both conditional variances on a time trend to corroborate this observation. In both regressions, the estimated time trend parameter was statistically significant, albeit small. The variances of the domestic food prices do not show to follow a trend, however, they tend to cluster during the 2007–2008 period following, to differing degrees, the world price volatilities.

The conditional covariances of Ethiopian wheat and world prices are not constant over the period under examination and also tend to cluster over time in line with the conditional variances. For the wheat price pair, the covariance assumes negative values suggesting opposite shocks in the innovations in the two markets. Even during the recent price shock, the covariance suggests that the volatility spillover was limited, although wheat prices surged above import parity, as fuel subsidies and restrictions on the foreign exchange market created a shortage of foreign currency, preventing private traders from importing grain (Minot, 2010). Perhaps the large negative value of the covariance in 2009 indicates a significant reduction in spillover, as Ethiopian wheat prices remained at high levels, in spite of the reduction in the world market price. The conditional correlations follow a similar pattern, being in general very low. It appears that, although world price changes are transmitted into the Ethiopian wheat market in terms of levels (or mean), there is limited volatility spillover, with domestic price volatility being persistent and mainly due to domestic shocks.

Both the world and the Indian rice markets appear to be characterised by very low volatility up to the year 2007. Indeed, since the mid-1980s, prices have been low and quite stable (Dawe, 2002). The world rice market is quite thin, with only about 7% of world production being traded, while all major producers manage their domestic markets mainly through trade policy measures. The Indian government intervenes in the rice market through procurement, stocking and distribution policies (Gulati and Dutta, 2010). The conditional variance of the Indian market prices exhibits sharp spikes in 2002–2003, due to climatic conditions during that harvest period, and in 2008 during the food price surge.

The conditional covariance of the Indian and world rice prices assumes positive values for most of the 2000–2009 period and also exhibits sharp increases during 2002–2003 and 2008, indicating volatility spillovers. In general, the covariances tend to assume values which are higher (lower) in times of high (low) volatility. This is also observed by the conditional correlation coefficient which assumes high values during the extreme volatility episodes, suggesting spillovers. Although our findings indicate significant volatility persistence and spillover, the volatility in the Indian market is significantly lower, as compared with that in the world market during the recent price episode, as government intervention in India stabilises the domestic price level. Indeed, during the 2008 price surge, the imposition of a ban in rice exports resulted in less domestic price volatility. As other major rice exporting countries followed suit by restricting exports due to food security fears, the world price of rice increased sharply and became more volatile.

The conditional covariance of maize prices in Malawi and the world market assumes positive values for most of the period under examination. The maize market in Malawi is characterised by a dual marketing structure where the government operates along the private sector through parastatal marketing boards and food security programmes and intervenes in the market. Both parastatals, the Agricultural Development and Marketing Corporation (ADMARC) and the Food Reserve Agency, respectively maintain a strong presence in the market.

In addition to unfavourable climatic conditions, which generate wide shocks, discrete and largely unexpected policy responses increase volatility. For example, during the food price surge of 2008, based on estimates of surplus production in May 2008, the government requested that the ADMARC accumulate stocks by initiating purchases in the domestic market. Within an environment of upward trending world maize prices, ADMARC progressively increased its price in order to outbid private traders and secure the requested quantities. Competition for maize between traders and the board was likely to have led to the domestic price increasing and remaining to high levels even after the world maize price decrease in the autumn of 2008 (Rapsomanikis, 2009). Such shocks have probably given rise to conditional covariances and correlations that change abruptly from positive to negative values. Again, irrespective of the signs, the conditional correlations are low, indicating insignificant volatility spillover from the world market, with the domestic maize price volatility being extreme, persistent and determined by domestic shocks.

10.4 Conclusions and Policy Implications

The effects of food price shocks on developing countries receive considerable emphasis whenever there are major international commodity price booms or slumps, such as the sustained price increases during the mid-1970s and the more recent price surge in 2008. Our main empirical findings can be summarised as follows. In the small developing countries examined, world price changes are partly transmitted to domestic markets. Although domestic markets are integrated with the world market in the long-run, the adjustment of food prices in these countries is exceptionally slow, suggesting that in the short-run such markets can be considered insulated. Volatility spillover is also quite limited. In general, domestic price volatility is persistent and mainly due to domestic shocks, rather than world market shocks, although some spillover takes place during extreme volatility episodes.

The analysis of the Indian rice market is of particular interest. India's market power in the world market results in a bi-directional causal effect. Changes in the price of rice in one market will affect the other. The results suggest that volatility is characterised by the same relationship. Nevertheless, price stabilisation policies in India, and more specifically the imposition of export restrictions during the recent price surge, dampen domestic market volatility, while increase volatility in the world market, if same measures are implemented by other major exporters.

Our estimates also tend to underline the point that the major policy focus for reducing extreme price volatility in insulated developing countries, such as Malawi, should be domestic policies leading to reductions in domestic shocks. Price volatility contributes significantly towards the vulnerability to poverty and inhibits development. It results in significant income risks which blunt the adoption of technologies necessary for agricultural production efficiency, as producers may decide to apply less productive technologies in exchange for greater stability. Self-insurance strategies, such as crop diversification, hinder efficiency gains from specialisation in production.

On the one hand, policies that aim to increase integration with the world market through investment on transport infrastructure and interventions in the marketing and movement of commodities are necessary. On the other hand, such measures will also enhance the volatility spillover during episodes of extreme volatility in the world market. Governments may intervene in providing commodity price insurance as self-insurance strategies, such as crop and income diversification and consumption smoothing, may be inadequate in reducing uncertainty. For food importers, it is possible to obtain a reduction both in the average level and variability of food security costs through futures hedging on relative to a simple import strategy (Dana et al., 2006). Market-based derivative instruments that provide insurance for internationally traded commodities consist of an important policy option (Larson et al., 2004). Market-based weather insurance that covers yields' risks has also been suggested (Skees et al., 2001).

Completely banning food exports was a common reaction to the food price surge across the developing world. Although, in general, export bans can lower domestic food prices and dampen volatility, there are also a number of negative consequences. First, export bans imply a tax on producers and lower the incentive to respond to the world price rise by increasing supply. In the long term, export restrictions may discourage investment in agriculture and thus can have negative implications for food security. Second, in the short term, export restrictions can harm traditional trading partners. For example, during the height of the food price surge in 2008, the National Cereals and Produce Board, the state marketing board of Kenya, was not able to import sufficient quantities of maize mainly due to export bans implemented by a number of countries in the region.

Concerted implementation of export restrictions by major exporters renders the world market unreliable as a source of food. Government control over exports and imports and food reserve management to defend pre-determined prices characterises the rice sectors of most Asian rice producing countries. During the 2008 price surge, bans in rice export triggered substantial instability 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.

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Chapter 11
Global Food Commodity Price Volatility and Developing Country Import Risks

Alexander Sarris

Abstract The world food price spike of 2007–2008 raised to the fore the issues of how countries can manage their basic staple food imports in times of crises. There are many risks to food imports, ranging from price risks to risks of non-performance and hence threats to domestic food supplies. The chapter first provides a review of the risks and food import access problems faced by various low and middle income net food staple importing countries and reviews pertinent policies to deal with them. A short review of some institutional issues in food importing is given to introduce more detailed discussion of food import risk management. Then a proposal for a food import financing facility designed to alleviate the financing constraint of many developing food-importing countries is presented.

11.1 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, largely because they were deemed difficult to implement. However, the fact that the later 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 galvanised attention on the issues facing global agricultural markets. The purpose of this chapter is to discuss issues relevant to assessing price volatility and managing food staple import risks, especially by developing food commodity importing countries.

The financial crisis that started to unravel in 2008 coincided with sharp commodity price declines, and food commodities followed this general trend. The

A. Sarris (✉)
Department of Economics, University of Athens, Athens, Greece
e-mail: alekosar@otenet.gr

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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 3 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% higher respectively, compared to November 2007. In other words within 1 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 longer-term planning very difficult. Analyses of food commodity market volatility indicate that, albeit not unusual from a historical perspective, this volatility is likely to continue and possibly increase in the future due to new factors, external to the food economy (Sarris, 2009, 2010). 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 the journal *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 concerned governments to take measures to curtail or ban exports, thus inducing further shortages in world markets and higher international prices. The latter in turn may induce permanent shifts in production and/or consumption of the staple 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 the shift of developing countries from the position of net agricultural exporters – up to the early 1990s – to that of net agricultural importers (Bruinsma, 2003). Projections to 2030 indicate a deepening of this trend (ibid.), 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, 2010), in 2009/2010 global imports of all cereals were 261.8 million tons, 201.7 million tons of which were imports of developing countries. Within developing countries, those classified as Least-Developed Countries (LDCs) have witnessed a fast worsening of their agricultural trade balance in the last 15 years. Since 1990, the food import bills of LDCs have not only increased in size, but also in importance, as they constituted more than 50% 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).

Table 11.1 Developments in African agricultural import dependence 1970–2004

	1969–1971	1979–1981	1989–1991	2002–2004
Share of agricultural imports in total imports of goods and services				
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				
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				
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

This trend has been particularly pronounced for Africa. Table 11.1 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 2002–2004. This suggests that agricultural (mostly food commodity) imports have necessitated a growing share of the export revenues of African countries.

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%, and the share of total food imports in total exports of goods and services has declined from 15.5 to 7.1%. 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% 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 indicates that based on current estimates developing countries will increase their net food imports by 2018 in all products except vegetable oils (OECD-FAO, 2010). Similarly, LDCs are projected to become an increasing food deficit region in all products and increasingly so. 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 LDCs 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.

An analysis by Ng and Aksoy (2008) supports the above observations. It reveals that of 184 countries analysed with data for 2004/2005, 123 were net food importers, of which 20 were developed countries, 62 middle income countries and 41 low income countries. From 2000 to 2004/2005, more low income countries have become net food importers. They 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. They also revealed that several small island states (which are generally middle income countries) and low income countries (LICs mostly in Africa) are 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%. Among small island developing states (SIDS) the same average is 68%.

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).[1] 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 global 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 per se.

Apart from the problem of 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

[1] 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 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.

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 Organization (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). However, no progress relating to this decision has been made since then.

The rest of the chapter proceeds as follows. In the next section, some conceptual issues pertaining to price volatility is discussed. Subsequently a review is presented 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 a short review of some institutional issues in food importing is presented. Then a proposal is discussed for a Food Import Financing Facility designed to alleviate the trade finance constraint that seems to affect LIFDCs. The final section concludes.

11.2 Some Conceptual Issues Relevant to Price Volatility

Market volatility normally refers to variations of market prices from period to period. As such it is an ex-post concept, in the sense that everyone can observe the market variations. However, what matters for both market participants as well as policy makers are not the market price variations *per se*, but their unpredictability, and the risks they create. Clements and Hendry (1998) define unpredictability of a variable x with respect an information set S, as the inability of the information set to make a difference in any estimate of the variable. More formally, this implies that the conditional probability distribution of the variable, given the information set, is exactly the same as the unconditional probability distribution of the variable. In other words knowledge of the information in S, does not improve prediction, and does not reduce any aspect of uncertainty about the variable x. This notion of unpredictability does not imply that various market agents do not have or do not use information about the future variable. It just implies that despite all the previous knowledge and information about the variable and the process governing it, there are some elements of the process determining x that cannot possibly be known ex ante.

Uncertainty of the variable x, when looked at from some period before its realisation, is basically a summary measure of the unpredictable elements in the process determining x, that are likely to occur between the time of the prediction and the time of realisation of the variable x. For instance, if a producer is contemplating producing a crop, he/she may know the basic process (the model) that determines the yield and the price of the commodity, but he also knows that there are elements of this process, such as rainfall and future price, that cannot possibly be predicted say 1 year ahead. These unpredictable elements are what create the uncertainty about the outcome of his action to produce the crop. Uncertainty then depends on how far into the future one is interested in the variable of interest.

Risk, in turn is generated by uncertainty. In other words, risk is generated by actions whose outcomes are subject to uncertainty. In the case of the producer, he knows that production of a crop is uncertain. As long as he does not produce the crop he is not at risk. If, however, he decides to produce it, he places himself at risk, as the outcome of the crop affects his income and welfare. Thus it is unpredictability that defines uncertainty, and it is the actions that have uncertain outcomes that create the attendant risks. In the face of uncertain outcomes and prices, agricultural producers, for instance, tend to reduce the risks facing them, by diversification, namely by producing a less uncertain mixture of products.

The detrimental effects of uncertainty or unpredictability on both private agents, as well as governments are not hard to understand, and have been the object of both discussion as well as research for a long time. For instance, Keynes (1942) argued that commodity price fluctuations led to unnecessary waste of resources, and, by creating fluctuations in export earnings, had a detrimental effect on investment in new productive capacity and tended to perpetuate a cycle of dependence on commodities, what we may call in modern growth terminology a "commodity development trap".

While Keynes viewed the issues largely from a macro perspective, in recent years his argument has been refined and applied to the microeconomics of households facing risks, but the concepts can easily be adapted to the problems of commodity dependent developing countries. All the recent literature is based on the idea that poor households are liquidity constrained, in the sense that they cannot easily borrow to smooth out any major income shocks (for the definitive paper on consumption and saving behaviour under liquidity constraints, see Deaton, 1991). This is the major and realistic departure from earlier work on commodity stabilisation, which assumed that commodity markets could be costlessly stabilised, and/or that agents (governments or households) could borrow to smooth shocks.

The basic insight of all the recent literature is that the presence of uncertainty, when there is inability to borrow to smooth negative income shocks, leads agents to accumulate liquid precautionary reserves, much like earlier analysts such as the economists cited above suggested that governments should do to deal with the undesirable commodity shocks. The difference from earlier research is first that on average the level of buffer stocks that must be carried is positive, even if the probability distribution of future outcomes is known with certainty. The second difference is that in poor country environments, these reserves must be liquid enough, in order to be readily accessible in times of need. This positive and liquid level of reserves implies that the resources devoted to buffer stocks or what has been termed "consumption smoothing" cannot be used for productive but illiquid investments, and it is this that leads to the negative impact on overall growth.

The above discussion implies that mere variability of outcomes does not constitute uncertainty, and may not be detrimental. This issue of uncertainty versus mere ex-post variability is important in the discussion of this chapter, as compensatory schemes like STABEX, as well as the IMF's Commodity Compensatory Financing Facility (CCFF) have adopted a notion of uncertainty that is related to the mere ex-post variability or fluctuations of outcomes such as export earnings or import costs, rather than to their predictability. More recently, there have been efforts to construct indices that correspond more closely to the theoretical notion of uncertainty, namely the notion of unpredictability. Dehn (2000), in the most detailed study to date, constructs an index of price instability that distinguishes between negative and positive shocks, and finds, as expected theoretically, that negative commodity price shocks have a significant negative effect on overall economic growth. This is the first study to establish a strong negative empirical link between negative unanticipated shocks and overall economic growth.

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 globalisation 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 (e.g. the consequences of the expensive and inefficient EU-based agricultural price supports are well-documented), as well as developing ones (e.g. 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 a 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.

11.3 Risks Faced by Food Importers

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.

The second 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 characterised 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 destabilising the economy and hinder 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.

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.

If households face 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.

The third 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 reactions 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 stabilise domestic prices. A range of interventions have also been implemented to mitigate the adverse impacts on vulnerable households, such as targeted subsidised food sales (Rapsomanikis, 2009).

Demeke et al. (2009, “Country responses to the food security crisis: nature and preliminary implications of the policies pursued”, Unpublished paper, FAO Initiative on Soaring Food Prices) made a review of policies adopted in response to the recent food price spike and they 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 characterised by an increased reliance on the market – both domestic and international – on the ground that this reliance would increase efficiency of resources allocation, and 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 export 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; by trying to acquire land abroad for securing food and fodder procurement; by trying to engage in regional trade agreements; or by 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 (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 each year 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 others 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 commodity 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

$$R_t = D(p_{ct}) - Q_t \tag{11.1}$$

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 Eq. (11.1).

The problem of the manager of the food agency is fourfold. 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 the other variables that enter the demand of the staple, such as disposable incomes, the prices of substitute staples, the behaviour of private stocks and many other variables. 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 stockholding 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 minimise 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. Finally, but not least, and related to the overall cost of fulfilling the requirements, the agent must finance the transaction, either through 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 lag, the domestic production situation, as well as the potential demand just like a public agent, and must plan to order import supplies so as to make a profit by selling in the domestic market. Clearly the private importer faces risks similar to those of 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 maybe more credit and finance constrained than the public agent. In fact the study by FAO (2003) indicated that the most important problem of private traders in LIFDCs is the availability of import trade finance.

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 depend on 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 2 years, it is interesting to examine the evolution of world market price volatility. Figure 11.1 plots the indices of annualised historic volatilities (estimated by normalised 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

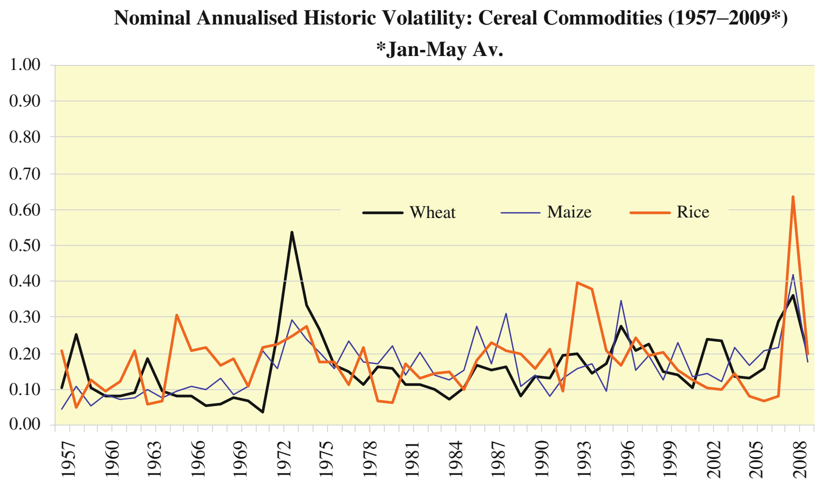

Fig. 11.1 Historic volatility of international prices for the major cereal commodities 1957–2009. *Source:* FAO Trade and Markets Division

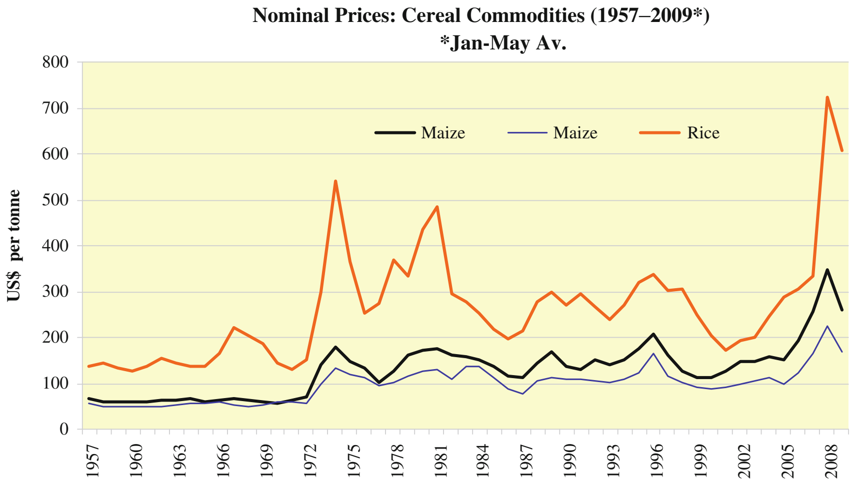

Fig. 11.2 Historic nominal international prices for the major cereal commodities 1957–2009. *Source*: FAO Trade and Markets Division

been known for a long time 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 is 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 Fig. 11.2 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 most recent boom of 2007–2008, 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 not 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 or 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 a 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 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 things such as 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.

11.4 Some Institutional Issues of Importing Staple Foods and Risks Involved

International staple food commodity 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 to a transaction (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 in the future. A first decision that must be made by the importer is the number of months to contract ahead of the actual delivery of the anticipated quantities 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 minimise 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 of anything going wrong, whether its price change or any other event that may impinge on the contract, is small, given the short amount of time between the award of the tender and actual delivery. However, in periods of market upheaval as in the last 2 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 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 in developing countries that may prevent the local agents, public or private to import the full amounts that they deem appropriate for their operations.

11.5 Policies to Manage Food Import Risks

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 towards 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 prices. 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 US 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 materialising. 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.

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. Recently Sarris, Conforti and Prakash (2011) have shown that developing food importers could have reduced considerably the unpredictability of their food commodity imports in the past, and could have had a lower import cost over the past

20 years, including the period of the recent crisis, if they had relied on continuous hedging through organised futures and option markets.

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 maybe. 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 has been 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 stabilise 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 tool and institutions available, and this 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 US 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 organised markets as well as in less-organised 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.

11.6 A Proposal to Create a Dedicated Food Import Financing Facility

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 of excess commercial imports.[2] 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 needs 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 is not intended to 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 FIFF will provide guarantees to these financial institutions so that they can increase their exposure to the importing country. It will do so by inducing 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 to guarantee increases in credit limits and 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 setup 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.

[2]This section draws on an unpublished note (FAO and UNCTAD, 2005) co-authored by the author of this chapter.

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 organised and OTC derivatives markets so as to minimise 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 or guarantees will be reimbursed to the FIFF within 6 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 trend 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 6 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 subsidise excess food imports, but to enable the realisation 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.[3] 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 exposure in the "trigger cases" specified by the FIFF and for amounts also specified by the FIFF. In this way, 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 or that the guarantees that it provides will be called to finance non-repayments. 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 risks, 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 minimise 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-rated 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

[3] This is a mechanism used for example in the United States 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.

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 2 weeks. This will ensure that normal commercial imports of foodstuffs can continue uninterrupted even in times of large external shocks.

Assuming that the FIFF's operational costs are covered by WTO member contributions,[4] 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 on 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 to 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.

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 analyse 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 organisations (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.

[4] 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.

To put some numbers behind the concept, some calculations have been made of the yearly average financing needs of a FIFF of the type proposed here, that would have been required during the period 1969–2007 if a FIFF had been operational, as well as calculations of the maximum financing needed in an exceptional year. The methodology involves first computing indicative food import bills (FIB) closely related with actual food import bills. Secondly, appropriate import bill trends (FIBT) are computed. Thirdly, the FIFF is assumed to finance the "excess food import bill" which is defined to be a fraction β of the amount above a certain fraction α above the trend FIB.[5]

In practice, the FIFF is postulated to finance the following amount:

$$\Delta\text{FIB} = \beta \times \{\text{FIB} - (1+\alpha)\text{FIBT}\} \quad \text{(when the bracket is positive)} \tag{11.2}$$

The idea behind the formula in Eq. (11.2) is that since the commercial imports that would have taken place without the financing constraints are not known, a method is needed to estimate them. The estimate made here assumes that these unknown excess commercial imports would have been proportional by a fraction β of the amount of actual imports that were observed to be a certain fraction α above the trend FIB, under the logic that credit constraints bind whenever there is an excess demand for food commodity imports.

Table 11.2 presents some calculations for different assumptions of the parameter α that defines what can be counted as "excess food imports", and for $\beta = 0.5$. The computations suggest that average yearly FIFF guarantee financing for LDCs would have been in the vicinity of US$ 200–430 million, while the financing needs in an exceptional year may have reached as much as US$ 2,400 million. To put these

Table 11.2 Estimates of the total annual excess food import financing needs during 1969–2007 of LDCs and LIFDCs for different values of the parameter α (all values in million US$)

LDC						
α	0.05	0.10	0.15	0.20	0.25	0.30
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	0.10	0.15	0.20	0.25	0.30
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

[5]The full details of the methodology as well as more empirical results can be found in Sarris (2009b).

figures in perspective, the average yearly LDC commercial food import bill for all foods between 2000 and 2007 was US$ 10.7 billion. Hence, the FIFF average annual financing needs would constitute about 2–4% 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% 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 US$ 960–1937 million, and this constitutes around 1.8–3.7% 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 US$ 10 billion, which would be about 19% of the total LIFDC average food import bill of the same period.

11.7 Summary and Conclusions

The chapter has presented various dimensions of the problem of staple food commodity market volatility and import management, and has discussed some ways to manage food imports.

The first conclusion is that the issue of market price volatility is quite separate from the issue of market predictability. While the proper way to view undesirable risks on agricultural agents as well as trading countries is through the prism of market unpredictability, much discussion as well as action in the past has revolved and tried to deal with the issue of ex-post volatility. As such any policy based on ex-post observations of market volatility is bound not to be able to affect actions of agents before any actual price spikes occur.

The second conclusion is that the problem of food commodity imports has many facets and cannot be examined only from the perspective of market volatility. It was pointed out that financing constraints as well as non-performance risks are major issues that affect many food commodity-importing countries.

It was pointed out that there are basically three ways to deal with market volatility, apart from doing nothing. Changing the exposure to the food risk is a long-run proposition, and is not a short-run response. In the short-run there is a competition between policies that purport to change the fundamentals of the market through commodity market interventions, and policies that try to manage the risks both ex-ante and ex-post. While many countries have pursued market management approaches, these are for the most part expensive and inefficient. Given the modern availability of many risk management instruments, it appears that a better way to manage food commodity market unpredictability and relevant risks is through active management of these risks by using whatever market and non-market based instruments are available.

The final part of the chapter discussed the idea of a Food Import Financing Facility (FIFF) to alleviate the trade financing constraint facing many low income food deficit countries. The idea proposed is based on a system of financial guarantees for financial institutions which could use these to increase their exposure limits to developing food importing countries, especially in times of elevated food import needs. It was seen that the amounts involved are not excessive given the current financing requirements for LIFDC food imports.

A lesson from the brief review here is that any mechanism to manage food imports or to deal with market volatility should not distort 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 perhaps such properties of market non-distortion that should be considered as the major desirable attributes or requirements of any mechanism or institution to better manage food import risks or to manage market volatility.

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Chapter 12
Dealing with Volatility in Agriculture: Policy Issues

Beatriz Velazquez

Abstract The chapter illustrates instruments available to deal with volatility, indicating advantages and disadvantages based on implementation experience. The role of market instruments as a product safety-net and that of decoupled payments is to make farms less vulnerable to fluctuations in prices and to provide an income safety-net independent of the market situation. Current CAP instruments need to be adjusted to achieve the objectives of market stability in light of the medium-term market perspectives, in the most effective and efficient way. A concluding paragraph indicates broadly what type of instruments could be suitable in a post-2013 context.

12.1 Reasons to Address Volatility

From an EU perspective, institutional reasons for addressing volatility lie within the original Common Agricultural Policy (CAP) objectives of stabilising agricultural markets and ensuring a fair standard of living for farmers from the Treaty of Rome, which have been left untouched by the Lisbon Treaty and thus remain valid for the future. The policy mix in place to achieve these objectives has been regularly adapted over the last decades in line with a changing economic, social and political environment.

The issue of volatility is central to today's CAP debate. The reason is twofold. On the one hand, the medium-term perspectives for agricultural markets are expected to be characterised by a gradual recovery supported by structural factors like the growth in global food demand, the development of the biofuel sector and the long-term decline in food crop productivity growth, which would combine to sustain prices above historical levels. But this market outlook faces a number of uncertainties. They concern in particular the pace of recovery from the financial and economic crisis (with its impacts on exchange rates, disposable income, asset values

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Disclaimer: The views expressed in this chapter are those of the author and should not be attributed to her affiliated institution.

B. Velazquez (✉)
Directorate General for Agriculture and Rural Development, European Commission,
Brussels, Belgium
e-mail: beatriz.velazquez@ec.europa.eu

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and energy prices); future changes in the policy environment (e.g. the outcome of the current Doha Development Round, the policies on renewable energy), as well as the path of technological change, in particular, productivity growth. All these factors could have far-reaching implications for the future pattern of agricultural markets.

On the other hand, the move towards greater market orientation has exposed European farmers to higher market volatility, and they are also more sensitive to changes in the macroeconomic environment (like GDP and/or exchange rate fluctuations). Instability on world commodity markets may also permeate to European Union (EU) markets as a consequence of greater trade openness.

The objective of this chapter is to illustrate the possible role of policy instruments in dealing with volatility. Thus, it starts by presenting existing and past policy instruments which have been used to deal with volatility, outlining their advantages and disadvantages (Section 12.2), then it shows how volatility is currently dealt with within the CAP (Section 12.3) and, based on experience from implementation, suggests in broad terms what instruments could be suitable in a post-2013 context (Section 12.4).

12.2 Instruments to Deal with Volatility

12.2.1 Price Support

For a long time guaranteed institutional prices were the main tool within the CAP to ensure support for farmers. Institutional prices set for agricultural products enabled domestic prices to be kept relatively high and stable in comparison to those in the world market. Moreover, in order to avoid increasing competition from imports, support prices had to be accompanied by a certain degree of border protection (e.g. tariffs). If on the one side EU markets were isolated – and thus protected – from external shocks, on the other, high domestic prices boosted production, which in many cases exceeded domestic uses. As a consequence, increasing amounts of production put market balances into risk (see Fig. 12.1).

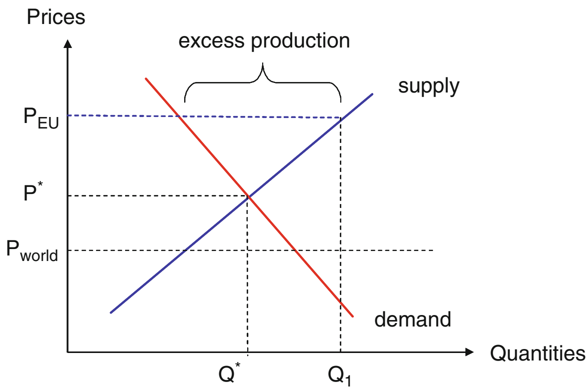


Fig. 12.1 Price support

To re-establish equilibrium, quantities had to be withdrawn from the domestic market through public intervention or exported to third countries. In such cases export refunds were paid to bridge the gap between EU and world market prices. Increasing stocks cumulated for many sectors (e.g. cereals, butter, wine). As a result, budgetary costs increased steadily, leading to the budgetary crisis of the 1980s and the ensuing reform in the mid-1990s.

Through the various reforms (1992, 1999 and 2003), and with support switching from product to producer support through decoupled payments, intervention systems have been reviewed accordingly, with intervention prices being progressively reduced and aligned to world prices. Public intervention today represents a targeted product safety-net (i.e. private and public storage). Institutional prices are set at a level that ensures they are used only in times of real crisis. However, intervention is justified under conditions of *force majeure* (e.g. extreme weather) to compensate farmers for high income variability due to extreme variations in prices (e.g. Arts 70–71 of Reg. 73/2009 on direct payments).

12.2.2 Supply Control

Quantitative restrictions, for example sugar and dairy quotas, had to be introduced in order to deal with market imbalances – including those created by high price support – as well as to contain budgetary costs.

Although it is true that in periods of over-production quotas contributed to reduce budgetary costs and to improve market balance, the rigidity they create has detrimental effects on price stability. The impact on prices of any shock on the demand (or supply) side is swelled by the fact that supply cannot adapt to these changes (see Fig. 12.2). This drawback is of particular importance for agricultural markets.

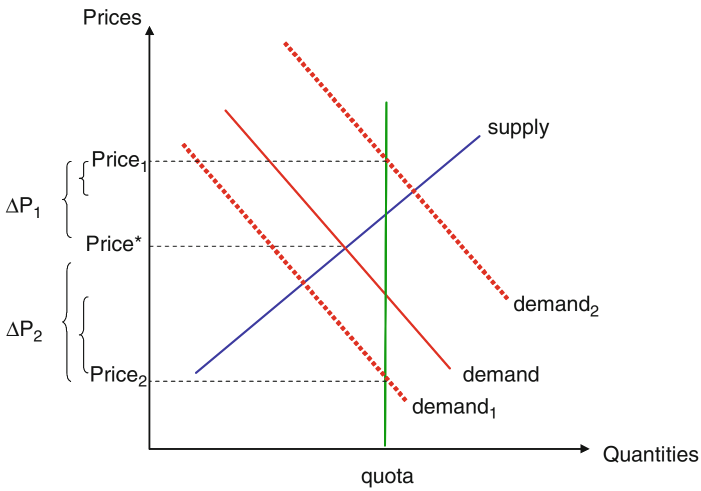


Fig. 12.2 Quotas

The recent dairy crisis provides a good example. Agricultural prices declined sharply from September 2008 until May 2009 following the demand drop resulting from the economic crisis and dairy farmers suffered more than other actors in the dairy food chain. This can be explained mainly by the rigidity of the sector, in particular by constraints hampering supply response to price signals.

Other factors played a part as well, among them a low price transmission along the food chain, lack of transparency and lower bargaining power with respect to other actors in the chain. These elements have been examined by the dairy High Level expert Group (HLG) on milk, which in its final report (European Commission, 2010) identified, in contractual and inter-professional arrangements, a way to increase the bargaining power of farmers and to improve the food chain organisation.

12.2.3 Stability Through Price Guarantee – Counter Cyclical Payments

Counter cyclical payments are implemented in the United States. They have been designed to support and stabilise product-specific revenue, and indirectly income, in years when current prices for historically produced commodities are lower than target prices (Dismukes and Coble, 2007). Thus, when market prices fall, payments increase. These programmes provide a payment when the actual price falls below a certain reference level, protecting farmers against price risks. A farmer gets no compensation through this scheme for low yields, as the price compensation is only paid for the actual yield.

Counter-cyclical payments have several major drawbacks. The unpredictability of budgetary expenditures and insulation of farmers from market signals are two of the best-known. They are also problematic from a WTO point of view as they are linked to current prices, and thus trade distorting.

The biggest drawback is the lack of any link to real farm income, since they do not take into account the total yield and the farm cost of production. When the yield is low, or when input costs increase but the market price of the related crops does not increase proportionally, the programme fails to deliver its targeted aim – it guarantees price for a specific crop but not income.

Figure 12.3 below shows how counter-cyclical payments work in the US model, introduced as an additional safety-net to the Loan Payments Programme by making up the difference between low commodity prices and pre-determined target prices.

12.2.4 Stability Through Decoupled Support

Decoupled direct payments have been introduced with the 2003 CAP reform. They can be seen as a way to stabilise and enhance farm income by guaranteeing a basic fixed income support to farmers and as such representing a producer safety-net. This is illustrated in Fig. 12.4, where real prices and revenues per hectare in the

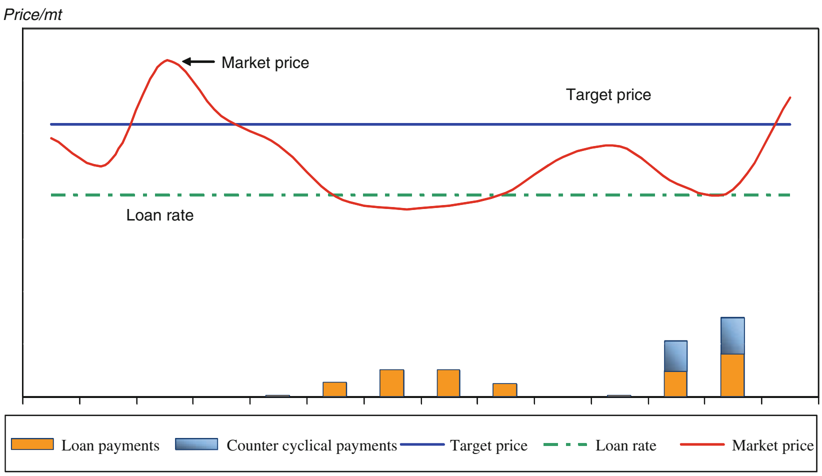


Fig. 12.3 Counter-cyclical payments

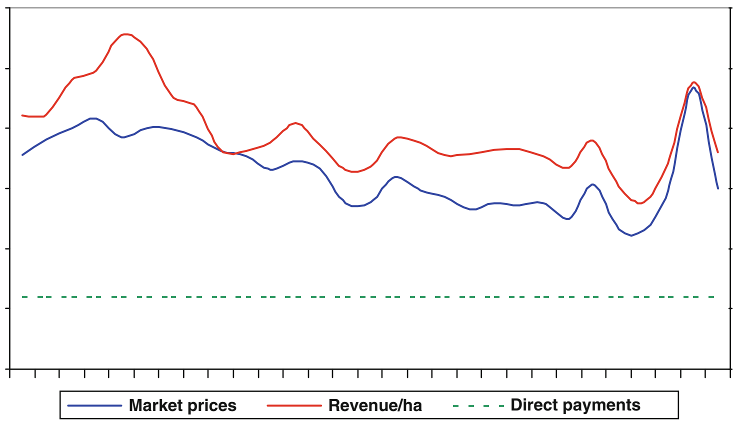


Fig. 12.4 Decoupled support

EU during the last 30 years are put together with the EU average value of direct payments.

This type of income stabilisation through direct payments makes farms less vulnerable to fluctuations in prices providing an income safety-net independent of the market situation. Without such stabilisation many farms, including economically viable enterprises that could potentially respond to the long-term demands of the sector, may come under threat and could be forced out of business. Reducing the income variability gives these farms the necessary liquidity to survive crises, reduces investment risks and, thereby, contributes to maintain economically sound farms in the sector in the long-run.

Results from simulations (ECNC, LEI, ZALF, 2009) showed that a sudden termination of direct payments would lead to disruptive income losses that could force a large number of farmers out of the sector. This supports the idea that income support smoothes out the structural adjustment process and allows a gradual adaptation of the sector and the rural areas to the new conditions, avoiding disruption to existing structures.

12.2.5 Stability Through Income Guarantee

In the EU the idea of an income stabilisation tool has been floating since the 2003 CAP reform. One option put forward in the 2005 Communication on risk and crisis management in agriculture examined an income stabilisation tool. Under this option farmers would be compensated for a serious fall in income, in particular a fall of more than 30%.

The Commission[1] made an analysis of the income stabilisation tool using FADN data for EU-25 in the period 1998–2006. The farm net value added (FNVA) was used as income indicator. Estimates have been calculated on the share (%) of farms that would be eligible for compensation, and budget needed for 70% compensation for EU-25 in the period 1998–2006 (see Fig. 12.5).

As can be seen in Fig. 12.5, the implementation of this instrument may be subject to a high yearly variability in terms of expenditure, which may also have an impact on potential recipients in terms of production behaviour. Other challenges

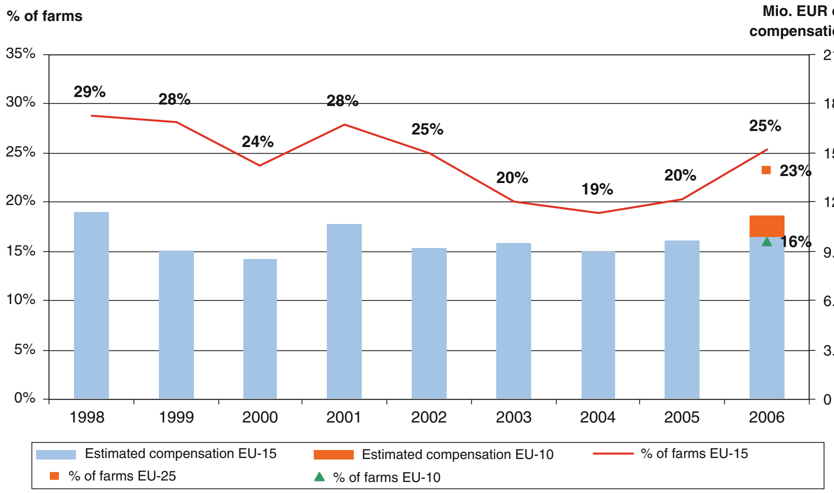
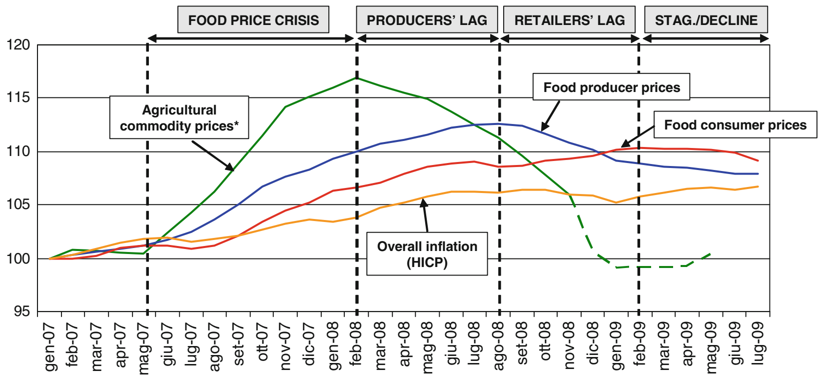


Fig. 12.5 Income stabilisation tool

[1] Directorate for Agriculture estimates calculated using FADN data.



** Quarterly data for agricultural commodity price index; from January 2009, the index has been extrapolated based on price levels of major commodities available in Agriview's database*
Source: European Commission – DG Economic and Financial Affairs, based on Eurostat and Agriview data

Fig. 12.6 Short-term price evolution along the food supply chain

for applying an income stabilisation tool at EU level are related to budgetary needs – this tool would require on average approximately 10 billion euros per year for EU-25 – also the organisational arrangements could also be complex to implement, both at EU and MS levels. Certainly, these challenges invite the comparison between such a scheme and decoupled support in terms of transfer efficiency.

A series of other questions needs to be addressed on its implementation: should it be an EU-wide tool or a more targeted one, articulated according to different situations across the EU and across sectors?; should it be a fixed or variable (e.g. like a top-up to compensate income variability)?; should it be financed exclusively by the EU or also by MS' own money?

12.2.6 Improving the Food Chain

The improvement of the functioning of the whole supply chain could be seen as an alternative way to indirectly address the issue of volatility because it may contribute to market stability. This is possible improving transparency and allowing an efficient price discovery along the supply chain.

The figure below illustrates how price transmission along the food chain is channelled through the different actors. Using price indexes (January 2007=100), it exclusively shows variations in the recent past. It should be noticed that after a steep positive trend, commodity prices at farm level already started a downward trend in February 2008, but prices paid by the industry and retailers showed a lag of 6 and 12 months, respectively. These time lags indicate that farmers were the actors along the food chain to have suffered most the price crisis since its very beginning.

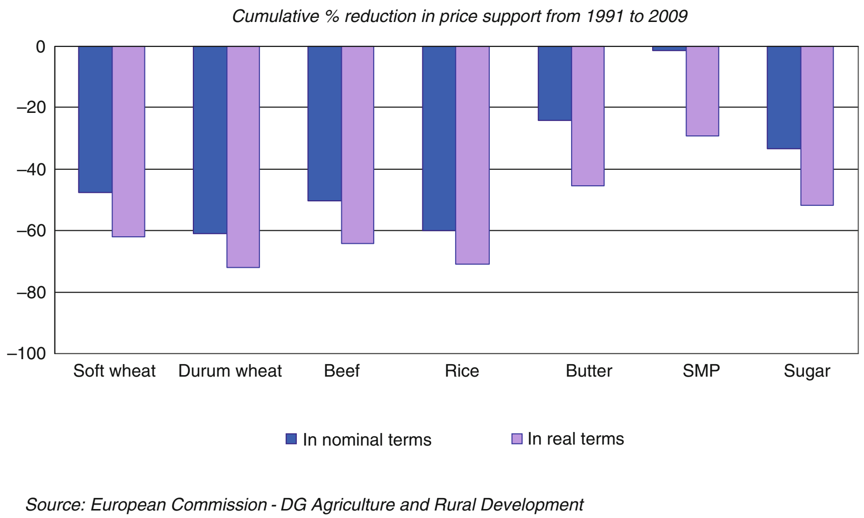


Fig. 12.7 Reductions in EU price support, bringing EU prices in line with world prices

These instruments have been successfully implemented in certain sectors (fruit and vegetables and wine) for a long time. In particular, measures aiming to promote the creation of farmer producer organisations (POs), inter-branch organisations (IBOs), as well as co-financing operational programmes. A series of competition rule derogations are granted. Such instruments tend to have strong sector-specific characteristics, reflecting the structure of the industry.

12.3 The CAP Today

The core element of the latest CAP reform process has been the greater emphasis placed on competitiveness and market orientation, with a decline in support for products and their prices in favour of support for producers and their income. Effectively, it meant the separation of the income support component (through de-coupled payment) from the market stabilisation component (through intervention). Intervention became less relevant with the increased role of world markets, flexibility in farmers' production choices and changes in supply chains and demand patterns. In this context, market stability is ensured, allowing the efficient functioning of markets, stimulating its development and transparency and facilitating participation of actors. The reform process also implied a move from policies concentrated mostly on commodity markets to horizontal instruments, which can benefit differentiated niche markets and a wide range of market actors.

Historical trends in EU prices highlight the results of this market orientation process. In most commodities, EU market prices have been decreasing over the last 15 years and today they are close to world prices.

In the same fashion, trends in EU prices for most commodities mirror those of world prices because markets are much more connected, but this higher "exposure" to market changes and trends increased beyond what was previously foreseen. This was obvious during the commodity price boom in 2007 and then during the price slowdown that followed the economic crisis in 2009. On both occasions, prices showed a historically high volatility, with very sharp variations in short periods of time.

The issue is now whether the current CAP instruments can continue to achieve its objectives in the light of the medium-term market perspectives in the most effective and efficient way, and what changes are needed to ensure them.

From the perspective of increased price volatility and climate change, active risk management will be increasingly important for farmers. The CAP already possesses several tools that address risks that farmers face. Firstly, there exists the possibility of subsidies for farmers that subscribe to crop, animal and plant insurance against adverse climatic events, and animal and plant diseases, creating mutual funds for combating animal and plant diseases, and environmental incidents. Secondly, there are special risk and crisis management measures for fruit and vegetables and wine: supporting (through producer organisations or national envelopes) production planning; concentration of supply; promotion of products; green harvesting; non-harvesting, harvest insurance, market withdrawals, free distribution, promotion and communication, mutual funds, potable alcohol distillation, crisis distillation, by-product distillation. Lastly, two measures address production risks among those of a Rural Development toolkit: introducing appropriate prevention measures against natural disasters in agriculture and forestry; and restoring agricultural and forestry production potential damaged by natural disaster (Measure 126 and 226), and "Vocational training and information", where risk management could be addressed as one topic (Measure 111).

Undoubtedly, the current reform path towards better effectiveness and efficiency must continue, while addressing in parallel new emerging issues.

The emergence of the biofuel sector in the United States and its impact on markets is one of the factors contributing to the expected increased market volatility, together with increased demand and speculation (see Baffes and Haniotis, 2010 for a detailed analysis of factors determining the latest prices hikes). While the biofuel sector is foreseen to reinforce the link between agricultural commodities and energy prices (both on the supply and demand side), thus contributing to higher price volatility, climate change may also lead to a significant increase in production risk. In this context agricultural prices would follow movements of non-agricultural prices (especially energy and minerals) much more closely, leading to a double squeeze of farmers' income both on the revenue and the cost side.

12.4 Volatility Instruments in a Future CAP

Based on what has been examined in preceding paragraphs, we can assert that thanks to progressive reduction of support prices, intervention systems today represent a targeted product safety-net, which is triggered only in exceptional circumstances and is no longer a structural outlet for farmers (e.g. dairy crisis experience). However, there is still room for improvement of the various intervention systems in place, to render them more efficient, and easy to implement promptly and control in case of crisis.

Since quotas generate rigidity in production and greater price volatility, any shock on the demand (or supply) side is amplified by the fact that supply cannot adapt to these changes. In a more market-orientated context, like that of the CAP post-2013, quotas cannot be seen as a solution to the market problems faced by the sector today. Phasing-out remains the least disruptive way of removing them.

Other instruments may complement intervention since they address sources of uncertainties and farm income variability, such as farmers' low bargaining power and transparency. A careful analysis of the possibilities for extending certain instruments designed to improve the formation of value added along the food chain is essential to contribute to market stability.

Decoupled direct support, which constitutes the bulk of our agricultural support provides a producer safety-net to our farmers, which is essential for farm economic viability. Effectively, it contributes to ensure a certain farm income stability which, in combination with cross-compliance, promotes sustainable farming activity. Nevertheless, there is place for adjustment and convergence within and across MS. It is no longer justified to have a distribution amongst farmers based on historical production and it is also pertinent to look at the rebalancing of direct payments among Member States. The difficulty in deciding the degree and the speed of such harmonisation has been amply demonstrated by the Impact Assessment of the Health Care (HC) CAP reform.

An income stabilisation tool could be seen as a more targeted measure than current decoupled direct payments in achieving market stability, making the price and production volatility more tolerable for farmers overall. However, its implementation raises the important questions of how to implement such a system and be effective and efficient, given the diversity of sectors and currently applied risk management and financial practices across MS.

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About the Authors

John Baffes is a senior economist with the Development Prospects Group. His responsibilities include commodity market monitoring and price projections for agricultural commodities as well as research on market structure and policy reform issues both in developing and OECD countries. Since joining the World Bank in 1993, he has worked in several operation departments, including Mexico and Bangladesh. John Baffes has a B.S. degree in Economics from the University of Athens (1983), an M.S. degree in Agricultural Economics from the University of Georgia (1986), and a Ph.D. in Agricultural and Resource Economics from the University of Maryland (1992). He has published over 30 articles in various academic journals and numerous chapters in books and other reports in the areas of economic development and agricultural economics. He contributes frequently to several internal and external World Bank publications. Mr. Baffes was a key contributor to the World Bank's flagship publication *Global Economic Prospects 2009: Commodities at the Crossroads*.

Christopher L. Gilbert is Professor of Econometrics at the University of Trento, Italy. Prior to moving to Italy in 2003, Gilbert was Professor of Finance at the Free University, Amsterdam. He studied at Oxford (from here has his doctorate) and LSE. His previous university positions were at London (Queen Mary and Birkbeck), Oxford and Bristol universities. He has consulted extensively for the EC, FAO, IADB, IMF, OECD, UNCTAD and the World Bank. He works on commodity futures markets, agricultural, energy and metals markets, financial econometrics, food security issues, African rural development and the history and methodology of econometrics.

Linwood A. Hoffman is a senior economist with the US Department of Agriculture, Economic Research Service. His recent duties include planning and conducting economic research and analyses for the grains and oilseed industries. His research focuses on issues of supply, demand, price, market structure and performance, trade, policy and program alternatives. Hoffman holds a Bachelor's and Master's degree in Agricultural Economics from the Pennsylvania State University and a Doctoral Degree in Agricultural Economics from the University of Illinois.

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Michael Keane B.Agr.Sc. (UCD), M.Sc.Econ (TCD), Ph.D. (TCD) has recently retired (Oct 2009) as Senior Lecturer in the Department of Food Business & Development, University College Cork, Ireland, where he has worked since 1981. He is now active as a dairy and food industry consultant while continuing to provide some teaching and research services to the University. His research and consultancy activity has focused on agri-food economics and market analysis with particular emphasis on the dairy industry and he is regularly invited to assist on EU, Government and business advisory committees considering agri-food issues ranging from market developments to EU and global policy.

Robert M'barek works as an agricultural economist at the Institute for Prospective Technological Studies (IPTS) of the European Commission's Joint Research Centre in Seville, Spain. He holds a Ph.D. in agricultural sciences and is coordinator of the modelling activities in the area of agricultural trade and market policies. He has a special interest in quantitative analysis of the CAP and international trade analysis.

C. Wyn Morgan is Professor in Economics and Fellow of the Centre for Economic Development and International Trade (CREDIT) in the School of Economics at the University of Nottingham. His research interests lie in food markets in general with particular interest in policy implications of price movements in national and international prices. Research has focused on price transmission along imperfectly competitive food chains; supermarket price behaviour; food price volatility; and risk management using futures markets to combat price risk effects. He has published in a range of journals including the Economic Journal, World Development, Journal of International Trade and Economic Development and has undertaken research for amongst others the UK Government (DEFRA, DBIS, DFID) and the Commonwealth Secretariat.

Harriet Mugera is currently pursuing her Ph.D. in Economics and Management, at the University of Trento. She holds a Master's Degree in Finance from the University of Trento. Before starting the Ph.D. program, she worked as a consultant at the Food and Agricultural Organization of the United Nations in the Trade and Markets and in the Agricultural Development Economics Divisions. Her main research interests are on small-scale agriculture in developing countries and volatility transmission in the commodity markets of developing countries.

Declan O'Connor B.Comm. Ph.D. is a lecturer at the Cork Institute of Technology Ireland. Following his degree in Commerce, Declan returned to University College Cork to complete a Ph.D. in Agricultural Economics where he examined price transmission in the EU Dairy sector. His research and teaching interests are in agricultural economics, agricultural policy and the application quantitative methods with particular emphasis on the dairy sector. His more recent research has focused on the emerging issue of price and income volatility. As well as having a number of publications in this field he has also made a number of presentations at international conferences.

Isabelle Piot-Lepetit is a senior economist. She holds a PhD in Economics (University of Bordeaux, France) and an Accreditation to Supervise Research awarded by the University of Paris I Panthéon-Sorbonne (France). She currently works at the Institute for Prospective Technological Studies (IPTS) of the European Commission's Joint Research Centre in Seville, Spain. Before joining IPTS, she worked at INRA – National Institute for Agricultural Research. Her research fields relate to the incorporation of environmental constraints and the introduction of dynamics into the microeconomic representation of producer and market behaviours.

George Rapsomanikis is an Economist in the FAO Trade and Markets Division. He holds a Ph.D. from the University of Reading. Before joining FAO, he held appointments at the Centre for European Agricultural Studies, Imperial College, University of London where he worked on numerous agricultural and rural development policy research projects, advising international organisations and national governments. Currently, his research focuses on issues related to food market analysis, international trade and small-scale agriculture development and transition. He is the author of many academic journal articles and has contributed widely to books mainly on econometric modelling of food markets and agricultural policy. He is also the Editor of the FAO Commodity Market Review.

Hadj Saadi teaches economics at the Université Pierre Mendès France (Grenoble, France). He has specialised on international economics and international primary commodity markets. He has published many articles and a book on primary commodity prices and markets dynamics.

Alexander Sarris since 1982 is professor in the department of economics, University of Athens, Greece. Between 2003 and August 2010, he was Director of the Trade and Markets Division, of the United Nations Food and Agriculture Organization (FAO). He holds a Ph.D. in economics from the Massachusetts Institute of Technology, USA, and has also held a faculty appointment at the University of California at Berkeley, USA, from 1976 to 1982. He has authored or co-authored more than 15 books and monographs, and more than 70 journal and book articles on various issues of international trade and development, has received the Best Paper Award by the American Agricultural Economics Association, in 1984, and the Best Doctoral Dissertation Award, by the American Agricultural Economics Association, in 1978 and has served in the editorial boards of several academic journals. He has advised extensively many UN organisations, the World Bank, the European Commission and other national and international agencies, and has field research and policy advice experience in over 20 countries. He has served as chairman of the Athens-based Center for Planning and Economic Research, as chairman of the Brussels-based Center for Development of Enterprise and in managerial and policy-making capacities in several Greek and international research and trade-related bodies. His professional and research interests include: Development Economics; Commodity Market and Price Analysis; Food and Agriculture Policy; Applied International Economics; Agricultural Risk Management; Macro-Micro Modelling; Income Distribution; and Poverty.

Jochen Schmitz is currently working at the Johann Heinrich von Thünen-Institute (vTI) as an economist/econometrician. His research interests lie in the areas of volatility spillover effects, price spikes (focus on energy markets) and Lévy processes. He has profound knowledge of the German electricity market and is a certified spot market trader (EEX). Before he joined the vTI, he worked as an econometric consultant. Jochen Schmitz has a degree in Economics from the University of Halle.

Monika Tothova currently works as an Economic and Policy Analyst in DG Agriculture and Rural Development of the European Commission in Brussels. Before joining the Commission in 2008, she spent 3 years in the Trade and Agriculture Directorate of the Organisation for Economic Co-operation and Development in Paris. She holds a Ph.D. in Economics and Agricultural Economics (joint degree) from Michigan State University.

Beatriz Velazquez graduated in agriculture economics both in University of Buenos Aires, Argentina, and University of Tuscia, Italy, holds a diploma and a Master on Agribusiness SMEA, University of Sacro Cuore, Cremona, Italy. Before joining the European Commission she worked as a researcher at the National Institute of Agricultural Economics, Italy, in the area of qualitative and quantitative evaluation of CAP reform impacts on specific sectors and regions in Italy. Currently she works at the European Commission – Directorate of Agriculture and Rural Development as Economic and Policy Analyst where she carries out preparatory work, economic and policy analysis for the CAP reform and strategic decision-making, currently focusing on the CAP post-2013. In particular, she coordinates the analytical activity of the unit in areas related to market measures, market stability and food security, and provides strategic support to policy makers in issues related to the ongoing CAP reform. In the recent past she provided analytical work and drafting of the Impact Assessment that accompanied the legislative proposals of the CAP Health Check (2007–2008), the reform of the Cereal Intervention System (2006) and the reform of the Sugar sector and drafting of the Impact Assessment of the Sugar sector Common Market Organization reform (2005).

Oliver von Ledebur is working at the Johann Heinrich von Thünen-Institute (vTI) as an senior researcher. He has nearly 10 years of experience in the analysis of cereals and oilseeds markets. For more than 10 years he has been working with modelling and simulating policy impacts on agricultural markets, most of it within the advisory work for the German Federal Ministry. His research interests lies in the fields of cash crop markets and trade, biofuels policy and markets, agricultural markets volatility and risk management and regional integration, mainly in Europe and South America.

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